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Internet Publication, Report of CCPS/OECD Conference and Workshop on Chemical Accidents Investigations (2002)

Special Publication, International Directory of Emergency Response Centres for Chemical Accidents (2002, revision of 1st edition published in 1992)

No. 10, Guiding Principles for Chemical Accident Prevention, Preparedness and Response: *Guidance for Industry (including Management and Labour), Public Authorities, Communitites and other Stakeholders* (2003, revision of 1st edition published in 1992)

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No. 12, Report of the Workshop on Communication Related to Chemical Releases Caused by Deliberate Acts, Rome, Italy, 25-27 June 2003 (2004)

About the OECD

The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental organisation in which representatives of 30 industrialised countries in North America, Europe and the Pacific, as well as the European Commission, meet to co-ordinate and harmonise policies, discuss issues of mutual concern, and work together to respond to international problems. Most of the OECD's work is carried out by more than 200 specialised Committees and subsidiary groups made up of Member country delegates. Observers from several countries with special status at the OECD, and from interested international organisations, attend many of the OECD's Workshops and other meetings. Committees and subsidiary groups are served by the OECD Secretariat, located in Paris, France, which is organised into Directorates and Divisions.

The work of the OECD related to chemical accident prevention, preparedness and response is carried out by the Working Group (formerly Expert Group) on Chemical Accidents, with Secretariat support from the Environment, Health and Safety Division of the Environment Directorate. The objectives of the Chemical Accidents Programme include exchange of information and experience, analysis of specific issues of mutual concern in Member countries, and development of guidance materials related to chemical accident prevention, preparedness and response. As a contribution to meeting these objectives, over a dozen Workshops have been held since 1989.

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 (see partial list on page 5 and 6). Publications include the OECD's *Guiding Principles for Chemical Accident Prevention, Preparedness and Response*; *Guidance Concerning Chemical Safety in Port Areas* (a joint effort with the IMO); *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, UNEP-TIE and the Joint UNEP/OCHA Environment Unit).

The Environment, Health and Safety Division produces publications in seven series: **Testing and Assessment**; **Good Laboratory Practice and Compliance Monitoring**; **Emission Scenario Documents, Pesticides**; **Risk Management**; **Harmonisation of Regulatory Oversight in Biotechnology**; and **Chemical Accidents.** More information about the Environment, Health and Safety Programme and EHS publications is available on the OECD's web page.

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

This report is available electronically, at no charge.

For the complete text of this and many other Environment, Health and Safety publications, consult the OECD's web page (http://www.oecd.org/ehs/)

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The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) was established in 1995 by UNEP, ILO, FAO, WHO, UNIDO and the OECD (the Participating Organisations), 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. UNITAR joined the IOMC in 1997 to become the seventh Participating Organisation. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organisations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

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FOREWARD

This report presents the main output of the OECD Workshop on *Sharing Experience in the Training of Engineers in Risk Management,* which took place in Montreal, Canada, on 21-24 October 2003. The Workshop was sponsored by the 'Ordre des ingénieurs du Québec' (OIQ), Environment Canada, Government of Quebec Ministries, and private sector organisations.

Approximately 80 experts representing twelve member countries and one non-member country, as well as a number of observers invited by OIQ, attended the Workshop. Worksop participants came from public authorities, academia, industry, professional organisations and other non-governmental organisations (see List of Participants in Annex 3).

The overall objective of the Workshop was to exchange experience concerning the training of engineers in risk management and risk assessment, and make recommendations for the implementation of education and training programmes.

The Workshop included sessions on: (i) ethical and legal aspects related to risk management; (ii) risk communication; (iii) multi-disciplinary approach to risk management; (iv) training examples including harmonisation/accreditation of training courses; (v) training of engineers working in industry and working as public authorities' inspectors; and (vi) research and development in risk management (see Workshop Agenda in Annex 2).

The first part of the report consists of the Workshop Conclusions and Recommendations. This is followed by the Discussion Document prepared for the Workshop (see Annex 1).

The OECD Working Group on Chemical Accidents recommended that this report be forwarded to the Joint Meeting of the Chemicals Committee and Working Party on Chemicals, Pesticides and Biotechnology, for consideration as an OECD publication. The Joint Meeting agreed that it should be made available to the public. It is published under the authority of the Secretary-General of the OECD.

CONCLUSIONS AND RECOMMENDATIONS

Introduction

This Workshop was organised under the auspices of the OECD Working Group on Chemical Accidents. It brought together almost 80 experts from 13 countries (as well as a number of observers), in order to exchange experience concerning the training of engineers in risk assessment and risk management, and to make recommendations related to the implementation of education and training programmes for students and practicing engineers.

Workshop participants represented public authorities, industry, academia, professional organisations, and other non-governmental organisations.

The Workshop included sessions on:
- ethical and legal aspects related to risk management;
- risk communication;
- multi-disciplinary approach to risk management;
- training examples including harmonisation/accreditation of training courses;
- training of engineers in economics and risk management;
- continuing training for engineers working in industry and working as public authorities' inspectors (as well as in other disciplines); and
- research and development in risk management.

This document does not summarise the presentations or discussions. Rather, it sets out conclusions and recommendations for "best practice" concerning the training of engineers related to risk management. It also identifies issues that should be further explored in a national or international context.

It is hoped that these conclusions and recommendations will be made widely available among relevant academic institutions and professional organisations, as well as among industry and public authorities. This should help to raise awareness of the issues related to training of engineers with respect to risk management, and lead to improvements in the skills of engineers, in light of the fact that their actions may have an impact on human health, the environment or property.

General Obligations of Engineers With Respect to Risk Management

Workshop participants agreed that engineers have a professional responsibility to society, as well as to themselves, their employers, their colleagues, and other stakeholders, to take appropriate account of the potential for their work to create, increase or decrease risks to human health, environment, and property. Therefore, safety and risk management considerations should be integrated into every aspect of engineers' work.[1]

- The moral obligation to take account of the consequences of their work should be instilled in all engineers throughout their training. Specifically, engineers should be encouraged to think about the risk potential of their actions and decisions (recognising that the ultimate responsibility for safety may rest with others such as directors, managers, lawmakers, etc.).

[1] Recognising the influence that engineers may have on the safety of enterprises does not affect the legal obligation of the operator to manage the enterprise safely.

In this regard, it was noted that there are enormous costs to businesses and society from accidents.

- Engineers should be aware of their obligation to take into account their potential to create, increase, or reduce risks throughout the process of planning, implementing, measuring, reviewing, and updating/revising relevant projects and activities.

- Risk management principles should be applied in all phases of an installation or enterprise, from design, construction, operation, audit/review, maintenance, and decommissioning. Furthermore, risk management is relevant to prevention, preparedness and response activities.

- The Workshop noted that it is important for engineers to communicate risk information to all relevant stakeholders during the various stages of projects/activities.

- It was suggested that consideration be given to the establishment of a written code of ethics for all engineers.[2] Such a code could identify, in general terms, the responsibilities of engineers, as well as the organisations that hire engineers, in light of the potential impacts of engineers' work on human health, environment, and property.

Safety/risk considerations should be integrated into the core of every engineer's activities and not be considered an add-on activity. Nor should safety be considered a concern only of safety specialists.

It was recognised that engineers may have different roles within organisations/enterprises[3]. For example, engineers may be employed by private companies with responsibilities for designing processes and products or for conducting audits/reviews, or they may be in management positions. In government agencies, engineers may be hired to help develop relevant laws and policies, or they may be hired as inspectors. The Workshop noted that it is important for engineers to have the appropriate skills and education for their positions.

Every enterprise should have a strong safety culture, with all personnel recognising the importance of safety. Senior managers, designers, operators, maintenance and support personnel, and others should have an appropriate understanding of hazards and risks, as well as an understanding of the relevant aspects of risk management needed to carry out their roles and responsibilities with respect to safety. In this regard, it was recognised that different groups of employees will need different types of knowledge and skills. The safety culture should encourage the recognition and documentation of hazards, and the sharing of information and experience related to risk management.

- One responsibility of engineers should be to influence the culture of their organisation in order to improve safety consciousness (both to be aware of risks caused by the organisation's activities, and to take actions to improve safety and reduce risks). Engineers should be able to influence corporate decision-making, to raise the awareness of senior executives and educate them with respect to issues concerning safety and risk.

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2 One example that was cited was the code of professional responsibility of engineers in the province of Quebec (see *http://www.oiq.qc.ca/lois/loi9A.htm).*

3 For purposes of this document, "enterprise" is defined broadly to include the range of private and public entities that have the potential for creating risks to human health, the environment or property.

- Managers should recognise the important role of engineers in risk management decision-making and seek input as to which situations might be unsafe and why, and how they can be improved.

- Decisions concerning risk management should be transparent, and be able to be communicated to stakeholders.

Engineers have a duty to identify safety issues and to provide leadership with respect to safety issues to others in their organisations and to their communities in general.

- Hazard and risk assessment activities should be undertaken proactively to predict potential problems, and thereby maximise inherent safety of facilities, rather than only undertaking retrospective reviews in order to identify concerns or justify an existing situation.

The Workshop pointed out the need to take into account diverse potential risks when undertaking risk assessments and making risk management decisions, in light of the increasingly complex technical and social environment. Because of the multidisciplinary nature of risk assessment and risk management, training activities should take this into account and integrate, to the extent practical, qualified and informed professionals from various engineering specialties and other sectors (e.g., health, economics, law, environment, psychology, sociology, etc.).

- Their experience and training should provide engineers with the knowledge and skills to be able to understand, and integrate, other issues into risk related decision-making along with technical aspects (including, e.g., legal, social, economic, health, environmental, psychological, and communication issues).

Making decisions about safety and risk necessarily involves a balancing act, to reach an appropriate choice among potentially competing interests, weighing relevant risks and benefits. Such decisions generally cannot be made mechanically; while there are many tools/methods for risk assessment that can inform risk management decision-making, the final decision should involve judgment, experience and intuition taking into account available information (which is often incomplete or uncertain, and perhaps biased). These decisions should reflect the relevant safety culture and local values.

- All engineers should be able to apply a structured approach when considering risks and to take into account the other factors that drive decisions within their organisations (e.g., economic, legal and political constraints). Engineers should also be aware of the limitations and biases of the information available to inform decision-making processes.

- It is important for engineers to be able to communicate effectively to their colleagues and superiors about safety and risk issues, taking into account the fact that others in the organisation may have different objectives and use different terminology. Such discussions can help to reach an appropriate decision about risks and safety.

- In this regard, the Workshop noted that effective risk communication (among engineers' peers, with their superiors, with the community, etc.) is a key element for improving safety of installations and activities.

- Participants stated that it is important for risk-related decisions to be consistent with the relevant organisation's and society's objectives, rather than simply meeting legal requirements as set out in codes and regulations. The legal requirements should be seen as minimum obligations.

Workshop participants stressed the value of engineers knowing themselves, in order to be able to define their own positions and understand their own biases. In addition, this personal knowledge is important in order to successfully promote the conclusions they have reached, even if these conclusions are not popular with their superiors and peers.

- As part of their training, engineers should be taught the skills necessary to persuade others to take into account, as appropriate, health, safety and environmental issues.

- It was suggested that two important personal characteristics of effective engineers are: first, the ability to push for a result they believe in, despite pressures to come up with a different result or to agree with others in his/her organisation; and second, the ability to question whether he/she has sufficient knowledge to be able to reach a conclusion.

- It is important for engineers to be aware of the limits of their own knowledge and to seek ways of acquiring additional information. Engineers should be aware of which forces drive the decision-making process and ensure that good engineering practices with respect to safety, health and the environment are considered appropriately.

- Organisations (including enterprises and government agencies) should be receptive to health, safety, and environmental concerns identified by engineers and, in fact, should encourage engineers to share their concerns.

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Training Programmes for Students and Practicing Engineers

General Principles

The Workshop was organised to address the question of how to meet the challenge of having effective training of engineers with respect to risks in a world with increasing complexity. The Workshop considered the various approaches to training students at both undergraduate and post-graduate levels, as well as training and education of practitioners (through provision of information, continuing education courses, etc.).

It was suggested that most engineers working today had little or no exposure to the concepts of risk assessment and management during their undergraduate training and that further efforts are needed to address this.

- The traditional training of engineers was structured, with students divided into specialties. However, in practice, engineers have to consider complex situations involving different disciplines. Therefore, training is moving to a more integrated approach, involving concepts from a number of disciplines (including social sciences and humanities) to expand the perspectives of engineers and to promote a multidisciplinary approach to decision-making.

There was a general consensus that the training of all engineers should, at a minimum, include concepts of risk and risk management, while recognising that specific training programmes should take into account the different educational systems in different countries/localities.

- The Workshop noted that engineering programmes should include a special course in risk management. Ideally, risk management concepts should also be integrated into all other relevant engineering courses. It was recognised that this integration will take time but efforts should be made to move in that direction.

- It was noted that it is critical to adapt courses to the level of understanding and objectives of the target audience. For example, it should not be expected that undergraduate engineering students will have an in-depth understanding of how businesses are managed. In addition, experience has shown that many students are not sufficiently familiar with mathematical and statistical concepts.

- There were suggestions that it is better to limit undergraduate training to awareness and understanding of risk assessment and management concepts, and that more in-depth training be provided only after gaining practical experience. Others were of the opinion that there is an important role to be played by engineers who are trained as undergraduates as risk management specialists (for example, to help facilitate discussions among various perspectives within an organisation).

- The Workshop did not reach agreement on whether any particular approach to training is preferable, and it was recognised that the type of training that is most effective is highly dependent on particular circumstances.

It was agreed that training on risk should, to the extent possible, integrate perspectives of different, relevant engineering disciplines as well as related social sciences and humanities (such as business management, law, economics, psychology).

- The Workshop noted that engineers should be prepared to take into account not just technical issues within their own sphere of expertise, but also other engineering aspects as well as potential risks from natural causes and the legal, environmental, economic and social context.

- The Workshop recommended university courses related to risk management involve students from all different engineering specialties. In this regard, it was noted that chemical engineering courses have generally made greater strides than other engineering courses in incorporating into their overall programme practical training related to risk management.

- It was suggested that one effective way of helping students learn how to integrate various perspectives into risk management decision-making is to include students from different disciplines in one class. This will help to promote sharing of experience and viewpoints. It provides an opportunity for the engineering students to gain experience in explaining to others how things are done and what might go wrong. It also provides an opportunity for discussion among individuals from different disciplines, which could reveal engineers' biases and challenge their premises.

Participants suggested that training in risk management should not be limited to engineers but should also be available for business managers as well as for other professionals such as lawyers, economists, chemists, biologists, etc.

It was recognised that programmes and methods for training of engineers have been expanding and evolving in light of the diversity of risks in a modern society and consequent increased demand. Such risks involve, for example, genetically modified organisms, terrorism, computer security, pandemics, as well as risks in the nuclear, chemical and transport fields.

- In some cases special courses on risk management are offered as part of the undergraduate engineering curriculum, whereas in other cases issues related to risk assessment and risk management have been integrated into existing classes, for example, through the use of case studies.

- Similarly, some special postgraduate degree programmes in risk management have been established; In other postgraduate engineering programmes, issues of safety and risk are considered in a more limited way.

- Furthermore, courses are available from universities and professional organisations to train practicing engineers.

The Workshop also noted that concepts of safety and risk, including risk assessment and management, should be introduced to all students in schools and universities (in addition to specialised engineering courses) in order to develop a safety culture in society generally.

While universities and training programmes can provide a good grounding for engineers, it remains necessary for employers to provide additional training relevant to the specific position and responsibilities of an individual employed as an engineer.

Participants suggested that professional associations (e.g., engineering societies) should support the continuing training of practicing engineers in the area of risk management. This can take a number of different forms, such as making available risk management information and reference materials, organising continuing training courses, and providing information on courses sponsored by other organisations.

The Workshop participants discussed the relative strengths and weaknesses of risk managers being generalists trained in risk management (with broad-based, inter-disciplinary training at university) versus more specialist engineers (e.g., process or chemical engineers) who move into risk management after having significant experience in their fields.

- There was a recognised role for both generalists and specialists, with the former being more skilled at integrating information from various disciplines and the latter having more in-depth knowledge about particular risks and how to address them.

- Participants suggested that it is important for individuals with responsibility for making risk management decisions to have practical experience.

It was suggested that courses be made available for engineering professors/teachers, especially for those that do not have industrial experience, in order to improve their ability to teach students about risk management and how risk issues should be addressed in industrial, governmental and other practical applications. These courses should help to improve the skills of professors/teachers in teaching risk concepts to others, and to understand how to integrate risk concepts in different types of engineering courses.

Engineers' training programmes should emphasise the importance of critical thinking and reflecting about their work. Engineers should be taught to have inquiring minds to think about what can go wrong and why, and be willing and able to ask the questions needed to understand the nature and extent of risks posed by different alternatives.

- One aspect of this critical thinking process is to help engineers to think creatively, for example, to consider more systemic approaches or to think "outside the box", and not be constrained by past practices.

- Engineers engaged in risk management activities also need to realise that they cannot know everything and, therefore, they should understand the limits of their knowledge and skills. They should take the steps necessary to get support to help them understand what is needed to make appropriate decisions.

- It is important for engineers to understand that the role of a risk assessment is not to prove a situation is safe, but rather to learn what is necessary to manage risks effectively.

It is important for risk management decisions to be well-documented, as a basis for any further decision-making as well as to facilitate communication. Engineers involved in risk management should understand how to prepare such documentation.

Engineers must maintain their level of competence, taking into account new technological, legal and other developments. This could be done through in-house training programmes, continuing education courses, on-line and written materials, training activities, etc.

- Workshop participants concluded that qualified engineers should be obliged to take a course in risk assessment and management, if they have not already done so.

- Companies and other organisations that employ engineers should support engineers maintaining their level of competence with respect to risk assessment and risk management training.

Elements of Training Activities

A number of speakers described in some detail the elements of risk management/safety engineering courses or programmes at their universities/institutes. These courses and programmes were all designed to teach engineers the skills needed to identify hazards and assess risks, to reduce the level of risk (likelihood and consequences), and to work with others to improve risk management. While there were some significant differences in the nature and scope of these courses (as well as differences in the target audiences and time frame), most if not all addressed the following three general subject matters:

- <u>Technical knowledge</u> (including such aspects as definitions, risk assessment methodologies, accident analysis, and statistics and probability);

- <u>Organisational knowledge</u> (such as roles and responsibilities of various stakeholders, economic/financial aspects, relevant laws and regulations, business and safety management systems, and decision-making processes);

- <u>Social/human knowledge</u> (including ethical issues, risk communication, and human factors).

There was a particular emphasis on the need for students to be able to communicate effectively, recognising that risk management decisions are made by groups representing diverse interests, and that it is important to be able to discuss issues of risk both within an organisation and outside. It was noted that it is critical to be able to listen to the views of others in order to reach agreement among possibly competing interests.

- For effective communication among team members, engineers should have the ability to speak in a language that others would understand (avoiding jargon) and make an effort to understand the language of others.

- It is also important for engineers in risk management to be good listeners, and be able to learn from others and communicate effectively with people who have different perspectives.

It was suggested that in order to be effective in risk assessment and risk management, engineers should have a good understanding of safety management systems and business management in general (including such concepts as "plan, do, check, act", ISO standards, etc.).

- It was recognised that greater emphasis should be placed on the implementation of risk management decisions, and upon their measurement (e.g., by developing leading indicators of risk).

It was also considered important for engineers to understand the complexity of the issues involved in risk management decision-making, including the need to take into account the range of risks (including technological and natural risks, as well as legal, economic and other related aspects).

It was agreed that training programmes should help target audiences to gain a better understanding of the situations as they may occur in practice (in industry and government) and, therefore, training courses should include the concepts of systemic/holistic approaches.

- The training courses should focus not only on addressing ideal or simplified conditions, but should provide the skills needed to deal with abnormal or unexpected situations, and to be able to respond effectively to the range of possible management conditions as well as changing political and economic climates.

- Training should help engineers understand the important role of humans in the design process. Courses should also recognise the role that humans play in ensuring the safety of hazardous installations. In fact, in many circumstances humans may be the only means for effectively responding to abnormal situations since they have the capability to reason and to override automated systems.

Participants agreed that effective training in risk management must build on experience and provide practical examples. Therefore, in addition to lectures and more traditional learning techniques, training in risk management should involve a variety of project-based approaches. Examples include: simulations, internships in industry/authorities, case studies, table-top exercises, inter-active computer programmes, multi-media presentations, site visits, and guest lecturers from industry, public authorities, and other faculties.

- Since the Workshop noted the value of learning from actual experience, it was therefore suggested that training programmes should use databases containing information about accidents and near misses. In this regard, it was recommended that such databases should be further developed. The use of databases on accidents and near misses should be widely promoted as tools for learning (not to assign responsibility or blame). The reports contained in such databases should not only look at what went wrong but also ask why the failure was not anticipated (taking into account technical as well as organisational, economic, social, cultural, legal and other related aspects).

- In addition, it was suggested that it is important that mechanisms be found to communicate practical experience to students and to practicing engineers, for example, through newsletters, seminars, etc.

- Many participants expressed the view that courses in risk management are more valuable if students have work placements within the period of the course.

The Workshop agreed that it would be beneficial for representatives of industry and public authorities to serve as guest lecturers and teaching staff for risk management training programmes.

It was suggested that an additional way to improve the quality of training programmes might be to have senior and junior engineers participate together in risk management training courses at universities. This could be a significant benefit to both groups, as the senior engineers can share their practical experience, while the younger students provide new ways of thinking about problems.

Concern was expressed that a normal university course (or masters programme) does not have sufficient time to cover the range and nature of subject matter that ideally should be covered. Therefore, care should be taken to avoid overloading students to the detriment of their overall experience.

It was suggested that it is important to consult with representatives of industry and public authorities when designing training programmes related to risk management to ensure the programmes are practical and fit the needs of potential employers.

- It was noted that focus groups can be a useful mechanism for helping to design training programmes. Such focus groups can involve students in order that the programmes meet their needs.

In order to remain relevant, training courses should be periodically reviewed and updated to take into account changing needs of industry/authorities, to incorporate any new laws, regulations, standards, technology and methodologies, and to reflect feedback from students, professors, alumni and others.

- The Workshop considered different measures for determining how successful specific training programmes might be. These include, for example:

  - The number of applicants for the programmes and how well-recognised the course is among students;
  - Whether graduating students are employable and at what salaries (relative to graduates from other institutions); and
  - Surveys of employers to determine level of satisfaction with graduates.

Concern was raised about how to maintain and expand interest in risk management programmes, particularly with the resource limitations being faced by industry and universities. Further efforts are needed to encourage engineering professors to review their programmes in light of the needs of industry and authorities to address risk management issues. In addition, efforts should be made to inform industrial and governmental organisations of the benefits to be gained from the participation of their employees in continuing education activities.

- It was suggested that one way to achieve the goal of increasing interest in risk management programmes might be to develop a recognition for risk management specialists, or accreditation of risk management training programmes. This might be done, for example, by a professional body or an engineering institution.

Roles of Inspectors

The role of inspectors is primarily related to compliance control, checking to see if the inspected facilities are operating in accordance with relevant laws and are carrying out what they say they are doing (e.g., in safety reports). Inspectors also have a secondary role related to sharing of experience.

- It is important that inspectors have appropriate competence (training and experience) to carry out their tasks, and they maintain this competence despite the pressures of political, legal, financial and other changes. It is also important for inspectors to have the authority needed to fulfill their responsibilities.

- Inspectors are not responsible for managing the risks at the installations they inspect (even though they may be engineers).

- It is important for inspectors to maintain impartiality in their work.

- To be able to carry their tasks effectively, inspectors require appropriate knowledge and experience, including a general understanding of the principles and methods of risk assessment and risk management, in order to review safety reports, assess compliance and investigate accidents. Thus, opportunities for training of inspectors should be made available.

- Training to gain this understanding of risk assessment and risk management principles can be done in a variety of ways. Given limited resources, it is often accomplished through in-house training, mentoring programmes and, in some cases, continuing training courses.

- In addition, opportunities exist to exchange experience via international programmes such as those managed by the European Commission (IMPEL and Mutual Joint Visits). Further in-country and international exchanges should be encouraged.

Maintaining and Sharing Information and Experience

The Workshop addressed the importance of understanding how organisations (enterprises, authorities, etc.) "learn" and retain knowledge and experience related to risk management. In this regard, it was agreed that it is important that engineers involved in risk assessment and management learn from others in their organisations, and that there be active communication between newly employed and more experienced personnel (with the former being able to share new ideas and methodologies, and the latter providing insights based on experience). This will help young engineers develop the institutional knowledge necessary to be effective.

- Concern was raised about developing methods to ensure transfer of experience in organisations, especially with the imminent retirement of "baby boomers". The Workshop suggested that universities (including continuing education courses for practitioners) can assist in this. In addition, professional associations can provide support, such as the efforts by the Center for Chemical Process Safety ("CCPS") to capture experience in the forms of guidelines and best practices.

Participants stressed the importance of sharing of experience in the development and implementation of programmes related to risk assessment and management, especially as it is a relatively new discipline in many universities. In this regard, it was suggested that universities and others involved in training related to risk management could exchange curricula, materials and even students, as appropriate.[4]

- When designing risk management courses, it is important to be aware of existing international tools that could be useful, including guidance materials and databases.

Proposals for Possible Follow-Up

Participants agreed that they should share the results of this Workshop within their countries and organisations, and among other interested parties. They also encouraged the members of the OECD Working Group on Chemical Accidents to make the report of the Workshop widely available.

It was suggested that an international forum be established to help define competencies for specialists working in the field of risk management and for other possible follow-up activities.

- In addition, it was suggested that there could be an international accreditation system for risk management programmes.

It was suggested that an international group could be established to investigate the need for, and practicality of, writing a set of model curricula for a risk management programmes (at, e.g., undergraduate, graduate, specialist, and continuing education levels). This effort could include identification of the contents of core courses.

- In was also suggested that research be undertaken on assessment of training activities, recognising the problems of assessing multidisciplinary training programmes.

Participants recommended that further research should be undertaken on different approaches and methods for teaching engineers about safety and risks. This could include developing means for monitoring professors/teachers for competency, as well as comparing different means for teaching students and practicing engineers (including, e.g., electronic learning methods).

It was agreed that simulations, case studies and other tools designed to provide practical experience are important components of training programmes. However, it was recognised that efforts should be made to refine such tools. For example, it was noted that some of the simulations currently in use have been found to limit the ability of the engineers to respond to unusual situations in their workplace. Thus, it is important to recognise the limitations (and benefits) of different teaching tools and methods.

- Those involved in the development and implementation of training programmes should seek feedback on the value of different tools and programmes, in order to improve the quality of the training and optimise the benefit to participants.

[4] The annex to this document contains a select list of references that may be useful to universities and others involved in training of engineers in risk management. Additional suggestions for publications and websites that should be on this list are welcome.

The Workshop recognised that concepts related to "safety" and tolerable levels of risk are dependent on local cultures and laws The Workshop suggested that it would be helpful to increase understanding about what is meant by safety and how this is affected by legal and cultural differences.

The Workshop recommended that a means for sharing good and bad experiences, as well as tools/methods used in training of engineers, should be established. For example, an "electronic discussion group" could be set up by the OECD, which is available to experts worldwide.

Appendix

Selected References

Codes of Ethics (associations of engineers):

American Institute of Chemical Engineers:
www.aiche.org/about/ethicscode.htm

Canadian Chemical Producers Association:
www.ccpa.ca/english/sitemap/index.html

Institution of Chemical Engineers (international):
www.icheme.org/about_icheme/bylaws2002.pdf

Ordre des ingéneiurs du Quebec (English version) :
www.oiq.qc.ca/lois/FRAME-loisA.html[5]

Publications:

American Institute of Chemical Engineers: Center for Chemical Process Safety (CCPS):
www.aiche.org/ccps/

Institution of Chemical Engineers (international):
www.icheme.org/

Canadian Chemical Producers' Association
www.ccpa.ca

UK Health and Safety Executive (HSE) Books:
www.hsebooks.co.uk/Books/

US Environmental Protection Agency
http://www.epa.gov/ceppo

US Occupational Safety and Health Administration
www.osha-slc.gov/pls/publications/pubindex.list

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[5] Following the Workshop, it was suggested that the following excerpt from the periodical "Plan", published by the Ordre des Ingenieurs du Quebec, is particularly relevant to this document:

> *Every employer is in a way linked to the duties of a professional. We can even assume that if an employer hired such a type of professional, it is because he would like to see him fulfill his duties, among others those related to ethics. In this regard, the engineer is equally responsible to execute his work in compliance with the codes, standards, best practices and regulations regarding its employer than he is regarding the"Ordre des Ingenieurs." If he doesn't do it in such a manner, he exposes himself to penalty from his employer and from the "Ordre". Globally, if a company needed an engineer, it is because there is a need for his competencies, his rigour and judgment; these are inseparable qualities. The engineer who complies with all rules related to his work provides good credibility to his employer. Inversely, the employer has to make possible the attainment of this compliance by the professional (e.g., provide the right environment and resources, etc.).*

OECD Chemical Accidents Programme
www.oecd.org/ehs/

UNEP APELL Programme
www.uneptie.org/apell

AcuSafe (the internet resource for safety and risk management information) (US)
www.acusafe.com

Hazard View (an information source for safety, environment and risk professionals in industry, government and academia) (UK)
www.hazardview.com

Safety and Engineering Education Programmes:

The Safety and Chemical Engineering Education Program (SACHE), a co-operative effort between CCPS and engineering schools:
www.aiche.org/sache/

Canadian Society for Chemical Engineering, Process Safety Division: www.cheminst.ca/division/psm/

Réseau Analyse du risque industriel (ARI) (France) :
www.agora21.org/ari/

Institution of Chemical Engineers (international), Training Packages:
www.icheme.org/shop/?search/searchCourses.asp

Union des Industries Chimiques (France) :
www.uic.fr/fr/08_formation.htm

Faculty of Engineering, University of Alberta, Canada Industrial Safety and Loss Management Program:
www.engineering.ualberta.ca/ISLMP/

Otto-von-Guericke-University Magdeburg, Faculty of Process and Systems Engineering
Institute of Process Equipment and Environmental Engineering
www.uni-magdeburg.de/iaut/as/index.htm

Swedish Department of Fire Safety Engineering. Risk Management Program: www.riskmanagement.lth.se

University of Pennsylvania, Wharton Risk Management and Decision Process Center (US):
http://opim.wharton.upenn.edu/risk/

ANNEX 1

OECD Workshop

on

Sharing Experience in the Training of Engineers in Risk Management

DISCUSSION DOCUMENT

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Introduction

The OECD Working Group on Chemical Accidents has now held 15 workshops on various elements of chemical accident prevention, preparedness and response. Workshops provide an opportunity for experts from practical and policy backgrounds to share their experiences and advance the knowledge related to the particular subject matter of a workshop. The conclusions and recommendations of those experts are then gathered into the *OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response*. The first version of the *Guiding Principles* was published in 1992 and the second version was published in 2003 and is now available both in hard copy and electronically.

In preparation for each workshop, a Discussion Document is developed. The purpose of the Discussion Document is to provide background on the subject matter of the workshop and to stimulate discussion by raising issues and posing questions that participants may want to consider. Following the workshop, the Discussion Document is revised and published along with the conclusions and recommendations in an OECD report. The workshop reports are available on OECD's Chemical Accidents web-site at www.oecd.org/ehs , then click on 'Chemical Accidents'.

This Workshop, while being held under the auspices of the OECD Working Group on Chemical Accidents, has a much wider scope than risk management issues associated with the chemical process industries. Both the Organising Committee and the Programme Committee are conscious of the need to reach the broad spectrum of engineers who deal with a wide variety of risks. That is a significant challenge.

In drafting this Discussion Document, the author has made a number of contacts to obtain information, has conducted research of relevant literature, and has examined several internet web-sites. But no matter how much time one spends on research, or with his or her own experience, the Discussion Document can never be said to be the 'definitive' piece on the subject. It cannot begin to cover the entire range of subject matter that could be addressed in such a Workshop nor to capture all of the ideas of the participants as that is the purpose of the Workshop, that is to share all of those experiences and knowledge.

While the Discussion Document has been reviewed by members of both the Organising Committee and the Programme Committee, the views expressed herein are those of the author and do not necessarily reflect the OECD or any of the sponsoring organisations or companies. Also, references to specific products, programmes or material does not necessarily imply endorsement.

Why hold a Workshop on Training of Engineers in Risk Management?

The manager of a technology-based organisation or facility has to assess the risk that an accident or other event disturbing business continuity can occur in that facility and take the necessary steps to avoid or limit the possibility of occurrence of such an event. The manager has primary responsibility for safety of the site and is in charge of assessing risks and hazards of the installation. In addition, those who might be concerned with the risk at the facility, including employees, public authorities, nearby residents, and communities should have an understanding of the risk issues.

Improved understanding of risk issues should help develop an informed 'safety culture' in society. To achieve this goal, it is necessary that engineers who deal with the technology, be it from an industry, public authority, or other stakeholder perspective, understand the concepts of risk assessment and risk management. Currently there is considerable variation in the ways engineers acquire that basic understanding or knowledge across the Member countries of the OECD. Member countries could benefit from exchanging information and sharing experience in the field of training of engineers in risk management.

Objectives of the Workshop

The primary Objective of this Workshop is to share experience concerning the training of engineers in risk assessment and risk management.

Workshop participants are expected to:

- Share experience on the training of engineers in risk assessment and risk management, particularly of interest would be the training of engineers at the undergraduate level and those who are practicing;
- Identify risk assessment and risk management content and means for undergraduate training;
- Identify risk assessment and management content and means for practicing engineers' training;
- Identify the various engineering disciplines that need training in risk assessment and management and the topics that should be covered;
- Share experience in the development of risk assessment and management training and undergraduate curricula;
- Identify methods for delivering training, such as academia, professional organisations, etc.;
- Share guidance and other materials for engineer training in risk assessment and management; and
- Identify cross-disciplinary training requirements and the means for achieving this training.

The output of the Workshop will be a Report which will include Conclusions and Recommendations concerning 'best practices' as discussed during the Workshop as well as identifying issues requiring further research. The Report will also include a revised Discussion Document taking into account the author's observations during the Workshop.

Session I – Setting the Scene

In developing the material for this Discussion Document, the author continuously tried to differentiate between a discussion of the principles and concepts of risk management and the actual teaching of the subject. This is not an easy task. So inevitably there will be many references to the subject of risk management.

For a previous OECD Workshop on Audits and Inspections (OECD 2001) held in Madrid, Spain, in March 2001, Keith Cassidy (formerly with the U.K. Health and Safety Executive) included in his Discussion Document an Appendix providing an outline of the principles of risk management and risk control. That description is reprinted as an Appendix to this Discussion Document because it is most relevant to the subject matter. It also notes the broad range of issues associated with the risk management process including:

- technical;
- legal (regulatory);
- economic;
- cultural (social); and
- political.

An equally valuable description is contained in the Appendices to the CAN/CSA-Q850-97 Risk Management: Guidelines for Decision-Makers (CSA 1997). Indeed many other references could be cited.

It goes without saying that life has always carried with it the possibility of risk or harm. And certainly people have had to manage or deal with these risks. So when did the subject of risk management as an engineering 'discipline' actually begin?

Consulting some old textbooks used in a couple of cases by long-departed family members, the author found no references to the subject of risk management. These textbooks included:

- Civil Engineering Handbook, L.C. Urquhart, McGraw-Hill, New York, 1934
- Chemical Process Industries, R.N. Shreve, McGraw-Hill, New York, 1945

The author also examined two texts from his own university training and again found no specific references to 'risk management'. These included:

- A Dictionary of Civil Engineering, J.S. Scott, Penguin Reference Books, Great Britain, 1958
- The Discipline of Design, Roe, Soulis and Handa, University of Waterloo, 1967

The latter text was used in an experimental version in Systems Design 101 course in 1966 at the University of Waterloo. It discusses issues such as:

- "Reliable information about outcomes is critical to the process";
- "Decisions under risk are the most common in technology design"; and
- "The existence of the solution and instructions for its implementation must be communicated to others".

It is also interesting to note that the authors describe the problem-solving process as having four major divisions as: problem identification, search for solutions, evaluation, and selection. Implementation was not considered part of the design process.

However, one can see some relationship to the steps in the note in the Appendix, namely, identification, assessment, control and mitigation. There is even a cursory resemblance to the more sophisticated model in the CSA Standard *Risk Management: Guideline for Decision Makers* (CSA,1997), as:

- Initiation;
- Preliminary Analysis;
- Risk Estimation;
- Risk Evaluation;
- Risk Control; and
- Action/Monitoring

In the literature that the author reviewed, the first references to risk management seem to appear throughout the 1980s in papers by authors including B. Fischoff, W. Leiss and P. Slovic. In 1985, the Risk and Insurance Management Society published the Principles of Risk Management (www.rims.org).

Over the last two decades, there has also been an increasing level of research and specialisation in the area of risk management. In 1982, the Institute for Risk Research (www.irr.uwaterloo.ca) was established at the University of Waterloo to conduct research on risk management and to establish a knowledge base to assist governments, public organisations, and industry in risk management decisions and policies. Another example of a highly-recognised center of excellence in this field is the Wharton Risk Management and Decision Processes Center (www.grace.wharton.upenn.edu/risk) at the Wharton School of the University of Pennsylvania. Both centers have published extensively on the subject.

In April, 1986, the Institute for Risk Research held a workshop on Risk Management for Dangerous Goods (IRR, 89). The most relevant Recommendation made by the participants in that workshop reads as:

> "Risk Management must be objective with the goal of risk reduction and with efficient use of all mitigation measures including prevention, emergency response, regulatory and non-regulatory methods. This will require development of risk analysis methods, improved databases, and an effective process. The process should be open, with government leadership, where appropriate, and involve all interested parties."

Unfortunately, the workshop participants did not go so far as to deal with the specific training required of professionals, such as engineers, to implement risk management programmes.

Finally, to really 'set the scene' for this Workshop, one should consider a report from the UK Health and Safety Executive entitled, "Education of Undergraduate Engineers in Risk Concepts" (HSE 1999) published in September, 1999. In this scoping report, Mr. John Lee notes many of the issues that we will be addressing in this Workshop, for example:

- "The concepts of hazard and risk are not well understood and differentiated by new graduates."
- "The familiarity of teachers in universities with techniques of hazard identification and risk reduction is variable and many would welcome good source material for integration into subject presentations."
- "Computer aided learning using an interactive learning package was considered ideal if used with case studies and hard copy material."

Questions for consideration in this session include:

1. What disciplines in engineering are we concerned with as ‘risk managers’? All disciplines? Chemical or Civil?
2. How should we try to engage engineers in aspects of risk management such as social, economic, financial or legal, etc.?
3. Who are we trying to influence through this Workshop? Practicing engineers? Professors? Students? Insurers? Engineering associations?
4. As many managers of large ‘technology-based’ organisations are engineers based on their previous academic training, how can we promote a better understanding of risk management within this group?

Breaking News

The Columbia Accident Investigation Board released its report on August 26, 2003. The Columbia accident occurred on February 1, 2003.

> “The CAIB report concludes that while NASA's present Space Shuttle program is not inherently unsafe, a number of mechanical fixes are required to make the Shuttle safer in the short term. The report also concludes that NASA's management system is unsafe to manage the shuttle system beyond the short term and that the agency does not have a strong safety culture”.

Two chapters in the 11 chapter first volume are devoted to *The Accident's Organizational Causes* and *History as a Cause: Columbia and Challenger*. The report makes a number of Findings and Recommendations in regard to establishing a formal risk management group called the Technical Engineering Authority. This Authority would be responsible for building a disciplined, systematic approach to identifying, analysing and controlling hazards throughout the life cycle of the Shuttle System.

The Report contains considerable information of relevance in teaching risk management to engineers, particularly in regard to a multi-disciplinary approach. The Report can be found at www.caib.us.

Session II – Ethical and Legal Aspects related to Risk Management

In Session I – Setting the Scene, reference was made to the evolution of risk management from the author's perspective as an engineering student. This Session will expand on that evolution of engineering culture and introduce the issues of ethics and legal aspects.

A. Ethical Considerations in Dealing with Risk Management

Following the Saguenay floods in Quebec in 1996, the Order of Engineers of Québec (OIQ 2002) formed a working group with four objectives:

- identify the competencies required of engineers in risk management and emergency management, in general terms and according to sectoral activity;
- determine the actual competencies required of engineers in emergency response;
- determine the target groups for which their competence should be maintained or improved;
- examine corrective measures to improve the conduct of engineers in case of emergency.

The Working Group conducted a review of existing information, collected data through surveys and ten discussion groups with some 92 engineers.

Some important findings of the Working Group included:

- *Identification of Essential Competencies*
  - over 80% of engineers agreed on the top 10 of 28 relevant competencies:
    - judgment
    - knowledge of processes
    - risk safety culture
    - global vision
    - good communication capacity
    - knowledge of applicable standards
    - open spirit (open mindedness)
    - awareness of the importance of good documentation
    - practical experience
    - teamwork.

- *Facing a Difficult Situation*
  - the Working Group identified four difficulties:
    - organisational cultures can limit the performance of engineers in risk management;
    - engineers recognise that they have an important responsibility in risk management and also that they underestimate the activities associated with risk management – in other words, they have limited practical experience;
    - engineers don't know the responsibilities they have in emergency management – many people have a role to play and they don't know what specific role to play; and
    - concurrently, due to their lack of knowledge in risk management and the often unfavourable organisational cultures, engineers say that they face some gaps in their competence that can lead to hazardous situations.

- *Solutions and Recommendations*
  - the Working Group presented several recommendations, which could be summarised as follows:
    - improve knowledge of the field of risk management;
    - improve awareness of ethical obligations in risk management;
    - improve other training in professional development for engineers;
    - contribute to learning programmes in early engineering curricula; and
    - further the establishment of a safety culture.

In terms of ethical/cultural obligations, the OIQ Code of "Professional Ethics of Engineers" (Article 2.1) states:

> "In all the aspects of his work, the engineer should respect his obligations towards mankind and take account of the consequences of the performance of his tasks on the environment and the life, health and property of all persons".

The above demonstrates the significance of the engineering culture in terms of the need to improve our knowledge and practice of the field of risk management.

B. Industry Programmes

Certainly within the chemical process and related industries, the issue of risk management has been a focus since the tragic accident in Bhopal, India in December 1984, almost 20 years ago. Lead by an Initiative of the Canadian Chemical Producers' Association (www.ccpa.ca), the development of the Responsible Care programme has grown into world-wide acceptance by process industry associations. Its Codes of Practice for six main elements provide guidance in the following areas:

- Community Awareness and Emergency Response (CAER)
- Research and Development
- Manufacturing
- Transportation
- Distribution
- Hazardous Waste Management

In particular, for the Manufacturing element, practical guidance has been developed to promote risk management through implementation of Process Safety Management Systems. This documentation is provided by all major chemical industry associations at least to members and through companies to suppliers and downstream clients as part of Product Stewardship.

The importance of exposing experts to the concept of ethics and risk management was recognised by many institutions, industry, governments, universities, and others. The internet offers numerous links related to this issue. But most of these links are in connection with health and medical aspects and financial issues. The attempt of a practical approach to integrating ethical principles into industrial practice seems quite new. The Responsible Care programme of the chemical industry may in fact be the only such case.

Further, while Responsible Care is often referred to as a 'voluntary' initiative, the proactive major associations require implementation and auditing of the individual company Responsible Care programmes as a condition of membership in the association.

Since 1986, the Center for Chemical Process Safety (http://www.aiche.org/ccps), in association with the American Institute of Chemical Engineers, has developed numerous texts and hosted conferences dedicated to improving risk management through process safety management. Three examples are:

- Guidelines for Technical Management of Process Safety – New York, 1989
- Proceedings of International Process Safety Management Conference and Workshop - San Francisco, September 1983
- Proceedings of International Conference and Workshop on Reliability and Risk Management – San Antonio, September 1998

C. Legal Frameworks as a Driving Force in Risk Management

Chemical Safety

In the field of chemical safety, perhaps the two most notable legislative frameworks driving the risk management approach are the so-called "Seveso" Directive 96/82/EU (www.europa.eu.int) of the European Union (adopted originally in 1982 and subsequently amended) and the US EPA Risk Management Plan rule (www.epa.gov/ceppo), which came into effect in June 1999.

The Seveso II Directive was adopted in December 1996 and Member States had two years to bring it into force through their national laws. The aim of Seveso II is two-fold: firstly, it aims to prevent major-accident hazards involving dangerous substances, and secondly, as accidents do continue to occur, it aims to *limit the consequences* of such accidents not only for man (*safety and health aspects*) but also for the environment (*environmental aspect*).

The extent to which the Seveso II Directive applies to establishments is determined by the quantity of dangerous chemicals present. All operators of establishments coming under the scope of the Directive need to send a notification to the competent authority and to establish a Major-Accident Prevention Policy. In addition, '*upper tier' establishments* require a Safety Report, a Safety Management System, on and off-site Emergency Plans, and the provision of information to the public.

The Seveso II Directive is currently being amended to reflect lessons learned from several major accidents in Europe.

The USEPA RMP rule requires companies of all sizes that have certain flammable and toxic substances to develop a Risk Management Program, which include a:

- Hazard assessment that details the potential effects of an accidental release, an accident history of the last five years, and an evaluation of worst-case and alternative accidental releases;
- Prevention programme that includes safety precautions and maintenance, monitoring and employee training measures; and
- Emergency response programme that spells out emergency health care, employee training measures, and procedures for informing the public and response agencies (e.g., the fire department) should an accident occur.

Facilities were to submit a summary of their RMP to USEPA by June 21, 1999.

The USEPA RMP rule complements Rule 29 CFR Part 1910 entitled "Process Safety Management of Highly Hazardous Chemicals: Explosives and Blasting Agents," which was developed by the US Occupational Safety and Health Administration and came into effect in May, 1992. This Rule spells out a very detailed requirement for Process Safety Management in effect providing a systematic risk management programme for management of hazardous chemicals. However, some critics suggest that the Rule is too specific and sets a bar for compliance rather than encouraging 'continual improvement'.

Environment Canada will soon implement new regulations developed under Part 8 of the Canadian Environmental Protection Act (CEPA) (www.ec.gc.ca/ee-ue). Sections 199 and 200 of CEPA allow the Minister of the Environment to require environmental emergency plans for toxic or other hazardous substances. The primary objective for requiring environmental emergency planning is to ensure that appropriate risk management measures are adopted and implemented for potential risks associated with the manufacture, storage and use of toxic and other hazardous substances in Canada.

Section 200 specifically allows for the establishment of a list of substances that, if they enter the environment as a result of an environmental emergency:

- have or may have an immediate or long-term harmful effect on the environment or its biological diversity;
- constitute or may constitute a danger to the environment on which human life depends; or
- constitute or may constitute a danger in Canada to human life or health.

An environmental emergency (E2) plan would be required of all facilities that manufacture, store or use any of these substances at or above specified threshold quantities, including in containers also exceeding the specified quantities. The E2 plan must address prevention, preparedness, response and recovery for an uncontrolled, unplanned or accidental release of the regulated substance at the particular location.

The E2 plan requirements are expected to come into force in September 2003.

Civil Protection

In the past five years, there have been any number of climatic events that have had serious implications on civilian infrastructure. In Europe, there have been several devastating floods resulting in loss of life and property. The same holds true in North America with major flooding of the Mississippi River, the Saguenay, the Red River and others in the United States and Canada. In addition, the '98 Ice Storm caused major disruption in northeastern states and Canadian provinces with some municipalities experiencing power outages for up to three weeks.

And on August 14, 2003, a major power system failure caused a blackout from New York City to Detroit in the United States and the declaration of a state of emergency in the province of Ontario lasting a full week.

One of the factors behind the proposal to hold an OECD Workshop on Sharing Experiences in Training of Engineers in Risk Management is the province of Québec’s Loi sur la sécurité civile (www.assnat.qc.ca/eng/publications/) which entered into force in December 2001. The law spells out responsibilities of citizens, companies, municipalities and government in all the principal dimensions of prevention, preparedness, response and recovery. The government will develop and implement a public safety plan.

Managers of enterprises that could be considered ‘risk generators’ must submit a declaration to either the municipality, regional government or the provincial ministry. The declaration describes: the activity or property causing the risk; the nature, location and possible consequences of the risk; and the safety measures taken to protect against the risks and to reduce the potential.

A regulation is being developed by the province of Québec which will specifically define what activities and property are covered and the timing of submissions of the declarations.

Other requirements include a procedure for monitoring and alerting authorities, implementation of measures contained in declarations, other reports to authorities, and reporting incidents.

Municipalities and regional governments must also develop a civil protection plan designed to identify disaster risks in their territory and to assess the degree of vulnerability. Regional authorities will then establish safety objectives pertaining to disaster mitigation (aimed either at eliminating or reducing the probability of a disaster or at mitigating the emergencies of the disaster), to emergency response to a natural or imminent disaster, and to post-disaster recovery.

All mitigation, emergency preparedness, emergency response and recovery measures established in accordance with the civil protection plan, including monitoring, warning and mobilisation procedures and the planning of exercises, shall be incorporated by the appropriate authority into a document called an "emergency preparedness plan" or, if the measures are dedicated to the management of one specific risk or class of risks, into a document called a "risk management plan".

Given these new legislative requirements in the area of risk management, the Order of Engineers of Québec proposed the Workshop to share experiences and learn from others.

The province of Ontario has recently twice amended its Emergency Management Act (www.e-laws.gov.on.ca), particularly in regard to municipalities (2002) and its own ministries (2003) possibly as a result of events such as September 11, 2001 and subsequent concerns about terrorism and the SARS outbreak.

Every municipality and government body must develop and implement an emergency management programme, which consists of:

- an emergency plan;
- training programmes and exercises for employees with respect to provision of necessary services and the procedures to be followed in emergency response and recovery activation;
- public education on risks to public safety and public preparedness to emergencies; and
- any other elements required by the standards for emergency management programmes set out.

In developing their emergency management programmes, every municipality and government body must identify and assess the various hazards and risks to public safety that could give rise to emergencies and identify the facilities and other elements of the infrastructure that are at risk of being affected by emergencies.

The European Union does not have the same level of legislative authority for civil protection as that noted above in dealing with the 'Seveso' Directive. Nevertheless, it can take Council Decisions (the latest being October 23, 2001) to establish a Community mechanism to facilitate reinforced co-operation in civil protection assistance interventions. The mechanism includes a series of elements to promote mutual assistance between countries in the EU, such as identifying intervention teams and emergency centres, facilitating training, and providing emergency intervention capability (e.g.,information sharing and communication). Each individual country retains the constitutional authority to develop emergency plans as it determines is necessary.

Questions for consideration in this session:

1. Is the role of government in promoting risk management limited to regulation of the 'risk creator or generator'?
2. Should industry take a leadership role since they are generally considered the 'risk creator or generator'?
3. If yes, then what should that role be? Financial assistance? Support to organisations such as CCPS?
4. Are there tasks or responsibilities that should be exclusive to specialists, particularly to engineers?
5. How can ethical aspects be implemented into industrial safety regulation and engineering education?
6. How can engineers influence improved risk management decision-making in politics, business and industry?

Session III – Training of Engineers in Economics (including Insurance) and Risk Management

The origins of "risk management" are found in the insurance industry. In 1963, the Association of Insurance Managers in Industry and Commerce (AIMIC) was formed in the United Kingdom to bring together insurance buyers from British Corporations. However, the field quickly expanded beyond the area of commercial insurance and, in 1974, the Association changed its name to the Association of Risk and Insurance Managers in Industry and Commerce (ARIMIC) (http://www.airmic.com/).

Today, in many companies, the senior safety engineer now holds the title of Loss Prevention Engineer (Manager), as the modern approach consists of identifying risks and treating the exposures through various engineering and/or financing techniques. It is even suggested that there is a need for "risk management to take a more encompassing, holistic approach which involved consideration of all of a firm's objectives as well as its interactions with society and the environment" (A&A 1993).

Over the years, there have been numerous incidents where the lack of a strong risk management programme had devastating results. The Bhopal accident had a major impact on the re-structuring of Union Carbide with many product lines being divested. The 1998 Ice Storm in eastern Canada had major impacts for both Ontario Hydro and Hydro Québec even though these were crown corporations and not private sector.

In the United States and Canada (and also in Europe) the issues of insuring environmental risks has been a significant concern for years. Indeed, a report of the Environmental Liability Committee of the Insurance Bureau of Canada (IBC 1994) contained a number of conclusions and recommendations. One of those recommendations include:

- "Insurance coverage – an issue here is the definition of "sudden", "accidental" risk management – deficiencies include information gathering, analysis and premium development, and role of governments and education."

While the focus of this report was on "Environmental Liability", it included issues clearly related to this Workshop in terms of risk management. For example, the following are cited:

- "Considering the role of governments with respect to environmental liability, the report identifies two urgent priorities: the need to harmonize environmental policy and regulation in Canada, and, more specifically, the establishment of national environmental standards as a means of improving the climate for insuring environmental risks."

- "The insurance industry must take steps to improve the level of education and awareness concerning environmental liability issues – both within and outside the industry".

It further noted:

- "Environmental liability is clearly an issue that will affect the Canadian economy and the property and casualty insurance industry for many years. In this respect, it is particularly important that insurance be understood and utilised as a mechanism for the prevention of environmental damage which will respond to the genuine, accidental occurrence".

Obviously, the insurance industry has a significant role to play in working with so-called “risk creators or generators”, risk managers, and professional organisations to improve the knowledge and capability of engineers to take on increasing risk management responsibilities.

While engineers are licensed through their professional organisations, there does not appear to be any particular body or organisation that licenses “risk managers”.

There are a number of professional associations such as AIRMIC (UK) and the Global Association of Risk Professionals (USA) (www.garp.com); however, these appear aimed at the insurance and financial sectors.

There are also centers of expertise focused on the broad range of risk subjects including the Institute of Risk Management (UK) (www.theIRM.com) and the Institute for Risk Research associated with the University of Waterloo (Canada).

Questions that could be raised in this session include:

1. What are the respective roles of governments, professional organisations, risk creators and risk insurers in promoting risk management for engineers?
2. Are there particular competencies that engineers lack through their education and training that need to be improved?
3. Is there a need to have particular licensing requirements for engineers who carry out risk management functions?
4. Should a specific requirement be included in binding regulations?
5. How can a more permanent awareness of risk and its consequences be obtained for people who work in the field of risk management?

Session IV - Risk Communication

Perhaps the one element of the risk management paradigm that has received the most attention is risk communication. And that is because good risk communication is absolutely essential to a sound risk management programme.

The OIQ Working Group, referenced in the previous chapter, found that 89% of the engineers believed that risk communication was one of the ten most important competencies.

The CSA Q850 Risk Management Standard states that "(a)t the earliest stages in the risk management decision process, it is important for the team to begin to develop a risk communication process. Communication efforts must be based on dialogue, rather than a one-way show of information from decision-maker to outside stakeholder."

A search on the internet for "risk communication" listed several thousand references so obviously there is no shortage of documentation on the subject. There are three documents which this author has used as reference points in managing risk communication processes in the area of emergency management. No doubt, others will have their own valued preferences.

The first document was a report commissioned by the New Jersey Department of the Environment in 1988. It was written by Peter Sandman and colleagues from Rutgers University and entitled "*Improving Dialogue with Communities: Risk Communication Manual for Government*" (NJ 1988). The chapter titles include:

- Earning Trust and Credibility
- Deciding When to Release Information
- Interacting with the Community
- Explaining Risk

Each chapter has an introduction and overview and a series of guidelines such as:

- "Recognize that peoples' values and feelings are a legitimate aspect of environmental health issues, and that such concerns may convey valuable information".
- "If you are explaining numbers that are derived from a risk management, explain the risk assessment process first".
- "Avoid comparisons that seem to minimize or trivialize the risk".

While this document has been over taken in time in a rapidly expanding field of risk communication research, the guidelines are for the most part still valid.

In *"Risk Communication: A Handbook for Communicating Environmental Safety and Health Risks"* (LUND 1998), Regina Lundgren and Andrea McMakin have built a first-class reference document covering various approaches to risk communication, legal and ethical issues, planning, and implementing the risk communication process including numerous checklists to guide the practitioner. The Handbook also contains an interesting section on using the internet to communicate information on risks.

A third reference document is *"Mad Cows and Mother's Milk: The Perils of Poor Risk Communication"* written by Douglas Powell, University of Guelph and William Leiss, Queen's University in 1997 (Powell 1997). The authors analyse seven case studies including such issues as BSE (Mad Cow Disease), dioxins (or chemicals), biotechnology, and even silicone breast implants. The final chapter then provides ten lessons to guide the practitioner. The lessons are:

1. A risk information vacuum is a primary factor in the social amplification of risk.
2. Regulators are responsible for effective risk communication.
3. Industry is responsible for effective risk communication.
4. If you are responsible, act early and often.
5. There is always more to a risk issue that what the science says.
6. Always put the science in a policy context.
7. "Educating the public" about science is no substitute for good risk communication practice.
8. Banish "no risk" managers.
9. Risk messages should address directly the "context and opinion" in society.
10. Communicating well has benefits for good risk management.

In addition to the three documents identified above, a final reference appropriate to this discussion area is a report published in 2001 by UK HSE, entitled, *"Reducing risks, protecting people – HSE's decision-making process"* (HSE 2001). The report is cited here as it clearly describes HSE's approach to reaching decisions on risk that is universally applicable. It provides valuable insight into issues such as "Tolerability of Risks," economic and social implications of cost benefit analysis, valuation of benefits, and comparison of risks against costs.

Questions that might be addressed in this session include:

1. How do we promote the interaction of engineers with society to improve communication skills? Who is responsible (e.g., engineer, facility manager, government, municipality, general public)?
2. Should risk communication be part of every engineering curricula?
3. What tools are available to the practicing engineer to improve his/her communication skills?
4. Should risk communication always be performed by a team of different disciplines (e.g., technical, social, psychological) both on behalf of the companies and the public authorities?
5. Would it be helpful to develop international (e.g., OECD, UNEP) recommendations with basic aspects on risk communication (including definitions, consideration of different types of audiences, elements of acceptability of risk, etc.) to promote risk communication in countries?

Session V - Multi-Disciplinary Approach to Risk Management

In Session II, we discussed legal aspects of risk management and we addressed factors such as culture, values, ethics, etc. Clearly, within any large enterprise or government organisation, there will be personnel who have particular expertise in disciplines of law, finance, engineering, safety, health and environment, and other skills.

If a major incident were to occur within an organisation and such an incident could be of a technological, financial, legal or other nature, the impacts of that incident could have impacts in all facets of the organisation.

As such it only makes sense that managing the risks within an organisation must follow a multi-disciplinary approach.

In terms of multidisciplinary approaches, several organisations have developed standards that that can be adapted to various problems/solutions in the risk management field.

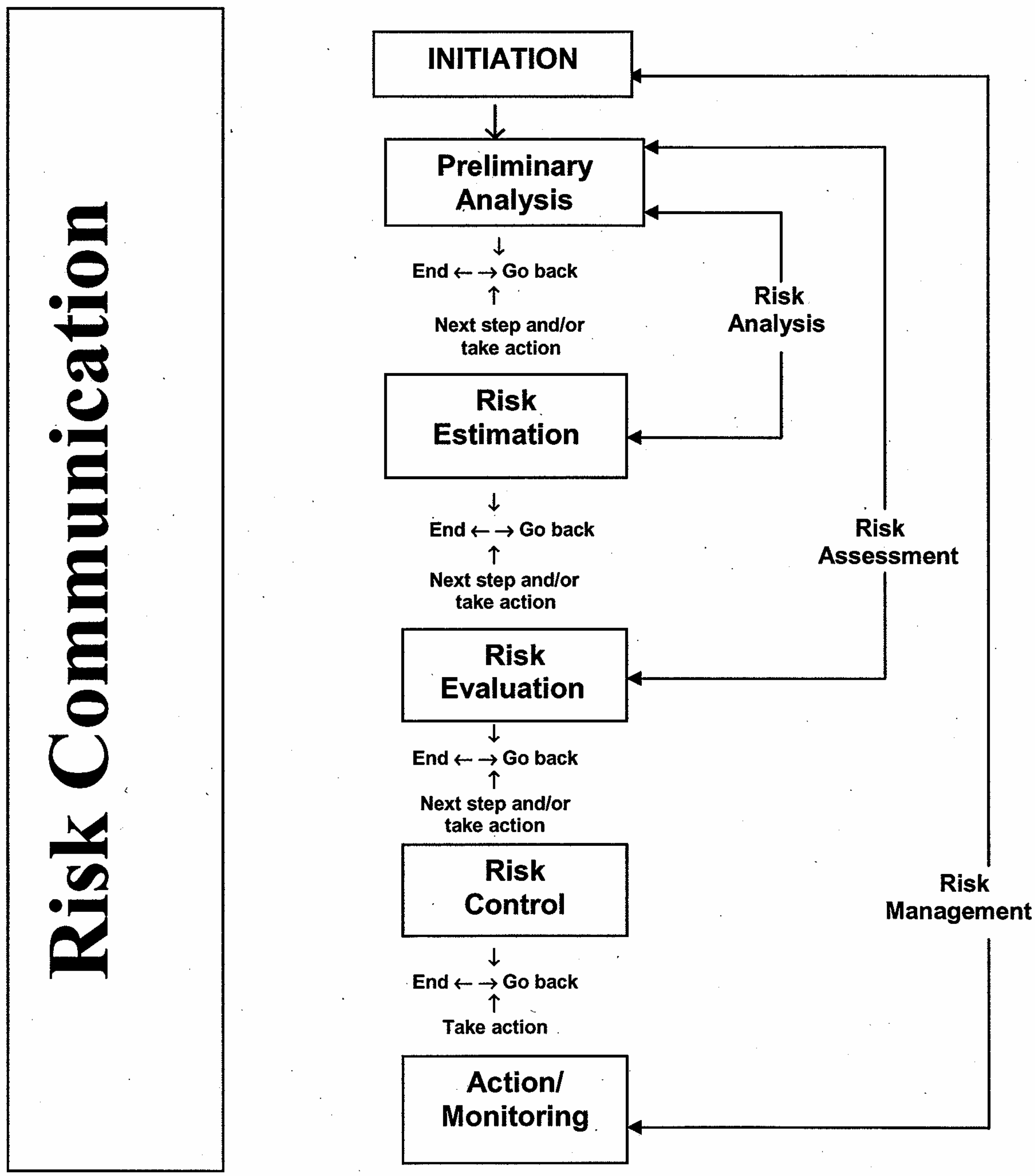
In September 2002, three major risk management organisations in the UK, the Institute of Risk Management (IRM), the Association of Insurance and Risk Managers (AIRMIC), and ALARM the National Forum for Risk Managers in the Public Sector (www.alarm-uk.com), launched the Risk Management Standard with the goal of formalising the risk management framework within their respective organisations. The standard can be downloaded free-of-charge at any of their web-sites with the view of advancing risk management as widely as possible.

The standard uses wherever possible the terminology for risk set out by the International Organization for Standardization (ISO) in its document ISO/IEC Guide 73 Risk Management – Vocabulary – Guidelines (ISO 2000) for use in standards.

In 1997, the Canadian Standards Association published CAN/CSA-Q850-97, Risk Management: Guidelines for Decision-Makers – A National Standard for Canada. The standard sets out the steps in the Decision-Making Process as shown in Figure 1 hereafter.

The document discusses each step of the decision-making process in detail including consultation on risk communication considerations, the decisions to be made, and documentation requirements. An appendix describes how this framework aligns itself with other risk management frameworks particularly that of the United States National Research Council.

It should be recognised that a multi-disciplinary approach doesn't only occur in the management of incidents but also and even in the first place in the steps of identification, assessment, solution decision and in prevention and mitigation of risk.



Note: *Risk communication with stakeholders is an important part of each step in the decision process.*

Figure 1.
Steps in the Q850 Risk Management Decision-Making Process – Simple Model

October 1997

Dam Safety as a Particular Issue

Another case of a multi-disciplinary approach comes in the area of dam safety. The International Commission on Large Dams (ICOLD), and the National Committees of its 81 member countries, provides a forum for technical interaction amongst dam designers, constructors and operators, and has recognised the importance of learning from failures and accidents with dams.

The ICOLD Committee on Tailings Dams and Waste Lagoons jointly with the United Nations Environment Programme (UNEP) published Bulletin 121 in the spring of 2001 entitled "Tailings Dams Risk of Dangerous Occurrences – lessons learnt from practical experiences" (ICOLD 2001). This document provides an approach for improved risk management, to quote:

> "The process of implementing decisions associated with the assessment, toleration and reduction of risks can be termed safety management. Owners and operators have specific responsibilities for their dams and the need to formulate safety management procedures. Technical and managerial approaches should be utilised to improve safety and reduce risk."

Clearly the approach taken in the document relating to dam safety corresponds closely with other approaches noted in this Discussion Document.

Questions for consideration during this session:

1. If risk management is really a multi-disciplinary process, how does that fit with most university engineering courses separated in civil, mechanical, electrical, chemical, etc. after first year?
2. What is the role of senior management of an organisation in forming multi-disciplinary teams?
3. How can smaller organisations implement a multi-disciplinary approach to risk management?
4. Can all concerned disciplines that have to be considered be covered by one person in a smaller enterprise?
5. Do standards serve a useful purpose in guiding multi-disciplinary teams?

Session VI – Training Examples - Harmonisation/Accreditation of Training Courses

The focus of this session is training examples in undergraduate and graduate programmes with the emphasis on engineers. The issue of attempting to use similar course content and therefore achieve some form of harmonisation then arises.

In the UK HSE scoping report referred to in Session I, the author notes the following:

> "Professional development does need a sound foundation, which includes an understanding and awareness of risk concepts, on which to build. It is proper that this foundation is provided during education of undergraduate engineers and offered to practicing engineers.

The foundation needs to be designed so that a learning outcome, based on an understanding of the concept of risk, is achieved. It will thereby permeate the presentation of subjects in all disciplines where the optimum engineering solution is uncertain and, very often, a compromise between conflicting requirements. This is a defining characteristic of the engineer's exercise of professional judgment. The transparency of the resulting decision is improved by systematic and structured assessment of the risks of failure of the potential solutions. Such assessment leads naturally to the practical design of precautionary measures, by designing out undesirable outcomes, and including rigorous measures to defend against remaining risks. Importantly, this process is common for addressing risks to success in all dimensions so that understanding of risk has much wider connotations than health and safety. In that wide sense, it seems quite proper that it should be fully integrated into the education of an engineer."

The extent to which universities teach the subject of risk management varies significantly from country to country and no in-depth survey exists. The Order of Engineers of Québec, through the Working Group mentioned earlier, noted that a survey indicated several universities presented obligatory and optional courses relating to risks in a number of fields. Indeed, the larger engineering schools in Québec, Laval, McGill, Sherbrooke and École Polytechnique, all appeared to have obligatory courses in civil and chemical undergraduate curricula.

At the University of Alberta, the Faculty of Engineering has included the "Industrial Safety and Loss/Risk Management" programme since 1988 in its curricula.

Many of the universities have well-established programmes in the area of risk management and research. But there appears to be a gap between the research carried out by the 'research centers' and the teaching of students.

This author suggests that such risk management programmes should be a fundamental element in every engineering curriculum as it would seem that in every field of engineering we are dealing with technology or technological changes that have "risk" associated with it.

As noted earlier in the HSE scooping report, one of the 'findings' referred to the need to provide "good source material" to teachers. One related effort is 'SACHE' developed by the American Institute of Chemical Engineers (www.aiche.org/sache/). "The Safety and Chemical Engineering Education (SACHE) programme, initiated in 1992, is a co-operative effort between the Center for Chemical Process Safety (CCPS) and engineering schools to provide teaching materials and programmes that bring elements of process safety into the education of undergraduate engineers."

The materials include lecture sets (slide or video), problem sets, course outlines, case histories, etc. Each year new material is provided. Annual workshops provide opportunities for professors to obtain on-site learning experiences at operating facilities.

Continuing learning in risk management for engineers in practice is recognised as essential. Many professional organisations provide courses for engineers and other professionals. One such course is provided by AIChE, entitled, "*Risk Assessment and Management for Continual Improvement"* (www.aiche.org/education/).

Courses are also available from private institutions such as the Process Safety Institute (www.jbfa.com) with titles such as "*Enterprise Risk Management*" and "*Compliance Auditing for Process Safety/Risk Management"*.

Questions for consideration for this session include:

1. Managing risk is so fundamental to the work of every engineer and indeed many other professions. Therefore, should universities teach this as a core subject instead of more specialised engineering science topics which may be only relevant to a few?
2. Should risk management courses be obligatory for all engineering students? In all disciplines?
3. How does one add Risk Management to an already fully-loaded engineering curriculum for undergraduates?
4. Is there a need for more harmonisation of teaching materials? If yes, will harmonisation of training materials be possible taking into account the different education methods amongst countries, the different approaches for risk management in general, and especially in the different disciplines?
5. Is there a need for accreditation beyond what is taught in universities and, if so, who is most properly placed to provide this service?
6. Is it desirable for the subject of risk management to impregnate the whole curriculum rather than just having a specific course on risk management?
7. We see that risk management training is obligatory in the chemical and civil engineering curricula. Should it be included in the programmes of other disciplines?

Session VII - Continuing Training in Risk Management for Engineers Working in Industry and as Public Authorities Inspectors

The increasing complexity of our technological world will only increase the need for improved understanding of risk management. An additional consideration is the extreme costs of low-probability/high-consequence events. In addition, the influence of natural disasters, such as floods, ice storms, tornados and hurricanes on technological infrastructure has increased losses in the last 15 years beyond anything ever before experienced.

In searching the internet for risk management training or courses, one finds numerous listings for many fields of risk management such as financial, health, food and technological risks. In terms of technological risks, training courses are available to both the private and public sectors.

Training of public authority inspectors in risk management is obvious where the inspector carries out enforcement of legislation or regulations such as the Seveso Directive Legislation in EU countries or the USEPA RMP rule and equivalent requirements in other countries.

Understanding risk management and all of its aspects, including auditing permits, the public authority inspector should have a more open appreciation of the range of options available to the ‘risk generator or creator’ for reducing, or controlling, risk.

Continuing education is also essential for those engineers associated with the ‘risk generator or creator’ and responsible for managing that risk. And management of the risk must not be targetted at simply being in compliance with a particular regulation or rule. This actually goes to the statements made earlier in regard to the “Code of Professional Ethics”.

Issues that might be considered in this session include:

1. How much training in risk management is necessary for a public authority inspector?
2. Is there a role for third parties acting as regulatory inspectors?
3. What is the role of third parties in fulfilling the role of either the ‘risk generator/creator’ or inspector?
4. Should inspectors have relevant industrial experience?
5. What tools/methods are appropriate and effective to train public authority inspectors and independent third party inspectors who usually deal with several different establishments and therefore, safety cultures?

Session VIII - Research and Development in Risk Management

A search of the internet under 'risk management research' yielded over two million results. A subset of these under 'technological risk management research' provided over 700,000 results. This makes it difficult to focus on any particular themes.

In examining some of the research themes of one major institute, The Risk Management and Decision Processes Center, of the Wharton School, University of Pennsylvania, there appears to be an increasing emphasis on research associated with:

- global environmental change; and
- uncertainty of world events (terrorism).

At the University of Waterloo's Institute for Risk Research, the focus has been on issues such as:

- life quality;
- environment/human health;
- industrial safety;
- risk assessment, management and communication;
- transportation; and
- waste management.

In 1997, the Network for Environmental Risk Assessment and Management (NERAM) was established to integrate the scientific knowledge and expertise that exists across many diverse disciplines which contribute to environmental protection in Canada. NERAM is supported by a Secretariat at the Institute for Risk Research and is led by Directors at five nodes across Canada. It has about 60 members mainly from universities.

Issues that could be considered during this session include:

1. Is university research in the risk management field relevant to practitioners in the private and public sectors?
2. Should partnership roles be explored where industry has a voice in the direction of, and sponsors university research? Are safeguards required to ensure veracity of results and wide dissemination?
3. How can research initiated by government and others be made more accessible to practitioners?
4. How can the internet be used more effectively to contribute to sharing experience in risk management?

Summary

This Discussion Document provides the author's views on a broad range of issues associated with the training of engineers in risk management. It includes a number of references to material in hard copy and available on the internet.

Questions have been proposed which hopefully will stimulate discussion in the various Sessions. Presenters will also share thoughts and experiences that will cover a wider range of issues than this Document.

Together, we should all learn from the Workshop, take back ideas that we can put into practice in our own spheres of activity and provide the OECD Working Group with some guidance for the future.

The author wishes to thank all those who have assisted in the writing of this Discussion Document through their comments and encouragement. In particular, the author gratefully acknowledges the support of the Ordre des ingénieurs du Québec in the preparation of this Discussion Document.

Appendix

A Short Note on Aspects of Risk Control and Risk Management[6]

Life inevitably brings with it the prospect, or the risk, of harm; and it is one of life's ironies that those branches of science and technology which have been prime movers in the improvement of many aspects of our lives – in particular the chemical and engineering industries – are held in greater disregard because of the hazards and risks of their products and artefacts, rather than for the benefits to life and its quality which these have brought.

The tensions that arise between the thrust for technological progress, and the concerns of those who might be affected by any adverse impact, are rarely easily resolved. In many cases the science or technology involved is far outside general public experience or understanding: and indeed public perception of the hazards and/risks may well be driven by issues which are more in the domains of the social rather than the physical sciences. It is in this context that the approach of "risk management" has been developed and applied, to try to reach a consensus of "tolerability" around which the various stakeholders – regulators, industry, consumers, etc., can operate. The basic principles of risk assessment and management are central to international initiatives such as the EU 'Framework Directive' on health and safety, and to more focussed Directives such as the so-called "Seveso' Directives on major industrial accident hazards, or the Directives associated with environmental protection. Similarly, they underpin the Risk Management Programs and Process Safety Management Programs of OSHA and EPA in the USA, and similar initiatives elsewhere (e.g., US 1997, A/NZ1999, 1999a, CSA 1997, BCC 1977). And they are at the core of regulatory criteria such as 'reasonable practicability', 'best environmental option', 'best practicable means' and so on (Sing 1998), which increasingly underpin goal-setting approaches to the control of such risks.

Not surprisingly, there is no agreed definition of the risk management process: the issues and interactions can be very complex, and much effort is going into defining how they can be characterised; but it is possible to sketch the overall process into a coherent architecture, based on the principles of:

- IDENTIFICATION – the recognition and location of any problem;
- ASSESSMENT – the bounding and dimensioning of any problem;
- CONTROL – the limiting of the scale of any potential problem, by prevention or avoidance;
- MITIGATION – the amelioration of the residual elements of any problem.

Measures used to parameterise, or to limit, the component elements may vary between different types of hazard or risk, between different elements of the overall environment, or between different economic and/or cultural systems; but the underpinning logic of the overall approach remains a transparent and potent taxonomy.

At the heart of the risk management approach lies an essentially simple set of critical questions. The core questions are: What If?. What Then?. Then What?. So What?.

[6] Reprinted from the Discussion Document prepared for the OECD Workshop on Audits and Inspections held in Madrid, Spain from 6 – 9 March, 2001

"What If?" requires a combination of technical expertise, experience, and a degree of imaginative insight. "What Then?" and "Then What?" are essentially the techniques and practices of risk assessment, usually quantified, at least in part. "So What?" is the area of objective judgement, informed but not constrained by the earlier inputs. It is a decision process, often rigorous, which involves:

a) dimensioning of likely risk with an understanding of the uncertainties inherent in the assessment process (and answering the further question "How much of what kind of what risk to whom/what?");
b) reference to the likely benefits generated and the associated political, social and economic considerations;
c) judgements as to tolerability or acceptability for groups directly and indirectly involved, and for any other stakeholders; and
d) sometimes, decisions as to further reduction in risk, taking cost (including effort, and available technology) into account.

It is, in short, a process which is essentially economic and political, and technically informed. And because the process relates to the human condition, or to the well being of other parts of the environment, it is ethics-rich.

The models and methodologies that have been developed for the processes of risk assessment and risk management are many and varied. Risk assessment involves an interactive process which considers (using risk assessment jargon) the source, the source term, the dispersion, the dose and the impact; a process in which there are many common components, including:

- in IDENTIFICATION, the use of substance/threshold approaches (and the current search for a hazard or risk equivalence approach);

- in ASSESSMENT, the classical approaches to consequence and probabilistic assessment, including:
  a) comparative methods (process/system checklists, safety etc. audits and reviews (technical and people), relative ranking, indices, preliminary/process hazard analyses etc.);
  b) fundamental methods (HAZOP, 'What if?' Analysis, Cause/Consequence Analysis, Failure Mode and Effects Analysis, Failure Mode, Effects and Criticality Analysis, Goal Oriented Failure Analysis etc.); and
  c) logic diagram methods (HAZAN, Fault Tree Analysis, Event Tree Analysis, Human Reliability Analysis, System Success Trees, etc.);

    - in CONTROL, conformity with regulatory, technical and operational standards, the use of justification packages (safety cases) and information packages (safety reports), and licensing and other permitting and approval activities; and

    - in MITIGATION, emergency and land use planning, and public information and involvement.

Risk assessment and particularly quantified risk assessment, has the capability to dimension, to rank, to focus, and to test the interdependence and interactive responses of the various component elements. There have been significant developments over the last 20 or so years in modelling techniques for such hazard and risk assessment, as a result of an enormous international research effort, especially in the areas of chemical and physical phenomenology (although the assessment of direct environmental and indirect human hazard or risk is currently less well developed and therefore even more uncertain than that of direct risk to man). Most of the scientific and technical bases for the techniques are described in the literature, and many computerised packages are becoming available for use. Generally, such packages use mathematical models to estimate the source term, the dispersion, the dose and the impact to estimate hazard ranges or dose concentrations, to which is added a frequency/probability figure to enable a risk figure to be derived. (A criterion for level of harm, or for probability or frequency of exposure, can then be added for the purposes of risk management). However, the effort in the field of reliability data has been less obvious, despite substantial progress in reliability modelling techniques. Such lack of progress seems to stem from the following areas of difficulty:

- decoupling the 'hardware and peopleware' elements of existing data;
- the paucity of specific data relating to low probability incidents;
- the tension between generic and specific data; and
- the 'in confidence' nature (and concomitant wider unavailability) of much of the data which does exist.

Similar difficulties arise in the 'peopleware' arena. For too long, 'Human Factors' was interpreted in the limited (but of course still very important) sense of operator error; and most research effort was deployed in the development and refinement of human error models based in ergonomics, cognitive behaviour, etc. These now sophisticated models are being further developed, but it is unlikely that such development will result in significantly more accurate (as opposed to prevision, which is not of the course the same thing) of fairly wide uncertainty boundaries. More recently, much development of 'culture', 'management', and 'organisational' models has taken place, most of which are grounded in audit techniques of one kind of another. Substantial further developmental needs remain, but such models can offer significant benefits in identifying critical risk nodes, and in their quantification. How such outputs can be integrated into existing QRA approaches is still a matter of contention; and a further problem for the future is the question of how such models (a difficulty of philosophy rather than technology) can be robustly built into the decision making process (QRA based or not).

There remain, of course, many uncertainties in the technical (and indeed in the related socio/economic/political) components of this process; but their criticality can often be tested and demonstrated by the transparency of the process (a very important issue in its own right), and by elements such as sensitivity testing, which can be used to identify and examine critical areas of control (both hardware and peopleware) to add insight to the adequacy of control measures, to any debate on tolerability, or to validate the relevance of any criteria which may have been applied.

The risk management component brigades into the assessment process, directly or indirectly, opening or covertly, judgements as to acceptability or (otherwise), 'tolerability' of the associated risks. As indicated above, this is an area of extensive (and often heated) debate, and little objective consensus, especially when actual, or defined, levels of tolerability are suggested. Of course, in an ideal world, any hazardous activity would not impose risks which were disproportionate to the benefits (such benefits can cover a wide spectrum, and inevitably involve economic as well as other, often less tangible, social value parameters), and any suck risks would be equitably distributed across society in proportion to the benefits received. In practice of course, such equitable distribution is rarely possible; and distributive principles of a more general kind are now suggested, involving tests to ensure:

- that when a risk is so great, or the hazard so unacceptable, a mechanism for prohibition exists;
- that there is a minimum level of risk, below which further precaution is unnecessary; and
- that if a risk falls between these two states, that it must be reduced to a level which recognises the benefits of (or from) the activity, taking account the costs of any further action to reduce the risk factor.

These principles combine with other generally accepted tenets:

- that risk should never be imposed unnecessarily; and
- that no individual or community should bear an unfair proportion of any risk.

Such value judgements involve very complex social processes. Hazards and risks are viewed quite differently, depending on the origins of the hazards or the nature of the risks that they present. Natural hazards seem to be 'tolerated' more readily than those which are man-made; and hazards which presage catastrophe appear less 'acceptable' than those presenting a lower level, continuous risk. A relatively well-established hierarchy has emerged, which involves issues such as:

- Voluntary vs. involuntary exposure;
- 'Natural' vs. man-made risks;
- Perceptions of personal control;
- Familiarity;
- Perceptions of benefits or disbenefit;
- The nature of the hazard or consequence;
- The nature of the threat;
- The special vulnerability of 'sensitive' groups;
- Public and personal perception of the type and extent of the risk;
- Perceptions of comparators; and
- Effect reversibility.

It is a decision hierarchy which pivots on the confidence, of those exposed to the hazards and risks, in those authorities and bodies who create the hazards and control the risks – regulatory and public authorities, operators, 'experts' of one kind or another, and the emergency services. Priority questions include:

- Do the stakeholders believe that all relevant views and interests have been adequately considered?
- Do the stakeholders have confidence in the effectiveness and independence of the regulatory authorities?
- Is there a consistent and credible consensus of scientific and technical opinion, or is there disagreement amongst the 'experts'? (Note: public perception of what constitutes 'disagreement' amongst experts is rarely consistent with the perspective of any 'experts' involved).
- What is known about the quality of the project, plant, and company management?
- Are the emergency and other responding services able to cope with foreseeable events, in the short and long term?

It is, in effect, a combination of physical and social detriments, in which some major elements may not be quantifiable in any meaningful way; and integrating the concepts into the risk management process, to the satisfaction of all stakeholders, can present severe difficulties, both philosophical and practical.

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ANNEX 2

Workshop on Sharing Experience in the Training of Engineers in Risk Management

21 – 24 October 200, Montreal, Canada

AGENDA

Tuesday 21 October 2003

8:00 – 9:00 REGISTRATION
Distribution of badges and documents

9:00 – 9:45 OPENING SESSION [Duration: ≤45 minutes]
Welcome and Introduction

Welcoming addresses

OIQ - Host country: [15-20 min]	***Gaétan Lefebvre,*** ing., président, Ordre des ingénieurs du Québec ***Sam Hamad,*** ing., ministre des Ressources naturelles du Québec
Environment Canada [10 min]	***Tom Foote***, Director of Environmental Emergency Branch

Introduction

Workshop Chairs [10 min]	***Tom Foote / Jean-Paul Lacoursière*** Workshop Objectives
OECD Secretariat [10 min]	***Marie-Chantal Huet*** Workshop Agenda

9:45 – 10:15 SESSION I [Duration: ≤30 minutes]
Discussion Document

Author of DD ***Wayne Bissett***, Consultant, Canada

10:15 – 10:30 BREAK / PAUSE (15 minutes)

10:30 – 12:00 SESSION II [Duration: 1h30]
Ethical and legal aspects related to risk management

Session Chair: ***Pierre Frattolillo,*** ing., AIEM, Montreal, Canada

This session will address issues related to the moral obligation to manage risks, competency in managing risks, and legal aspects that govern the profession of engineers specifically related to risk management. Session II will discuss the ethical and legal requirements in OECD countries and how those are taken into account in engineer training.

Presentations:

- ***Graham Dalzell,*** Hazards Forum, UK
  ″Safety leadership: What it should mean to engineers?″
- ***Ben Ale***, NIBRA, The Netherlands
  ″Non-technical issues in risk management education″
- ***Paul-André Dastous***, Ecosfera Inc., Canada
  ″Ethical management of risk in engineering″

DISCUSSION

12:00 – 13:30 LUNCH / DEJEUNER

13:30 – 15:30 SESSION IV [Duration: 2 h]
Risk Communication

Session Chair: ***Barbara Polak,*** KGPSP, Poland

This session will look at the needs of various stakeholders that arise in moving from risk assessment process to decision-making. Risk assessment and management are not goals in themselves. It is important that the results of a technical assessment lead to a decision that either the situation is tolerable or the situation should be changed. In this step there are a number of communication processes that need to be considered: between the managers of the infrastructures/installations and the users, within the industrial companies, between industry and authorities, between industry and communities and other stakeholders (NGOs, journalists, etc.). A lack of understanding of risk and/or of how the results are to be interpreted can lead to conflict situations. Communication is not exclusive to engineers, it involves teams of specialists including communication experts, scientific experts, etc.

Presentations:

- ***Hélène Denis,*** École Polytechnique de Montréal, Canada
  ″Teaching risk communication to engineers: The case of major socio-technological risks″
- ***Jean-Pierre Sabourin***, Centre risque et performance, École Polytechnique de Montréal, Canada
  ″Risk communication and engineer training″
- ***Adrian Sepeda***, CCPS, USA
  ″Process incident database and newsletters: Learnings and communication″
- ***Ruth Do Coutto***, UNEP-APELL
  ″Risk communication in the context of the APELL Programme″

DISCUSSION

15:30 – 16:00 BREAK / PAUSE

16:00 – 17:30 SESSION V – 1st block of 3 presentations [duration: 1h30]
Multi-disciplinary approach to risk management

Session Chair: ***Ben Ale,*** NIBRA, The Netherlands

Risk is present in all engineering activities. Engineers must work continuously with uncertainty as a result of the available data and also from limited technical knowledge. In their work, engineers always do some kind of risk management; it is often unconsciously done and in a passive manner. The use of standards is a perfect example of this. The Workshop should allow participants to become aware of this situation which applies to all fields of engineering and all traditional activities undertaken by engineers.

The components of risk management are highly multidisciplinary. Risk integrates all aspects (technical, human factors, etc.) in which engineers play an important role. However, engineering projects do not currently combine risk management expertise from various fields (civil, mechanical, electrical, informatics, chemical, etc.). The fundamental problem lies in the basically ″vertical″ training given to engineers, since those are taught in narrow and well-defined specialised fields. Risk management definitely requires a horizontal approach: there is a need for such a horizontal vision and integration of knowledge and expertise in engineering and other disciplines. The Workshop should suggest actions to be taken to make trainers aware of this multidisciplinary approach.

Presentations at this session should give examples that illustrate conscious and unconscious risk management in all engineering activities. The session will explore perspectives from different countries and from various fields of engineering not traditionally associated with risk. Speakers are expected to present expertise in risk management that engineers should master and how this is integrated in training.

Presentations:

- ***Ulrich Hauptmanns***, Magdeburg University, Germany
  ″Education in risk management and risk assessment at the Otto-von-Guericke University″
- ***Benoît Robert,*** Centre risque et performance, École Polytechnique de Montréal, Canada
  ″Engineers at the centre of risk management″
- ***Diana del Bel Belluz***, Risk Wise Inc., Canada
  ″Team approach for risk assessment and risk management″

DISCUSSION

17:30	End of day 1

17:45	COCKTAIL

Wednesday 22 October 2003

8:30 – 10:00 SESSION V (continued) **–** 2nd block of 3 presentations [Duration: 1h30]
Multi-disciplinary approach to risk management

Presentations:

- ***Graham Dalzell,*** Hazards Forum, UK
  ″Risk assessment or hazard management?″
- ***Olivier Salvi,*** INERIS, France
  ″Complexity and multi-disciplinary sciences: Which job for risk managers?″
- ***Phuong Nguyen***, Hydro-Quebec, Canada
  ″Dam risk management and engineer's training at Hydro-Quebec″

DISCUSSION

10:00 – 10:30 BREAK / PAUSE

10:30 – 12:00 SESSION V (end) **–** 3rd block of 3 presentations [Duration: 1h30]
Multi-disciplinary approach to risk management

Presentations:

- ***Rosa Calvez-Cloutier***, Université Laval, Canada
  ″The use of toxicological risk notions in the management of contaminated sites in urban areas″
- ***Roland Akselsson***, Lund University, Sweden
  ″Safety control in dynamic society: What engineers have to understand?″
- ***Alexandre Debs***, Ministère des Transports du Québec, Canada
  ″Strategic sites of a highway network: An instrument for risk management and civil protection planning″

DISCUSSION

12:00 – 13:30 LUNCH / DEJEUNER

13:30 – 15:00 SESSION VI – 1st block of 3 presentations [Duration: 1h30]
Training examples including harmonisation/accreditation of training courses

Session Chair: ***Craig Matthiessen,*** EPA, USA

This session will present examples of training methods, including undergraduate engineering programmes, curricula in universities, continuous learning programmes, e-learning, workshops, and discuss the issue of best practices in risk management training. Session VI will also address the needs for harmonisation of training courses. Engineering disciplines (e.g. nuclear, chemical, aeronautical engineering) have differing degrees of sensitivity to risk; this session will consider how these disciplines can incorporate notions/elements of risk management. Recognising that certification and accreditation bodies have responsibilities in risk management, this session will also discuss what should be the requirements for accreditation/certification.

Presentations:

- ***Robert Jönsson / Johan Lundin,*** Lund University, Sweden
  ″Master of science in risk management and safety engineering at Lund University, Sweden″
- ***Ben Ale,*** NIBRA, The Netherlands
  ″Risk management education in the Netherlands″
- ***Doug McCutcheon***, University of Alberta, Canada
  ″Training program in safety, loss and risk management at the University of Alberta, Canada″

DISCUSSION

15:00 – 15:30 BREAK / PAUSE

15:30 – 17:00 SESSION VI (continued) **–** 2nd block of 3 presentations [Duration: 1h30]
Training examples including harmonisation/accreditation of training courses

Presentations:

- ***Jerzy Jurewicz***, ing., Université de Sherbrooke, Canada
  ″Experience in the training of chemical engineers in risk management at the Faculté de Génie, Université de Sherbrooke″
- ***Graham Creedy***, CCPA, Canada
  ″Development of an educational module for teaching process safety management to engineering students″
- ***Heidi Ivic***, ETH, Switzerland
  ″Postgraduate course in risk and safety of technical systems: lessons learned″

DISCUSSION

17:00	End of day 2

Thursday 23 October 2003

8:30 – 10:00 SESSION VI (end) **–** 3rd block of 4 presentations [Duration: 1h30]
Training examples including harmonisation/accreditation of training courses

Presentations:

- ***En Sup Yoon***, Seoul University, Korea
  ″Education and training materials of risk management for university, industry and public government in Korea″

- ***Richard Thibault***, ing., Université de Sherbrooke, Canada
  ″Risk management training developed for Quebec engineers: Innovative pedagogic methods and course content″

- ***Ronald Willey***, Northeastern University, Boston, USA
  ″Risk management in undergraduate chemical engineering curricula: The use of SACHE case studies″

- ***Ertugrul Alp***, Alp & Associates Inc. Canada
  ″Risk management success factors: Where can an engineer learn about them?″

DISCUSSION

10:00 – 10:30 BREAK / PAUSE

10:30 – 11:45 SESSION III [Duration: 1h15]
Training of engineers in economics (including insurance) and risk management

Session Chair: ***Peter Neumann,*** AON, Canada

This session will address the issue of engineers' awareness with respect to the economical dimension of risk management, how this aspect is integrated into engineers training. Session III will also discuss the connection between economics, including insurance, and decision-making. This will take into account the fact that risk management involves costs and benefits, which can be considered on a short-term or long-term (sustainable development) basis.

Presentations:

- ***Bernard Sinclair-Desgagné***, HEC Montreal, Canada
  ″The economics of engineering risk management: A primer″

- ***Paul Kleindorfer***, University of Pennsylvania, USA
  ″The RMP rule and management system regulation″

DISCUSSION

11:45 – 13:00 LUNCH / DEJEUNER

13:00 – 15:30 SESSION VII [Duration: 2 h30]
Continuing training in risk management for engineers working in industry and as public authorities inspectors

Session Chair: ***Graham Creedy,*** CCPA, Canada

The purpose of this session is to explore needs for requirements in professional training for both engineers employed in companies and inspectors of industrial facilities employed by public authorities. It will also investigate the need to make recommendations for minimum qualification requirements. Minimum qualification requirements for engineers may be safeguarded through, for example curricula in universities or associations of engineers. However after qualification there is still a need for continuing training. Industry is responsible for the employment of competent engineers in positions requiring their knowledge; they are also responsible for ensuring that these persons remain competent for their tasks. Similarly, public authorities have the responsibility to employ competent engineers as inspectors.

This session should compare and contrast the requirements of industry and public authorities related to the qualification and continuing education of engineers. The role of governments in organising the training of engineers in risk management (government and private sectors), specifically in setting minimum requirements licenses, will be discussed. The different approaches used in various countries will be reviewed.

Presentations:

- ***Cesar Antonio Leal***, UFRGS, Brazil
  ″Using risk analysis tools for licensing″

- ***Mark Hailwood***, LfU, Germany
  ″Training of engineers as inspectors: How much risk do we need?″

- ***François Fontaine***, INERIS, France
  ″Installations carrying major technological risks: Training of inspectors in France and Europe″

DISCUSSION

- ***Barbara Kucnerowicz Polak***, KGPSP, Poland
  ″Training programmes on risk management for industries, public authorities and services: Experience of Poland″

- ***Robert Reiss***, Environment Canada, Canada
  ″Training of inspectors regarding implementation of Environment Canada Environmental Emergency Plan″

- ***Craig Matthiessen***, EPA, USA
  ″Risk management training: Perspectives for the future″

DISCUSSION

15:30 – 16:00 BREAK / PAUSE

16:00 – 17:30 SESSION VIII [Duration: 1h30]
Research & Development in risk management

Session Chair: ***Olivier Salvi,*** INERIS, France

The purpose of this session is to present the main research axes related to risk management. The different research projects in various countries will be reviewed.

Presentations:

- ***César Antonio Leal***, UFRSG, Brazil
  ″Teaching and research in risk analysis: A Brazilian example″
- ***Benoît Robert***., Centre risque et performance, École Polytechnique de Montréal, Canada
  ″Analysis of an ′e-learning′ teaching experience″
- ***Marc de Fouchécour***, ENSAM / ***Jean-Paul Leroux***, INRS, Réseau ARI, France
  ″Development of a ′risk management′ web site″
- ***Hans Pasman***, Delft University, The Netherlands
  ″Developments in loss prevention / process safety / risk assessment methodology: Layer of protection analysis, and beyond″

DISCUSSION

17:30	End of day 3

Friday 24 October 2003

9:30 – 12:30 CLOSING SESSION [Duration: 3h]
Conclusions and Recommendations – General Discussion

Workshop Chairs:

Tom Foote, Director of Environmental Emergency Branch, Environment Canada
Jean-Paul Lacoursière, Engineer, member of OIQ

Workshop Rapporteurs:

John Shrives, Environment Canada, Canada
Eric Clément, University of Sherbrooke, Canada
Mark Hailwood, LfU, Germany
Francine Schulberg, OECD Consultant

During this session, the Workshop rapporteurs will present draft Workshop conclusions and recommendations, which will:

- Summarise the main Workshop discussion issues;
- Present recommendations concerning "best practices";
- Identify issues that should be further explored in a national or international context; and
- Include proposal(s), as appropriate, for developing guidance on how to improve or implement education and training programmes in risk management.

12:30 End of Workshop

ANNEX 3

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