CONCORDIA UNIVERSITY
FACULTY OF ENGINEERING AND COMPUTER SCIENCE

ENGR 201
PROFESSIONAL PRACTICE AND RESPONSIBILITY

PROFESSOR : REMI ALAURENT, ENG.

CHAPTER 04

RISK MANAGEMENT

TOPIC 1 : GENERAL PRINCIPLES

The concept of risk

- Definitions :
  - Danger : a potential source of prejudice or a situation which contains a potential source of prejudice
  - Risk : a combination of the frequency or the probability and of the consequences of a specific dangerous event
  - Accident : an unplanned event or a sequence of events which result in undesirable consequences

- A risk is not a danger : for example, the danger potential of a machine may be neutralized by safety measures

- the perception of risk is not uniform, and it evolves with factors such as :

- is exposure voluntary ?
- is the risk well known ?
- are the consequences immediate ?
- is it fair (the actors willingly expose only themselves) ?
- can it turn into a catastrophy ?
- are the scientific evaluations to be trusted ?

- " zero risk " does not exist :
  - risk is in the nature of Man; however, it must be tolerable to those who bear its consequences
  - major accidents are few and far between; this brings indifference

Risk management : a social issue

- the 20th century witnesses the emergence of social programs and labour laws, safety standards, trade unions, disability and retirement pensions...

- "technoscience" develops at an astounding rate :
  - applications follow discoveries very quickly, and at a quickening pace, changing forever the way we live, eat, move, work, communicate, record, play...
  - there is little time for reflecting on the consequences (e.g. nuclear power, genetically modified food, supersonic aircraft)

- risky practices are reconsidered or even outlawed in light of expanding knowledge :
  - discharging raw sewage in rivers
  - dumping chemical waste anywhwere
  - producing nuclear waste from power generation, medical or military uses
  - marketing unsafe products
  - driving drunk

- control and monitoring systems are limited :
  - the planet has become a " Global Village " (Marshall McLuhan): information and goods travel everywhere – and fast
  - we all depend more and more on what others do – or do not do
  - thus the rise in standards, tests, certification

    - the concepts of liability, compensation for damage, and insurance take new meanings
    - since there is no real limit to preventive and protective measures, compromises are made (pharmaceutical innocuousness vs. delay, vehicle safety vs. fuel economy, building standards vs. costs, watchdog agencies vs. taxes...)

- avoidable man-made diasters happen as never before :
    - cars, trucks, trains, aircrafts, even spacecrafts crash
    - supertankers spill oil
    - chemical and nuclear plants spew deadly contaminants
    - air and water pollution brings wide-ranging and long-lasting contamination (perhaps weather changes)
    - major power outages

- Risk perception :
    - more information, albeit of varying quality and reliability
    - more educated and sophisticated people
    - emotional perception changes with our capacity to take risks and face anguish (recklessness, bravery, cowardice)
    - subjective perception changes with the relativity of values (children vs. self), sense of control (driving a car vs. taking a plane), personal or informational experience (having been hurt before vs. seeing the WTC coming down on TV)

- The social responsibility of the corporate world
    - responsibility extends far beyond the cash register
    - Unprecedented liability, often court-ordered
    - Quality control, Total Quality, etc.
    - Customer service prevails in a services-oriented economy

- The social responsibility of the professional
    - A new management paradigm
    - the " line of command " gives way to " management by objectives "
    - empowering employees, reducing useless controls
    - professional organizations manage how certain individuals discharge themselves of their new obligations towards society
    - the engineer is subject to such rules

Risk management as a strategic activity in modern business practices

- The main causes of accidents and incidents in goods and services industries are management-related :
  - Ignorance or bad identification of a danger
  - Lack of adequate supervision and accountability
  - The growing complexity of process units
  - Faulty design process
  - Faulty equipment design and construction
  - Error-ridden software
  - Hasty and thoughtless changes to procedures, parameters, settings, machinery and ancilliary services
  - Inadequate personnel qualification and/or training
  - Badly written and/or implemented production and/or safety procedures
  - Bad housekeeping
  - Lack of maintenance

- Managing safety effectively makes good business sense :
  - Accidents are costly in lost life or quality of life, medical expenses. lost production, repairs, lawsuits, insurance premiums, government inquiries, bad press, etc...
  - Prevention is demonstrably cheaper, although its immediate return on investment is not always obvious

Ethical risk management

- Risk management often requires the engineer to make choices based on compromise between :
  - technical possibilities
  - company values
  - costs
  - the engineer's social responsibility
  - public opinion / perception of risk

- The *Code of Ethics of Engineers* contain rules of conduct such as :

  - **3.02.03.** An engineer must, as soon as possible, inform his client of the extent and the terms and conditions of the mandate entrusted to him by the latter and obtain his agreement in that respect.

- 3.02.05. An engineer must inform his client as early as possible of any error that might cause the latter prejudice and which cannot be easily rectified, made by him in the carrying out of his mandate.

- How does this reconcile with the rights of the general public, or any part thereof, to " benefit " from clauses such as :

  - 2.01. In all aspects of his work, the engineer must respect his obligations towards man and take into account the consequences of the performance of his work on the environment and on the life, health and property of every person

- The environment may hold unknowns, standards may be outdated, public discourse may be contradictory (jobs vs. pollution vs. way of life vs. costs vs. alternatives, etc.)

Communication in risk management

- A very delicate operation : provide enough information about the risks to allow for informed consent, but do not overwhelm, confuse or scare

- Credibility is paramount and fragile : if you "talk the talk", be ready to "walk the walk"

- Communication must follow some practical rules :
  - they must be issued by the persons in charge
  - all interested parties must be identified and catered to (management, employees, unions, government representatives, shareholders, media, neighbours, activist groups, customers, suppliers, insurers .... lawyers)
  - the information must be coherent, regular and timely
  - plan ahead

TOPIC 2 : LEGAL FRAMEWORK

The main laws respecting risk management

- Three main domains :
  - the environment

- occupational health and safety
- safety of people and property

Environment

At the provincial level :

- *Environment Quality Act* (R.S.Q., c. Q-2)
  - A comprehensive act covering water, air and land protection, cleanup and reclaim, waste management, hazardous materials, rays and other energy vectors, noise...
  - It also contains various procedural and penal provisions

- dozens of regulations, including the *Regulation respecting environmental impact assessment and review* (R.Q., c. Q-2, r.9)

At the federal level :

- *Canadian Environmental Protection Act*, 1999 (CEPA 1999)
  - " An Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development. "
  - The Canadian Environmental Protection Act came into force on March 31, 2000 and is presented in the Environmental Registry as it appeared on that date.
  - approximately 45 regulations

- *Environmental Emergency Regulations* (SOR/2003-307)
  - The Environmental Emergency Regulations aim at enhancing the protection of the environment and human health in environmental emergency situations by promoting prevention and ensuring preparedness, response and recovery. They will mandate persons who own or manage specified toxic and hazardous substances at or above the specified thresholds to provide required information on the substance(s), their quantities and to prepare and implement environmental emergency plans.

Occupational health and safety

At the provincial level :

- *An Act respecting occupational health and safety* (R.S.Q., c. S-2.1)
    - Section 51 : general employer's obligations include :

      51. Every employer must take the necessary measures to protect the health and ensure the safety and physical well-being of his worker. He must, in particular,
      [...]
      5) use methods and techniques intended for the identification, control and elimination of risks to the safety or health of the worker;

    - Sections 58 to 61 : prevention programme. An excerpt :

      59. The object of a prevention programme is to eliminate, at the source, risks to the health, safety and physical well-being of workers.

      Such a programme, in addition to any component prescribed by regulation, must contain, in particular,

      1) programmes for the adaptation of the establishment to the standards prescribed by the regulations respecting the layout of workplaces, work organization, equipment, material, contaminants, dangerous substances, processes and collective safety measures and equipment;

      2) measures of supervision of the quality of the work environment and of preventive maintenance;

      3) the specific standards of sanitation and safety for the establishment;

      4) the terms and conditions of implementation of any other rule relating to health and safety in the establishment, which must include, as a minimum, the contents of the regulations applicable to the establishment;

> 5) identification of the individual protective devices and equipment which, while in compliance with the regulations, are best adapted to meet the needs of the workers of the establishment;
>
> 6) training and information programmes, for the workers, in matters of health and safety.
>
> The components contemplated in subparagraphs 5 and 6 of the second paragraph are determined by the health and safety committee, if any, in accordance with paragraphs 3 and 4 of section 78. "

- and many regulations.

<u>At the federal level :</u>

- *Canada Labour Code* [R.S., 1985, c. L-2]
- many regulations, including the *Canada Occupational Health and Safety Regulations* [SOR/86-304]

  Part XIX : Hazard prevention program

Safety of people and property

- *Fire Safety Act* (R.S.Q., c. S-3.4)
  - Sections 8 to 31 : safety cover plan. An excerpt :

> **14.** After making a list and an evaluation of the risks, means, measures and resources reported, the regional authority shall propose the optimum protection objectives that may be achieved by the development of appropriate measures and the efficient management of all available resources. The objectives may pertain to prevention, personnel training, emergency preparedness and emergency response procedures.

> The regional authority shall also propose strategies for achieving those objectives, such as the adoption of minimum safety rules, the development of uniform operational procedures and the establishment or sharing of services.

- *Civil Protection Act* (R.S.Q., c. S-2.3)
    - Sections 8 to 15 : Persons whose activities or property generate a major disaster risk. It covers :
        - Reporting of risks
        - Monitoring procedures
        - Safety measures
        - Emergency response capabilities

Other domains with legally mandated risk analysis requirements :

- Dams
- Food and drugs
- Transportation
- Nuclear power
- etc.

TOPIC 3 : AN OVERVIEW OF CURRENT METHODS OF ANALYSIS

Many methods exist

- Comparative methods:
    - Control lists
    - Risk index
    - Historical data review
- Fundamental methods of process hazards analysis :
    - Failure Mode and Effects Analysis (FMEAs, sometimes extend to FMECAs (Failure Mode, Effects and Criticality Analyses)
        - A technique, primarily qualitative (although it can be quantified) by which the effects or consequences of

individual component failure modes are systematically identified. It is an inductive technique based on the question "What happens if". Each major part or component of the system, how it may fail and the effect of that failure is analysed. The analysis is mainly descriptive and the results are presented in table or worksheet form.
    - See : http://www.fmeainfocentre.com/

- Hazard and Operability (HAZOP)
    - A form of FMEA. Originally developed for the chemical industry. A standard hazard analysis technique used in the preliminary safety assessment of new systems or modifications to existing ones. The HAZOP study is a detailed examination, by a group of specialists, of components within a system to determine what would happen if that component were to operate outside its normal design mode. Each component will have one or more parameters associated with its operation such as pressure, flow rate or electrical power. The HAZOP study looks at each parameter in turn and uses guide words to list the possible off-normal behaviour such as 'more', 'less', 'high', 'low' or 'no'. The effects of such behaviour is then assessed and noted down on study forms or worksheets. The categories of information entered on these forms can vary from industry to industry and from company to company.
    - See : http://pie.che.ufl.edu/guides/hazop/

- Preliminary Hazard Analysis (PrHA)
  see : www.ntnu.no/ross/srt/slides/pha.pdf

- Job Safety Analysis (JSA)
  see : CCOHS publication "Job Safety Analysis Made Simple"

- Safety Integrity Levels (SIL)
  see : IEC standard 61508-1 (CEI:1998) respecting functional safety of electrical/electronic/programmable electronic safety-related systems

- Hazard Analysis and Critical Control Points (HACCP)

see :
www.inspection.gc.ca/english/fssa/polstrat/**haccp**/**haccp**e.shtml

- Layer of Protection Analysis (LOPA)
- Process Safety Management (PSM)
- Failure Tree Analysis (FTA)
- Event Tree Analysis (ETA)
- What If / Checklist
- and others (variations of the above and other methods exist and are often marketed under various names)

- For a comparison of common analysis methods :
  - Rasche, T. "Risk Analysis Methods – a Brief Review", 2001, The University of Queensland – Mineral Industry Safety and Health Centre (Australia)
  - Runciman, H. & R. Sallabank "Comparison of risk assessment methods", 2002, Loughborough University (U.K.) http://www.lboro.ac.uk/departments/cg/Projects/2001/runciman/compari.htm
  - There are many books and software sold on the market; you may research them easily on the internet using common search engines.

A management tool

CAN/CSA-Q850-97 (R2002) "Risk Management: Guideline for Decision Makers"

- CSA Guideline CAN/CSA-Q850 is intended to assist decision-makers in effectively managing all types of risk issues, including injury or damage to health, property, the environment, or something else of value.

- This Guideline describes a process for acquiring, analyzing, evaluating, and communicating information that is necessary for decision-making.

- This Guideline provides a description of the major components of the risk management decision process, and their relationship to each other, in a step-by-step process.

- This Guideline does not provide :
  (a) a legal definition or specification for risk management;
  (b) a necessary basis for qualifying for insurance, a monetary loan, or other financial considerations; or
  (c) specific technical tools for risk analysis, evaluation, and control.

- Note: CSA has developed guidance documents to address risk analysis (CSA Standard CAN/CSA-Q634) and environmental risk assessment (CSA Standard Z763)

A Canadian specialized guide in the environment domain (CEPA)

- Guidance Manual for the Risk Evaluation Framework for Sections 199 and 200 of CEPA 1999
  - http://www.ec.gc.ca/ceparegistry/documents/regs/e2_guidance/toc.cfm
  - Decisions on Environmental Emergency Plans
  - Sections 2.1 to 2.3 are the heart of the framework

The risk management program of the Conseil pour la réduction des accidents industriels majeurs (CRAIM)

- ***Risk Management Guide for Major Industrial Accidents (rev. 2007)***
- Adopted by the Conseil pour la réduction des accidents majeurs (CRAIM), this guide is intended for decision-makers and focuses on protecting human health and life, as well as environmental quality, in the event of a major industrial accident.
- Available in electronic format, in French only : see www.craim.ca

REQUIRED READING

Rasche, T. "Risk Analysis Methods – a Brief Review", 2001, The University of Queensland – Mineral Industry Safety and Health Centre (Australia)

SUGGESTED READING

CAN/CSA-Q634-M91 " Risk Analysis Requirements and Guidelines "

CAN/CSA-Q850-97 (R2002) "Risk Management : Guideline for Decision Makers"
