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Module 2

SAFETY MANAGEMENT AND SAFETY CULTURE

OBJECTIVES:

After completing this module you will be able to:

CRO 2.1 Define the following terms:

a) Nuclear safety ⇔ *Page 2*

b) Safety Culture ⇔ *Page 5*

c) Self checking ⇔ *Page 12*

d) Independent verification ⇔ *Page 12*

e) Conservative decision making ⇔ *Page 12*

2.2 Explain how a Utility knows when its nuclear safety program is successful. ⇔ *Page 3*

2.3 List three key effectiveness areas (KEAs) of a managed nuclear safety program. Give and explain the relevance of one performance measure for each KEA. ⇔ *Page 3*

2.4 List and briefly describe the impact on nuclear safety of three Federal Acts. ⇔ *Page 6*

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2.5 Explain how each of the following organisational elements shows a utility's commitment to a safety culture, and explain why commitment of all three organisational elements is necessary to create and maintain a good safety culture:

Page 9 ⇔ a) institutional, policy-level

Page 9 ⇔ b) management

Page 10 ⇔ c) individual employees, from CEO to shop floor.

Page 13 ⇔ **CRO** 2.6 List four performance indicators that point to the health of a nuclear power plant 's safety culture. Describe the relevance of each indicator to a good plant safety culture.

INTRODUCTION

What is *nuclear safety*? Why must nuclear safety be managed? How is it managed? What is a *safety culture* and what role does it play in achieving nuclear safety? These questions will be addressed in Module 2.

Nuclear safety Managed Program

Obj. 2.1 a) ⇔ **Definition:** *Nuclear safety* is the protection of workers, the public and the environment from the radiological hazards arising from the operation of nuclear power plants.

A well-managed nuclear safety program can help prevent accidents like Three Mile Island (TMI) and Chernobyl, and hence the severe economic penalties and loss of public confidence resulting from such accidents.

A nuclear safety program is managed in essentially the same way as any other program. *Vision, mission,* and/or *high-level policy statements* enunciate the program focus. *Key effectiveness areas (KEAs)* show where results are expected, and *performance measures* and *standards* permit performance monitoring, reporting, and follow-up. Facilities, equipment, and human resources are committed to execute the program. Policies and procedures detail organisational and administrative processes.

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Ontario Hydro's Nuclear Safety Policy, approved in 1993, is quoted below:

> ***Ontario Hydro's nuclear facilities will be operated and maintained in a rigorous and vigilant manner to ensure that the radiological risk to workers, the public and the environment is acceptably low and in keeping with the best international practices.***

A utility knows its **nuclear safety program is successful when its performance standards are being met, providing its performance standards are "in keeping with the best international practices". Ontario Hydro has access to international performance benchmarks by virtue of its memberships in the World Association of Nuclear Operators (WANO), the Institute of Nuclear Power Operators (INPO), and the CANDU Owners Group (COG).**

⇔ *Obj. 2.2*

The definition of nuclear safety indicates that the three overall KEAs are worker radiation safety, public nuclear safety, and environmental nuclear safety. In the following table, *Public Nuclear Safety* is broken out as five KEAs —*equipping the organisation, defining the safe operating envelope, accident prevention, accident mitigation*, and *accident management*. Typical performance measures appropriate to these KEAs are also tabulated.

Equipping the organisation is the quality management KEA, whereas the other four public nuclear safety KEAs are technical in nature. The overall quality management performance objective is that work shall be effectively managed and performed to achieve the required quality and continuous improvement in nuclear safety, and to foster a positive *safety culture*. This overall objective can be broken down into the 13 quality principles discussed in module 13.

⇔ *Obj. 2.3*

Key Effectiveness Area	Example Performance Measures
1.0 Worker Radiation Safety	Worker collective dose per unit per year
2.1 Public Nuclear Safety-- Equipping the organisation	Number of OP&P noncompliances/station/year
2.2 Public Nuclear Safety-- Defining the safe operating envelope	Frequency of operation outside of the safe operating envelope

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2.3 Public Nuclear Safety-- Accident Prevention	Frequency of serious process failures
	Number of reactor trips per unit per 7000 hours
2.4 Public Nuclear Safety-- Accident Mitigation	Number of Special Safety Systems failing to meet their unavailability targets per station per year
2.5 Public Nuclear Safety-- Accident Management	**Quality of response to real and simulated incidents
3.0 Environmental Nuclear Safety	Dose to person living at boundary of exclusion zone
	Annual volume of solid radioactive waste produced

**This is an example of a *qualitative* measure. In fact, there are qualitative measures for several of these KEAs, as the quantitative measures do not by themselves adequately describe nuclear safety performance—eg, under KEA 1.0, *Equipping the Organisation,* typical qualitative measures are the number and safety significance of PEER audit findings and significant event reports (SERs).

SAFETY CULTURE

Although a familiar concept in the industrial health and safety business since the 1970's, the term *safety culture* was first used in the context of nuclear safety after the Chernobyl accident of 1986. The work practices and safety attitudes at Chernobyl prior to the accident exemplified a very poor safety culture. A good safety culture at Chernobyl could have prevented the accident.

Some of the various attempts to define *safety culture* are described below to help the reader come to grips with this rather nebulous concept.

Safety Culture was defined by the International Safety Advisory Group from the IAEA, as

> ***that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an over-riding priority, nuclear power plant safety issues receive the attention warranted by their significance.***

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This is actually a definition of an ideal safety culture--it doesn't recognize that all organisations have a safety culture, which may be good, bad or indifferent. Nor does it say anything about *competency* and *proficiency*, which are prerequisite to achieving and maintaining a good safety culture.

The Confederation of British Industry described *safety culture* as

> *the mix of shared values, patterns and behaviour that give the organisation its particular character. Put simply, it is "the way we do things around here"...the safety culture of an organisation could be described as the ideas and beliefs that all members of the organisation share about risk, accidents and ill-health.*

While this definition recognizes that all organisations have a safety culture of *some* quality, and emphasizes the influence and importance of shared perceptions, it still doesn't capture the necessary elements of *competence* and *proficiency*.

The Human Factors Study Group of the UK Advisory Committee on the Safety of Nuclear Installations (ACSNI) addressed itself to this deficiency. It observed in its report *Organising for Safety* (1993):

> *The idea of culture...covers everything learned or otherwise acquired by a social group, organisation or society that is preserved and passed on to future members. Hence it takes time to cultivate, but once achieved, it transcends the individual members of the organisation.*

ACSNI's widely accepted definition of *safety culture* is given below:

Definition: ***The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management.***

⇔ *Obj. 2.1 b)*

Organisations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures".

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Role of Government in Nuclear Safety

Government legislates policies setting broad safety objectives. It establishes and supports the necessary institutions and regulatory agencies. Government promotes the international exchange of safety information. Regulators are given considerable discretionary authority in matters of nuclear safety. Government and its organisations which regulate economic aspects of nuclear power, must take into account the fact that decisions based on purely economic factors could be detrimental to nuclear safety.

Obj. 2.4 ⇔ The regulatory environment for a nuclear safety culture is embodied in various Federal and Provincial legislative Acts, including the following:

- ***Atomic Energy Control Act,*** which establishes the Atomic Energy Control Board as the regulator of atomic energy, and defines its limits of authority. Under the auspices of the Ministry of Energy, Mines and Resources, the AECB has the authority to make binding regulations, such as the Atomic Energy Control Regulations, the Physical Security Regulations, and the Transport and Packaging of Radioactive Materials Regulations, and to prosecute offenders.

- ***Nuclear Liability Act,*** which establishes the Federal Government as the damage claims administrator in event of a nuclear accident, and limits Utility liability to $75 million.

- ***Environmental Protection Act (Federal),*** which sets limits on contaminants entering the environment.

- ***Transportation of Dangerous Goods Act,*** which requires shippers of radioactive material to file emergency response plans with the Federal Ministry of Transport, to maintain an emergency response capability for traffic accidents involving their radioactive shipments, and to rehearse this capability periodically.

- ***Environmental Protection Act (Ontario),*** which establishes emission limits, requires notification of spills to the Provincial Ministry of the Environment and Energy, and mandates the MISA program of emissions reporting and reduction.

- ***Ontario Boiler and Pressure Vessels Act,*** which mandates immediate reporting of pressure boundary ruptures to the Ministry of Consumer and Commercial Relations (MCCR), and establishes the MCCR as the regulator of pressure boundary design, construction and repair. Under the Act, the MCCR approves Welder and Quality Control Technician qualifications.

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- ***Ontario Emergency Plans Act,*** which gives the Province emergency powers upon declaring a nuclear emergency, and requires each NPP to have a radiation emergency response plan consistent with the Provincial Nuclear Emergency Response Plan developed by Emergency Measures Ontario, under the auspices of the Ministry of the Solicitor General.

Nuclear regulation in Canada follows the European approach of *regulation by results* whereby desirable results are defined by the regulatory authority, but the method of achieving those results is largely left up to the licensee. The licensee's ultimate responsibility for the safety of a nuclear power plant is in no way diluted by the separate activities and responsibilities of designers, suppliers, constructors and regulators.

Safety Culture in a Nuclear-Electric Utility

The creation and maintenance of a good Safety Culture in a Utility depends on the commitment of the following organisational elements:

1. institutional, policy-level

2. management, and

3. individual employee (including everyone from the CEO to the shop floor).

A Safety Culture model is illustrated in Figure 2.1, adapted from INSAG-4. The model depicts various elements embedded in the box representing *safety culture,* because *safety culture* is both the *environment* in which all these elements flourish and the *result* of these elements.

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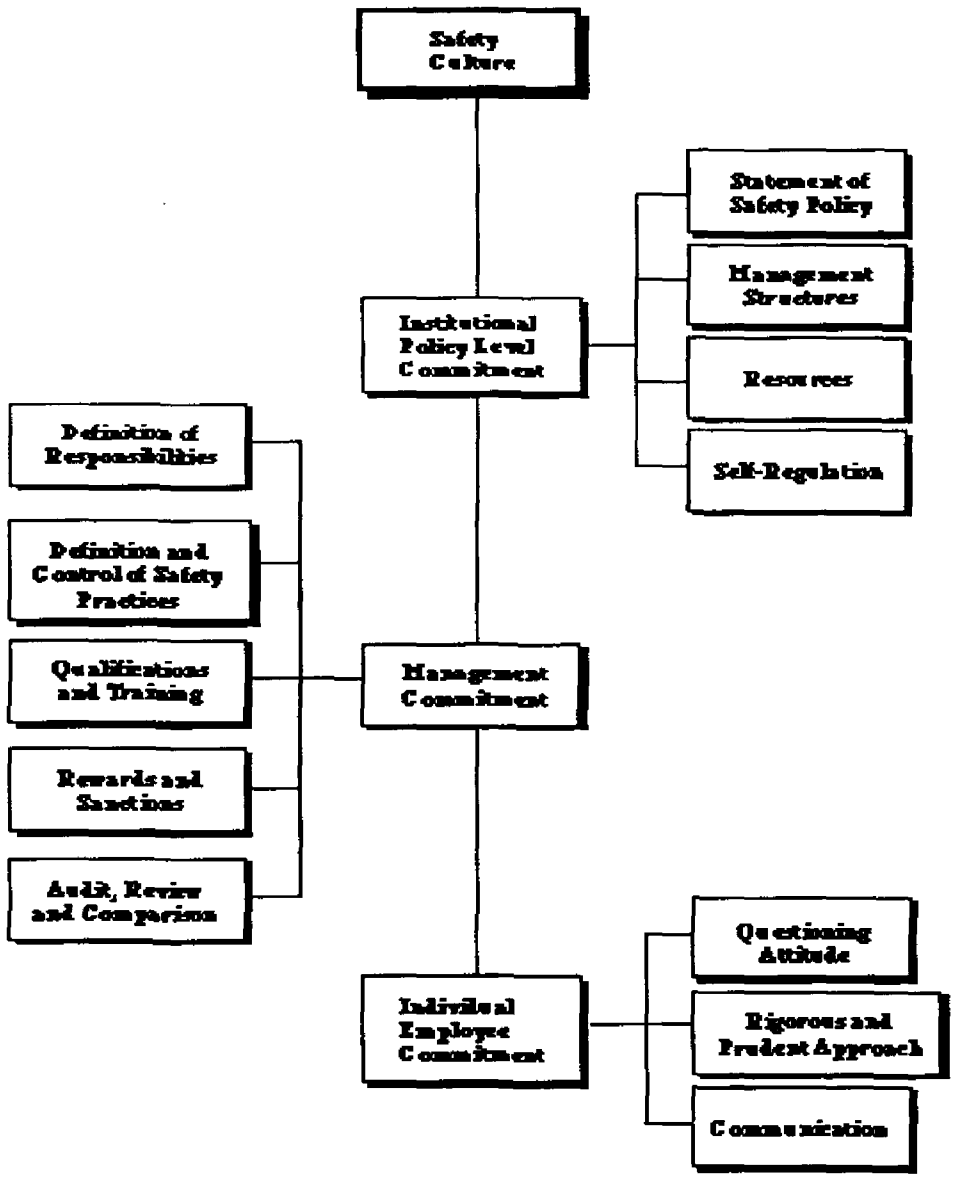

Fig. 2.1 Model for Safety Cluture

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Institutional, Policy-Level Commitment

⇔ *Obj. 2.5 a)*

Senior executive commitment is required to provide clear safety policy direction, and to establish and fund a well-managed nuclear safety program. A Utility's institutional commitment to its safety culture is declared and supported by the following:

- **Statements of Safety Policy**
  Utilities operating NPPs enunciate their commitment to nuclear safety via high-level policies designed to create a safe working environment and to condition individual employee behaviour. Ontario Hydro's *Nuclear Safety Policy* was quoted earlier.

- **Management Structures**
  Utility management structures typically feature independent and effective nuclear safety management units. For example, Ontario Hydro Nuclear has the Nuclear Safety Division to address corporate nuclear safety issues, and each station has a Nuclear Safety Department to manage nuclear safety issues at the site.

- **Resources**
  The Utility must commit enough resources to permit effective program execution.

- **Self-Regulation**
  This is accomplished by such activities as staff appointments, training, self assessments, audits, performance monitoring, corrective action follow-up, and the feedback of operating experience. The intent is to bring fresh judgement, allow new approaches, and use competent individuals outside of the normal chain of command, to bring about the self-regulation process.

Management Commitment

⇔ *Obj. 2.5 b)*

Management commitment is prerequisite to a good safety culture, because Managers establish and enforce safe work practices and, by attitude and example, motivate staff toward high levels of personal performance in their duties. Managers can encourage a good safety culture via the following stratagems:

- **Definition of Responsibilities**
  The responsibility assigned to individuals is defined in clear lines of authority, particularly in the area of responsibility for plant safety.

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- **Definition and Control of Safe Practices**
  Managers ensure that all work on matters related to nuclear safety is carried out in a rigorous manner--eg, that procedures are clear, unambiguous and logical. Managers mandate safe work practices such as procedural compliance, personnel error reduction strategies, pre-job briefing of workers by supervisors, and conservative decision making.

- **Qualifications and Training**
  Managers ensure their staff are qualified, and understand the significance of their duties and the consequences of mistakes. Above all, staff must understand the constraints on their activities by OP&Ps, and the potential nuclear safety consequences of OP&P violations.

- **Rewards and Sanctions**
  Praise and reward are used to motivate excellent performance, while errors are viewed as operating experience from which valuable lessons can be learned.

- **Audit, Review and Comparison**
  The process of audit, review and comparison includes quality assurance, internal checks and external comparisons (benchmarking). The role of quality assurance in nuclear safety is described in Module 13.

Obj. 2.5 c) ⇔

Individual Employee Commitment

The commitment of all employees, from the CEO to the shop floor, to nuclear safety is required, because personnel errors of commission or omission can result in nuclear accidents. Staff who strive for excellence in nuclear facility operation, do so by a personal dedication to nuclear safety. This personal dedication manifests itself in the following ways:

- **A Questioning Attitude**
  This should be quite deliberate for new tasks. For routine tasks, questioning must also be encouraged. For example, individuals might ask themselves questions along the lines of the nuclear safety management KEAs discussed earlier:

  1.0 *Worker Safety:* What are the radiological hazards? Have I planned the job and protective measures properly to minimize the dose?

  2.1 *Equipping the Organization:* Am I properly equipped to carry out this assignment? Do I understand the task? Do I need additional training, information, assistance or equipment?

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2.2 *Defining the Safe Operating Envelope:* Do I understand the operating limits of the system I'm working on? Will the job take the system outside of those limits? Do plant supervisors understand the system impact of what I plan to do?

2.3 *Accident Prevention:* Could this procedure cause an upset which might escalate into an accident? If so, do the right people know this, and have appropriate risk reduction measures and contingency plans been laid?

2.4 *Accident Mitigation:* Will this task in any way compromise the station's capability to mitigate an accident, if one should occur? If so, do the right people know this, and have they devised appropriate compensating strategies?

2.5 *Accident Management:* Will this procedure compromise the station's capability to manage the response to an accident, should one occur? If so, do the right people know about this, and have appropriate countermeasures been taken?

3.0 *Environmental Nuclear Safety:* Does this procedure involve an elevated risk of releasing radioactive material to the environment? If so, do the right people know about this? Have all reasonable precautions been taken to minimize this risk? Have appropriate contingency plans been laid to minimize the consequences of such an incident?

- **A Rigorous and Prudent Approach**
  This involves following safe work practices such as procedural compliance, OP&P compliance, conservative decision making, use of personnel error reduction strategies, and attention to orderliness, timeliness and housekeeping. This approach encourages seeking help if necessary, not proceeding in the face of uncertainty, stopping and thinking if a problem arises, and foregoing shortcuts.

- **Communication**
  Good communication is particularly important in safety matters. The communicator obtains useful information from others, and transmits information to others. Managerial expectations must be clearly communicated downwards, and the workface realities must be communicated upwards. Supervisors and Managers must know how things are at the workface, so that corrective action can be taken as required--eg, to provide needed training or resources, to replace procedures that don't work, to correct safety violations, etc.

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These behaviours contribute to a high level of safety, and generate pride in dealing with important tasks effectively.

Work Practices and Programs Characteristic of a Good Safety Culture

In a NPP, *safety culture* must be translated from a buzz phrase into a concept of practical value for each and every employee. An effective safety culture will impact day-to-day plant activities. Work practices and programs contributing to a good safety culture at a NPP include the following:

Obj. 2.1 c) ⇔

1. **Self Checking**--a personnel error reduction stratagem where individual workers follow the ***STAR*** procedure when executing critical actions. ***STAR*** consists of the following steps:

   Stop before acting

   Think anticipate system response, confirm proposed action consistent with intent

   Act execute action

   Review confirm expected system response

Obj. 2.1 d) ⇔

2. **Independent Verification**--a personnel error reduction strategy whereby a second qualified individual independently verifies a critical action or step of a critical procedure prior to implementation.

3. **Pre-job Briefing**--A safe work practice whereby the supervisor reviews both the conventional and radiation safety hazards of the job, and the appropriate protective measures, with the employee before dispatching him/her to the job site.

4. **Procedural Compliance**--a policy whereby persons doing work follow approved procedures.

Obj. 2.1 e) ⇔

5. **Conservative Decision Making**--a policy whereby individuals take a cautious, considered approach to reactor operation, giving safety priority over productivity, and acting promptly to place the unit in a safe state when safe operating limits are exceeded, or when the unit is responding unpredictably.

6. **OP&P training**--training delivered to staff to acquaint them with the operating constraints imposed by OP&Ps, and the potential nuclear safety consequences of OP&P violations.\

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Performance Measures Pointing to the Health of a NPP's Safety Culture

⇔ *Obj. 2.6*

A NPP's actual safety *performance* over an extended period reflects the health of the plant's safety culture. Having an impressive safety policy and many other elements of a well-managed nuclear safety program in place is no guarantee of good nuclear safety performance. The effectiveness of the managed safety program could be undermined by cynicism, skepticism and false perceptions amongst opinion formers in the organization. Success depends both on having the managed program and on people's *perceptions* and *beliefs* about the program elements.

The following performance measures are particularly indicative of the health of a plant's safety culture, because they are sensitive to the "perceptions and beliefs" held by individuals about nuclear safety program elements.

- frequency of OP&P violations
- frequency of significant events due to inadequate
  - — self checking
  - — independent verification
  - — pre-job briefing
  - — procedural compliance
  - — conservative decision making
  - — communications
  - — managerial methods

Safety Culture at TMI and Chernobyl

Was a good Safety Culture in evidence at the Chernobyl and Three Mile Island plants? Both sites had safety systems and operating policies in place to prevent accidents resulting in releases to the environment. But in the case of Chernobyl, safety systems were bypassed in an attempt to keep the reactor critical. The primary cause of the Chernobyl accident was a series of deliberate operating violations. Contributing causes were managerial methods and design vulnerability, but equipment failures were <u>not</u> a factor in the accident!

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In the case of Three Mile Island, a loss of boiler feedwater caused an overpressure in the reactor vessel. The resulting accident was entirely preventable, but due to misdiagnosis and inappropriate actions, fuel melting occurred, and the reactor was destroyed. The containment system in this case protected the public and the environment from large releases of radioactivity. Equipment failure and inappropriate maintenance procedures did initiate the incident, but the reactor could have been saved had the operating crew responded appropriately. A questioning attitude, better training, and a rigorous and prudent approach would have gone a long way towards preventing both the TMI and Chernobyl accidents.

Investigations showed that the Safety Culture was also deficient at organisational levels above the TMI and Chernobyl operating crews. Inadequate training and qualification of staff, poor control of safety practices, and inadequate review and comparison resulting in design deficiencies, are three examples of a weak Safety Culture at the management and institutional levels.

ASSIGNMENT

1. Carefully prepare answers for each of the Module 2 learning objectives.
2. List eight elements of a managed nuclear safety program.
3. How does the organisational structure of your Utility support nuclear safety?
4. Discuss the role of Government in fostering a good nuclear safety culture.
5. What is meant by "a rigorous and prudent approach" on the part of a NPP employee?