Safety Reports Series

No. 11

DEVELOPING
SAFETY
CULTURE IN
NUCLEAR
ACTIVITIES
PRACTICAL
SUGGESTIONS TO
ASSIST PROGRESS

DEVELOPING SAFETY CULTURE IN NUCLEAR ACTIVITIES

Practical Suggestions
to Assist Progress

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DEVELOPING SAFETY CULTURE IN NUCLEAR ACTIVITIES

PRACTICAL SUGGESTIONS
TO ASSIST PROGRESS

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 1998

FOREWORD

The term 'safety culture' was introduced by the International Nuclear Safety Advisory Group (INSAG) in Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident, published by the IAEA as Safety Series No. 75-INSAG-1 in 1986, and expanded in Basic Safety Principles for Nuclear Power Plants, Safety Series No. 75-INSAG-3, issued in 1988. To provide guidance in and interpretation of safety culture, Safety Series No. 75-INSAG-4, issued in 1991, dealt with the concept as it relates to organizations and individuals engaged in nuclear power activities and formed a basis for judging its effectiveness.

Although the definition and concept of safety culture as presented in INSAG-4 is widely known, the practical applications and characteristics of the principle of safety culture have not been adequately summarized or widely disseminated. This publication supplements INSAG-4 by describing practices that have proved valuable in establishing and maintaining a sound safety culture in a number of countries.

This Safety Report has been developed with the help of experts from regulatory, operating and engineering organizations and is intended for those who design, construct, manufacture, operate, maintain or decommission nuclear installations. It should be particularly useful for all those involved in operating nuclear facilities, large or small. It will also provide a reference for groups such as regulators who have an interest in developing, improving and evaluating safety culture, for professional and standards associations which play an important role in the safety culture training of individuals engaged in nuclear activities, and for bodies such as ethics review committees who should take into account safety culture issues for certifying professional excellence in the medical field.

The IAEA is grateful to all the experts, particularly M. Merry, who contributed to the preparation of this Safety Report.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The concept of safety culture was introduced by the International Nuclear Safety Advisory Group (INSAG) in the Summary Report on the Post-Accident Meeting on the Chernobyl Accident in 1986 [1]. The concept was further expanded in the 1988 INSAG-3 report, Basic Safety Principles for Nuclear Power Plants [2], and again in 1991 in the INSAG-4 report, Safety Culture [3]. Recognizing the increasing role that safety culture is expected to play in nuclear installations worldwide, the Convention on Nuclear Safety [4] states the Contracting Parties' desire "to promote an effective nuclear safety culture".

Section 4 of The Safety of Nuclear Installations [5] addresses many safety culture principles. Paragraphs 513 and 514 of Establishing a National System for Radioactive Waste Management [6] and paragraph 2.28 of International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [7] place firm requirements on safety culture for nuclear applications in general.

In view of the increase in attention being given to the safety culture concept it is important for organizations to share their experience, particularly for the benefit of those in which the development of safety culture is still at an earlier stage. The present Safety Report supplements the above IAEA publications by describing practices that have proved valuable in many Member States in developing, maintaining and evaluating safety culture.

1.2. OBJECTIVE

This Safety Report is intended to offer practical advice to assist in the development, improvement or evaluation of a progressive safety culture. The approach to developing a safety culture has much in common with the approach to developing an effective organization. The process can be assisted by a learning process within an organization. This publication offers practical advice on ways to encourage this learning process.

1.3. SCOPE

The development and improvement of safety culture is a dynamic, progressive process. This report focuses on the organizational culture and learning processes required to implement all aspects of safety culture.

There is no prescriptive formula for improving safety culture. However, some common characteristics and practices are emerging that can be adopted by organizations in order to make progress. This publication refers to some approaches that have been successful in a number of countries. The experience of the international nuclear industry in the development and improvement of safety culture could be extended and found useful in other nuclear activities, irrespective of scale. Smaller scale nuclear activities include nuclear pharmacy installations, medium sized hospitals providing radiotherapy, and plants making use of radiation sources in their processes. This report has been prepared in the belief that all those associated with nuclear activities in general are committed to the highest standards of safety and the participation of their employees in achieving that goal.

Examples are given of specific practices found to be of particular value in assisting the development of a sound safety culture. They cover a wide range of activities including analysis of events, the regulatory approach, employee participation and safety performance measures. Many of these practices may be relevant to smaller organizations and could contribute to improving safety culture, whatever the size of the organization.

The practices can be adopted individually, but the most effective approach is to pursue a range of practices that can be mutually supportive in the development of a progressive safety culture, supported by professional standards, organizational and management commitment. Some guidance is also given on the assessment of safety culture and on the detection of a weakening safety culture.

The practical development of safety culture is a challenge facing those who design, construct, manufacture, operate, maintain or decommission nuclear installations. Those involved in other nuclear activities face a similar challenge. Irrespective of the stage of development of safety culture in their organizations, people will find in this publication some positive suggestions for accelerating the safety culture development and improvement process. The publication may also be a useful reference for others who have an interest in implementing and improving safety culture.

1.4. STRUCTURE

Section 2 elaborates the concept of safety culture introduced in INSAG-4 [3], discusses some issues which may be encountered during implementation, and touches on the benefits that would ensue.

Section 3 sets out three stages of development of safety culture and offers advice on practices appropriate to specific stages that would be useful to organizations seeking further direction in implementing additional improvements.

Section 4 suggests some general practices to develop organizational effectiveness as a means of implementing and improving safety culture.

Section 5 describes some specific practices to develop safety culture: they are intended to apply to all stages of a nuclear installation's life cycle.

Section 6 makes some suggestions on assessing the progress of development of safety culture in an organization and on evaluating the influence of major environmental and internal organizational factors on that culture.

Section 7 gives some guidance on the detection of incipient weaknesses in safety culture that may be of particular interest to regulators and those responsible for self-assessment in organizations.

Section 8 comprises concluding remarks.

2. SAFETY CULTURE

2.1. CONCEPT OF SAFETY CULTURE

The concept of safety culture is defined in INSAG-4 [3] as follows:

"Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."

Safety culture is also an amalgamation of values, standards, morals and norms of acceptable behaviour. These are aimed at maintaining a self-disciplined approach to the enhancement of safety beyond legislative and regulatory requirements. Therefore, safety culture has to be inherent in the thoughts and actions of all the individuals at every level in an organization. The leadership provided by top management is crucial.

Safety culture applies to conventional and personal safety as well as nuclear safety. All safety considerations are affected by common points of beliefs, attitudes, behaviour, and cultural differences, closely linked to a shared system of values and standards.

2.2. GENERAL REMARKS ABOUT SAFETY CULTURE

The significance of nuclear safety issues will vary among organizations and reflect particular needs. It will always be necessary to decide which are the priority

issues, using the resources available. The efforts made to enhance safety culture can benefit plant engineering, construction and performance through improved organization, analyses, anticipation and work processes, such as better planning of outages. Enhanced safety culture can also prevent accidental over-exposure of persons involved in industrial or medical radiography. A strong safety culture can lead to more effective conduct of work and a sense of accountability among managers and employees, who should be given the opportunity to expand skills by training. The resources expended would thus result in tangible improvements in working practices and skills, which should encourage further improvement of safety culture.

In promoting an improved safety culture, some countries have favoured an approach emphasizing the use of behavioural sciences while others have emphasized the quality management system approach to enhancing safety performance. There is consensus that account should be taken of both national and organizational culture and that an appropriate balance of behavioural sciences and quality management systems approaches should be pursued.

Many features of a strong safety culture have long been recognized as 'good practices' in numerous areas of safety activities, for example in the nuclear industry and aviation. In recent years there has been increased emphasis on a systematic approach to the development of an improved safety culture, and there is increasing awareness of the contribution that human behavioural sciences can make to developing good safety practices. Just as nuclear facility performance relies on the technical advice of specialists, some aspects of safety and organizational performance can be improved by seeking advice from experts in the behavioural sciences.

The characteristics and attitudes referred to in the definition of safety culture should be commonly held and relatively stable. The term 'commonly held' implies that there is a core of key attitudes and values that are acknowledged by the majority. 'Relatively stable' implies that any change tends to be evolutionary rather than revolutionary. Safety culture is important in that it is an influence on behaviour, attitudes and values, which are important factors in achieving good safety performance. Organizations with a mature safety culture focus more on the overall goals and key points than only on compliance with procedures.

Developing and implementing the safety culture concept needs both a 'top-down' and a 'bottom-up' approach. Although this change in culture must stem from all directions, consistent and visible leadership from the top is essential. For management-led changes to be successful, both effective co-operation and two-way communication are essential at all levels of the organization. Honest and open communication depends on the development of trust throughout the organization. Technical specialists, human factor specialists, operating personnel and management must work together to develop a common understanding across their various functions. This is in itself a learning process and, as such, a characteristic of a good

safety culture. Continuous learning and improvement processes play a central role in developing and maintaining a good safety culture.

An organization with a good safety culture relies on close interdependence between technical safety and organizational processes. In practice, a high level of safety culture means the systematic organization and implementation of activities aimed at creating high quality technical, human and organizational systems.

Whatever the level of technical sophistication, a mature safety culture can offer a defence in depth against the risk of accidents. An investment in improving safety culture could be beneficial in nuclear facilities designed to earlier standards.

3. STAGES OF DEVELOPMENT OF SAFETY CULTURE

All organizations involved in nuclear activities obviously have a common concern for the maintenance and improvement of safety. However, there is substantial diversity among organizations in their understanding of the concept of safety culture and of the actions necessary to influence it in a positive way. This diversity may reflect different levels of awareness in highly technical organizations of the safety impact of human behaviour and attitudes. These organizations may eventually evolve and develop this understanding, as experience has shown in many cases.

Three stages of development seem to emerge, each displaying a different awareness of and receptiveness to the effect on safety of human behaviour and attitudes. The characteristics of each stage, identified below, provide organizations with a basis for self-diagnosis. The characteristics may also be used by an organization to give direction to the development of safety culture by identifying the current position and the position aspired to. It is possible for an organization at any time to exhibit any combination of the characteristics listed under each of these stages.

3.1. STAGE I — SAFETY BASED SOLELY ON RULES AND REGULATIONS

At this stage, the organization sees safety as an external requirement and not as an aspect of conduct that will help the organization to succeed. The external requirements are those of national governments, regional authorities, or regulatory bodies. There is little awareness of behavioural and attitudinal aspects of safety performance, and no willingness to consider such issues. Safety is seen very much as a technical issue; mere compliance with rules and regulations is considered adequate.

For an organization which relies predominantly on rules, the following characteristics may be observed:

- Problems are not anticipated; the organization reacts to each one as it occurs.
- Communication between departments and functions is poor.
- Departments and functions behave as semi-autonomous units and there is little collaboration and shared decision making among them.
- The decisions taken by departments and functions concentrate upon little more than the need to comply with rules.
- People who make mistakes are simply blamed for their failure to comply with the rules.
- Conflicts are not resolved; departments and functions compete with one another.
- The role of management is seen as endorsing the rules, pushing employees and expecting results.
- There is not much listening or learning inside or outside the organization, which adopts a defensive posture when criticized.
- Safety is viewed as a required nuisance.
- Regulators, customers, suppliers and contractors are treated cautiously or in an adversarial manner.
- Short term profits are seen as all-important.
- People are viewed as 'system components'— they are defined and valued solely in terms of what they do.
- There is an adversarial relationship between management and employees.
- There is little or no awareness of work or business processes.
- People are rewarded for obedience and results, regardless of long term consequences.

3.2. STAGE II — GOOD SAFETY PERFORMANCE BECOMES AN ORGANIZATIONAL GOAL

An organization at this stage has a management which perceives safety performance as important even in the absence of regulatory pressure. Although there is growing awareness of behavioural issues, this aspect is largely missing from safety management methods, which comprise technical and procedural solutions. Safety performance is dealt with, along with other aspects of the business, in terms of targets or goals. The organization begins to look at the reasons why safety performance reaches a plateau and is willing to seek the advice of other organizations.

- The organization concentrates primarily on day to day matters. There is little in the way of strategy.
- Management encourages cross-departmental and cross-functional teams and communication.

- Senior managers function as a team and begin to co-ordinate departmental and functional decisions.
- Decisions are often centred on cost and function.
- Management's response to mistakes is to put more controls in place via procedures and retraining. There is a little less blaming.
- Conflict is disturbing and is discouraged in the name of teamwork.
- The role of management is seen as applying management techniques, such as management by objectives.
- The organization is somewhat open about learning from other companies, especially techniques and best practices.
- Safety, cost and productivity are seen as detracting from one another. Safety is thought to imply higher cost and reduced production.
- The organization's relationship with regulators, customers, suppliers and contractors is distant rather than close; there is a cautious approach where trust has to be earned.
- It is important to meet or exceed short term profit goals. People are rewarded for exceeding goals regardless of the long term results or consequences.
- The relationship between employees and management is adversarial, with little trust or respect demonstrated.
- There is growing awareness of the impact of cultural issues in the workplace. It is not understood why added controls do not yield the expected results in safety performance.

3.3. STAGE III — SAFETY PERFORMANCE CAN ALWAYS BE IMPROVED

An organization at Stage III has adopted the idea of continuous improvement and applied the concept to safety performance. There is a strong emphasis on communications, training, management style, and improving efficiency and effectiveness. Everyone in the organization can contribute. Some behaviour is seen within the organization which enables improvements to be made but there is also behaviour which acts as a barrier to further improvement. Consequently, people understand the impact of behavioural issues on safety.

The level of awareness of behavioural and attitudinal issues is high, and measures are being taken to improve behaviour. Progress is made one step at a time and never stops. The organization asks how it might help other companies.

- The organization begins to act strategically with a focus on the longer term as well as awareness of the present. It anticipates problems and deals with their causes before they happen.

- People recognize and state the need for collaboration between departments and functions. They receive management support, recognition and the resources they need for collaborative work.
- People are aware of work or business processes in the organization and help managers to manage them.
- Decisions are made in the full knowledge of their safety impact on work or business processes as well as on departments and functions.
- There is no goal conflict between safety and production performance, so that safety is not jeopardized in pursuit of production targets.
- Almost all mistakes are viewed in terms of work process variability. It is more important to understand what has happened than to find someone to blame. This understanding is used to modify the work process.
- The existence of conflict is recognized and dealt with by trying to find mutually beneficial solutions.
- Management's role is seen as coaching people to improve business performance.
- Learning from others both inside and outside the organization is valued. Time is made available and devoted to adapting such knowledge to improve business performance.
- Safety and production are seen as interdependent.
- Collaborative relationships are developed between the organization and regulators, suppliers, customers and contractors.
- Short term performance is measured and analysed so that changes can be made which improve long term performance.
- People are respected and valued for their contribution.
- The relationship between management and employees is respectful and supportive.
- People are aware of the impact of cultural issues, and these are factors considered in key decisions.
- The organization rewards not only those who 'produce' but also those who support the work of others. People are also rewarded for improving processes as well as results.

3.4. THE THREE STAGES: CONCLUSIONS

The above characteristics of each of the three stages of evolution could serve as the basis for a survey to establish which stage an organization has reached. They are also clearly relevant to large organizations typically associated with major nuclear installations. Most of the characteristics are also relevant to smaller organizations or groups of people involved in a wider range of nuclear activities such as industrial or

Experience

Experiment   Reflect

Implement   Review

Concepts
Ideas

Experience

Experiment   Reflect

Implement   Review

Concepts
Ideas

Experience

Experiment   Reflect

Implement   Review

Concepts
Ideas

Scope

Stage I	Stage II	Stage III
Technical solutions	Procedural solutions Retraining	Behavioural solutions Culture
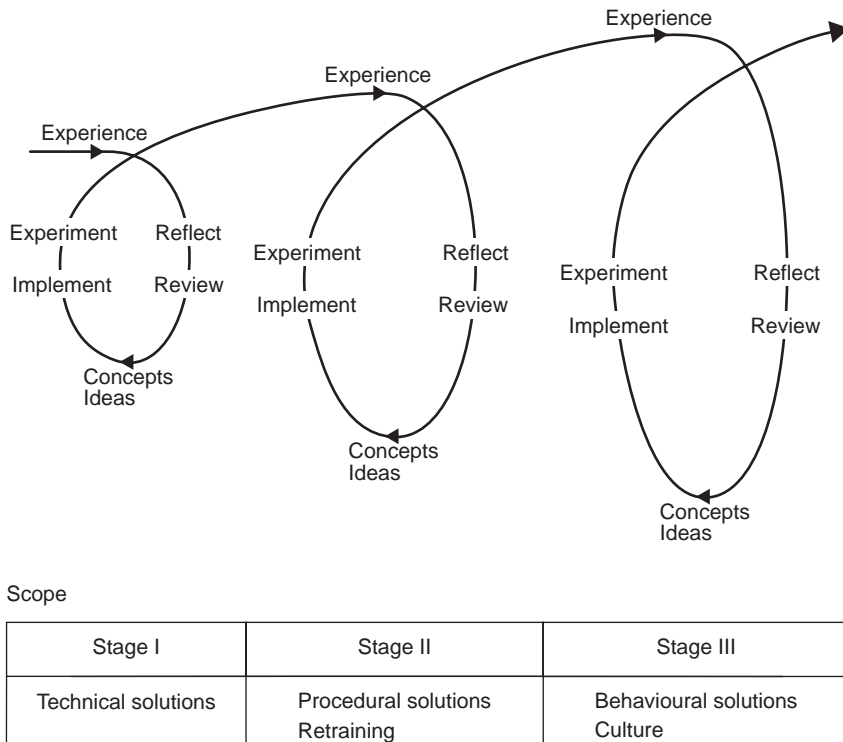
FIG. 1. Simple model of organizational learning (after KOLB [8]).

medical radiography, or the operation of research reactors. Large scale organizations present particular challenges to ensuring good communications and co-operation between the various functions within the organization. Communications tend to be more direct in smaller groups. The response to pressure from peers is likely to be quicker in small groups, but partially countering this is the potential influence the culture of a professional institution can have on individuals within these groups. Multicultural influences may thus be more visible in smaller groups. In large organizations there is more likely to be a dominant organizational culture. Pursuing the development of a good safety culture in a small group may require some attention to the status of safety culture in any professional institutions affecting people in the group.

Irrespective of the size of the organization, a prerequisite for the development of a good safety culture is the visible commitment of the person or persons responsible for leading the organization or group.

As noted earlier, the process for the development of safety culture can be assisted by the use of a learning process within an organization. A simple model, based on the Kolb Learning Cycle [8], is shown in Fig. 1. A person or organization

learns by reflecting on what they have experienced, formulating concepts and ideas for change while continuing existing best practice. The implementation of such concepts and ideas is intended to improve performance and thereby modify future experience. At an appropriate time this modified experience can itself be reviewed and lessons learned. When additional ideas are implemented, the cycle is repeated.

There is a wide range of practices of potential value in the practical development of a progressive safety culture, most of which have already been identified in INSAG-4. Some additional practices not specifically mentioned in INSAG-4 are listed in Appendix I. Many of them are already commonly accepted as being of value in the development of an effective organization. A subset of practices judged to be of particular relevance to the development of a safety culture is described in more detail in Section 5.

Organizations interested in promoting awareness of safety culture issues among their employees, particularly managers, can use the list of questions given in Appendix II to encourage discussion. In responding to the questions, employees will explore the meaning and characteristics of safety culture.

The time-scale required to progress through the various stages of development cannot be predicted. Much will depend upon the circumstance of an individual organization and the commitment and effort it is prepared to devote in order to effect change. Historical experience to date indicates that the period of time required for change can be long. However, it should be recognized that many of the organizational concepts that provide a new perspective on the influence of culture on safety have only been conceived in recent years. Now that these concepts and supporting principles are acknowledged internationally, and since practical experience will be shared by means of this Safety Report, it may well be possible to progress through the stages more rapidly. However, sufficient time must be taken at each stage to allow the benefits from changed practices to be realized and to mature. People must be prepared for such change. Too many new initiatives in a relatively short period of time can be organizationally destabilizing. The important point is that any organization interested in improving safety culture should start doing so and should not be deterred by the fact that the process will be gradual.

3.5. LINKING PRACTICES TO THE DEVELOPMENT STAGES OF SAFETY CULTURE

Certain practices may be better suited to one of the three stages of development of safety culture, but it should be noted that the complexity of the cultural change process precludes any universal guidance. Some general advice on those practices which may be particularly appropriate at given stages is given below.

Stage I

- Senior managers commit the organization to improving its safety performance and agree on a safety vision.
- Senior managers review or formulate safety policy and communicate it to the workforce.
- Managers review safety training and start to develop employee participation by inviting employees to identify training needs.
- Managers establish safety performance measures and analyse statistics to establish trends. They share information with employees.
- Senior managers make other managers aware of relevant publications.
- Joint management/employee safety meetings are held to discuss safety issues in a non-adversarial way.
- Managers introduce regular review and audit of safety in order to identify areas for improvement.
- Senior managers liaise with regulatory bodies to make them aware of initiatives being taken.
- Managers seek suggestions from employees on how to improve safety.

Stage II

- Senior managers make managers aware that values, attitudes and behaviour of employees are important factors in achieving good safety performance and help employees to contribute to improving safety performance.
- Managers make use of positive indicators (see Section 5.10) when providing employees with information on safety performance trends.
- Managers make employees aware of other organizations which have successfully improved their safety performance in order to demonstrate that this can be achieved. Employees are thus introduced to external ideas which may be worth adapting.
- Managers seek active involvement of employees in improving safety.
- Managers review contractors' safety performance.
- Senior managers make managers aware of human factors and introduce root cause analysis.
- Senior managers introduce positive safety performance measures.
- Managers introduce self-assessment of safety performance and ensure that there is a comprehensive corrective action programme.
- Senior managers encourage managers' awareness that good safety performance is good for business.

Stage III

- Senior managers remain alert to the possibility of learning from other organizations and establish systems for doing this. They recognize the effects of processes on safety results.
- Managers review safety targets and objectives. They remain alert to potential safety improvements.
- Managers co-operate with suppliers and contractors to improve their safety performance.
- Senior managers introduce organizational cultural indicators (e.g. standards of housekeeping, reporting of 'near misses') that have a bearing on safety performance.
- Senior managers make comparisons with external organizations chosen as benchmarks.
- Senior managers communicate with the public on safety issues.
- Managers encourage employees to assist in the further improvement of existing processes.

Whatever stage an organization has reached, one fundamental requirement is essential, namely the genuine and visible commitment of the top management of the organization to the improvement of safety. Top management should be knowledgeable about safety culture issues so that they are able to undertake the leadership role in creating and communicating the future safety vision for their organization. Managers should not only know how to motivate their team but also how to avoid demotivating them.

3.6. INFLUENCE OF NATIONAL CULTURE

In developing an improved safety culture, attention needs to be paid to the national culture. In some countries there may even be significant differences among regional cultures. The characteristics of a national culture can amplify or attenuate the factors associated with a good safety culture.

A simple example of the potential for the national culture to influence safety culture in a positive or negative way is provided by a national culture which readily accepts large differences in status and power, and provides limited access to persons with authority. In such a culture there may be strict compliance with regulations and commands. This could be considered a positive benefit in developing safety culture. Conversely, blind acceptance of instructions and adherence to them could result in serious safety problems in the event of some unanticipated change of hazard level during an operation. What would really be required is a cessation of activity and

consultation with management without fear of criticism, and then reassessment. Failure to pursue this course of action would have a negative impact on safety.

Awareness of significant differences in national culture is important in the case of multinational projects. In an international turnkey contract the vendor may import his national culture into the design and procedural framework. This framework may not be totally compatible with the local culture and any mismatch could have potential adverse consequences for future safety performance.

There are organizations that conduct business on a global basis and have plants and facilities located in many countries of the world. Whilst operating in diverse national cultures, some of these organizations have developed sufficiently strong organizational cultures in which working practices, behaviour and attitude are relatively uniform and independent of the geographical location. The international nuclear community comprises a large number of professional technical specialists who have been exposed to a technological culture whose influence may lessen the differentiating features of their individual national culture. Nevertheless the development of a good safety culture should be sensitive to the characteristics of the national culture.

Irrespective of national culture, the interest within the international nuclear community in strengthening safety culture is also driven by the nuclear industry's awareness that any serious nuclear accident has significant, and potentially long lasting, implications for the health and environment of the locality of the accident as well as for geographically distant regions. There would also be serious implications for many future nuclear activities.

A fundamental principle that underpins a good safety culture, namely respect for human health, safety and well-being, is entirely compatible with the value framework of all national cultures. National culture should not be viewed as an impediment to safety culture. Being sensitive to its characteristics enables us to take advantage of cultural strengths and work with rather than against the flow of the world's rich and diverse cultural streams.

4. GENERAL PRACTICES TO DEVELOP ORGANIZATIONAL EFFECTIVENESS

Within an organization, safety culture is a subset of the wider organizational culture. Many practices which are used internationally to improve organizational effectiveness can contribute to developing improved safety. This section contains information on some of these general practices.

Many organizations recognize the importance of ensuring that there is unity of purpose among their employees and that they are motivated to achieving the

organizational goals. These organizations also recognize that guidance should be given to employees on how they should behave towards each other and towards others external to the organization. Openness, trust and two-way communication are keystones to establishing effective organizations. The concepts of **vision**, **mission**, **goals** and **values** are often used to achieve these desired requirements. Although normally used in a business planning context, these concepts can also be usefully applied to promote safety improvement. The individual concepts are briefly described below in the context of safety.

4.1. VISION, MISSION, GOALS AND VALUES

4.1.1. Vision

The **vision** describes in a few key words the future aspirations of the organization, and paints a picture of where the organization would like to be in the future. The time-scale for achieving the vision will vary with each organization, but it is usually several to many years. Vision can be used to align the efforts and energies of employees. An example of a safety related vision for an organization would be "to be regarded as the best safety performer in its sector of industry".

The creation of the fundamental vision is the responsibility of top management but it is essential that employees have an opportunity to learn and understand the driving force for the vision so that they are committed to achieving it. All managers have a heavy responsibility to communicate the vision to their workforce.

4.1.2. Mission

The **mission** briefly summarizes in a few paragraphs what has to be done in order to achieve the vision. It may refer to the organization's intended relationship with employees and external groups. It may also contain quantitative targets and can undergo change during the time-frame of the vision. An example of a safety related mission would be "to improve safety performance such that the organization is in the top 25% of performers in radiological, environmental and conventional safety". When this mission is achieved, the journey towards the achievement of the vision may require the "top 25%" to change to the "top 10%", and so on.

4.1.3. Goals

A range of actions will have to be taken to achieve the mission. Each action will have a specific goal. Each **goal** can be regarded as a focal point for an action plan within the organization and serve as motivation for employees. An example of a

safety related goal is "to reduce the average radiation exposure of employees by 10% during the next year".

4.1.4. Values

Values are those standards and principles which people in a group or locality might share. Values govern attitudes which show themselves in the behaviour of people towards each other. In organizations, values will be present implicitly. The aspirations of an organization on how people should be treated, and how the people themselves want to be treated, may be explicitly stated in values set by top management. These values have to be shared and must be made known to all levels of the organization. They are considered inviolate. A value which addresses safety is that "safety is never compromised".

4.1.5. Process for developing and implementing vision, mission, goals and values

The real power of these concepts lies in the process created to develop them rather than in the words themselves. The concepts have no benefit unless they are genuinely shared by the workforce. Employee involvement is essential, but top managers and their subordinate managers must lead, communicate and seek input from their workforce.

Developing safety related vision, mission, goals and values may be a good starting point and a focus of activity for initiating improvements in safety culture. Once the vision, mission, goals and values have been developed, a strategic plan should be developed to facilitate their implementation. This plan should include policy, organization, planning and implementation, and a means of measuring performance and review mechanisms, supplemented by appropriate audits.

4.2. FACILITATION/COACHING

Coaching of employees by managers to improve safety performance is important. There should be a process of continuous evolution of improved safety rather than satisfaction with the achievement of safety targets. Some organizations make use of individuals who have special skills in encouraging change in human attitude and behaviour; they are referred to as **facilitators.** Some general characteristics of a facilitator are listed in Appendix III. In some organizations the manager would assume the role of facilitator.

The facilitator helps others to cope with change and acts as a teacher of skills to teams and leaders, incorporating any feedback and constructive dialogue on safety

culture. Whoever undertakes the role of facilitator must model and exemplify the behaviour and attitudes of any new culture developed for the organization. An ongoing activity for this individual is the constant coaching and encouragement of all staff, including managers, in learning new attitudes and behaviour, with emphasis on promotion of feedback of progress. The facilitator must be resilient and a person on whom others can safely vent their frustrations related to change without feeling threatened or judged. A key function of the facilitator's job is to initiate approaches and practices which build relationships and trust among co-workers.

No single facilitator usually develops skills in all these areas or serves in all these roles at once. However, a small cadre of people who meet these organizational needs as the culture evolves can be very helpful.

In Stage III, an organization will probably be moving towards the development of these facilitation skills in all individuals who will serve in leadership positions within the organization.

4.3. OPENNESS

Experience has shown that organizations found to be very open to the public, professional associations and the regulator, as well as internally, have gained public confidence and improved the successful management of safety. When secrecy and a tendency to cover up failures is discovered, it will take a long time to restore confidence and trust. Openness is also a basic requirement for sharing experiences which, in turn, provides a basis for an organization's ability to learn and improve over time.

4.4. TEAMWORK

Most successful organizations actively encourage teamwork among their employees, particularly when a problem is complex and its solution requires the input of different disciplines. Many organizations have invested in training their employees to work effectively in teams. By providing employees with some basic understanding of group behaviour and the stages of development that groups undergo, they have enhanced the quality of teamwork. Some organizations have also trained employees in techniques that allow a structured approach to problem solving, and this training has been combined with team development. Excellent teamwork is beneficial to all aspects of the organization and is of particular benefit for safety, which often depends on an effective relationship between groups or between individuals. When using teams for specific tasks, it is important to ensure that there is no dilution of accountability and that accountability is clearly defined at the individual level. The

high quality standards attained by nuclear installations could not have been achieved without extensive teamwork both within the organization and with outside groups such as contractors.

It is important, however, that strong team loyalties should not prevent openness in reporting safety related failures or near misses.

4.5. CONTINUOUS EVOLUTION OF IMPROVED SAFETY PERFORMANCE

An organization needs to focus on continuous evolution. In other words, no matter how well the organization is currently performing, it must always be looking at how it might perform even better. This includes seeking ways to improve current systems and processes, as well as taking advantage of changing technology. Continuous evolution is most effectively sustained by focusing on improvements generated by employees. Although the design of a nuclear facility has to be frozen at some stage, this does not prevent the evolution of future design standards.

The concept of employee empowerment can be misunderstood. It does not mean the abdication of management accountability or uncontrolled and undirected employee participation. The aim of empowerment is to provide employees at all levels and in all parts of the organization with the skills, support and commitment required to maximize their contribution to organizational performance. A commitment to the continuous evolution of improved safety performance and the empowerment of employees to contribute to that improvement can be a potent force in achieving sustained high levels of safety.

5. SPECIFIC PRACTICES TO DEVELOP SAFETY CULTURE

The specific practices of this Safety Report are intended to apply to all aspects of nuclear installation design, engineering, operation, manufacturing, construction, maintenance, decommissioning and regulation. The practices are also relevant to other smaller scale nuclear activities such as industrial and medical radiography and research reactors.

5.1. PRACTICES FOR SENIOR MANAGEMENT

The involvement and commitment of senior management in pursuing high standards of safety is essential. Without a visible and genuine demonstration of this

commitment by personal behaviour and leadership by senior managers, other workers in the organization will not be convinced of the importance of safety compared to other organizational issues. Words without deeds will create an illusion of safety that will result in the development of a superficial safety culture.

To support the development of a good safety culture, senior managers can contribute by:

- Gaining understanding of safety culture concepts and practices through appropriate training;
- Demonstrating a leadership style with an appropriate balance between caring and controlling;
- Being visibly interested in safety;
- Having safety as a priority item on the agenda at meetings;
- Encouraging employees to have a questioning attitude on safety issues;
- Ensuring that safety is addressed in the strategic plans of their organization;
- Having personal objectives for directly improving aspects of safety in their areas of responsibility;
- Regularly reviewing the safety policy of the organization to ensure its adequacy for current and anticipated circumstances;
- Monitoring safety trends to ensure that safety objectives are being achieved;
- Taking a genuine interest in safety improvements, giving recognition to those who achieve them, and not restricting their interest to situations where there is a safety problem.

Senior management should ensure that their organization has a safety management system that provides a structured systematic means of achieving and maintaining high standards of safety performance. The key elements of a safety management system are given in Fig. 2.

The board of management with the highest level of executive authority in an organization should routinely discuss and review safety performance. A practice adopted by some boards of management is to nominate one of their members to assume a special responsibility on behalf of the board in monitoring safety performance and the proactivity of line managers in implementing plans that include seeking improvements in safety.

5.2. PREDICTIVE MEASURES TO ANALYSE RISK

A way forward is to use **predictive risk analysis** or **risk assessment methodology** during the preparatory phase of an activity. This analysis of risk of
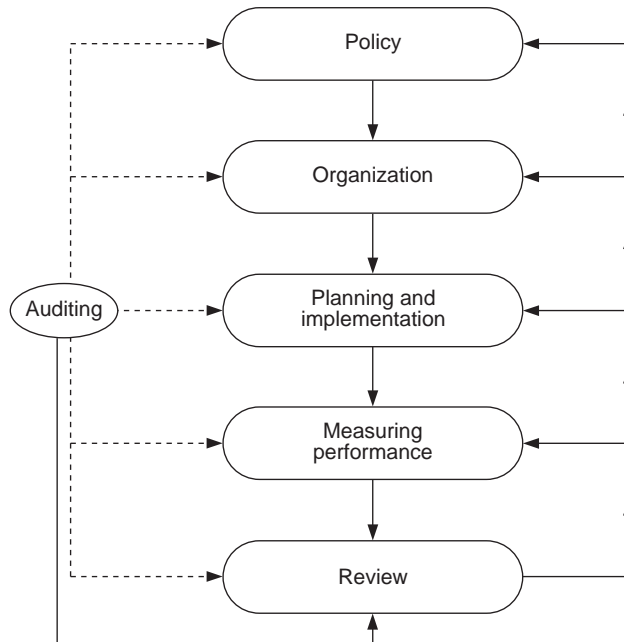
Examples of topics considered at stages of the process

Organization:
  Structure of organization
  Responsibilities
  Managerial control
  Communication
  Co-operation
  Independent advice
  Competence

Planning and implementation:
  Standards
  Safety assessment
  Work planning
  Operational controls
  Emergency planning

Measuring performance:
  Self-monitoring
  Independent monitoring
  Audit

FIG. 2. Key elements of a safety management system.

errors and their consequences is a basic requirement for quality. Performed by a multidisciplinary team, it should focus on quality requirements for the main safety related issues and thereby contribute to better understanding and communication between servicing and operating teams. It also increases the awareness of each member of the team of the key points and overall aim of the activity and its connection with other activities.

Some organizations draw up a guide to risk analysis for use by plant personnel as a practical way of avoiding recurrence of events. This guide uses typical experience feedback examples to help identify potential risks of errors at the different stages of the activity. It also defines the main preventive measures and hold points and includes

them in the quality plan of the activity. It can be implemented at the system level in order to cover multiple activities associated with the equipment, interfaces and requalification of the system. This methodology is also used for sensitive operational activities.

If well applied, this predictive risk analysis is a learning process and good tool to spread safety culture by contributing to better understanding and adherence to safety requirements.

5.3. ERRORS AS A LEARNING OPPORTUNITY

The first goal of any manager is to improve both safety and production. Any event related to safety, especially human or organizational errors, must be first considered as a valuable opportunity to improve operations through experience feedback and lessons learned. It is of the utmost importance to encourage employees to develop attitudes that give them confidence, without fear of blame, to report errors fully, particularly human errors, so that the opportunity can be taken to learn how to further improve the process. Managers should promote employee participation in professional and standards associations in order to share experiences and learn lessons.

Experience has shown that one consequence of this approach is that the number of events reported can actually increase. This is a consequence of the higher safety awareness which will lead to better detection and reporting. Only in the longer term can the number of events related to a definite cause be expected to decrease following better mastery of the problems identified. It is essential that management is aware of this and does not use indicators, such as the number of incidents, in a misleading or discouraging way. This approach should not, however, affect organizational disciplinary measures if wilful or criminal neglect has occurred. Attention should also be paid to unconscious mechanisms. Sometimes when an individual is experienced, the actions taken at a conscious level become automatic and no longer require conscious control. This can inhibit learning from errors.

5.4. IN DEPTH ANALYSIS OF EVENTS

To derive benefit from events, the development of a systematic in depth event analysis method is of fundamental importance. The first step is the detection of events by reporting against clear criteria including analysis of human factors. The reporting system should cover near misses, which are events with no tangible but some potential consequences, and which result in no injury to persons or damage to plant or environment.

After detection of an event or near miss a thorough analysis should be performed to identify the direct and indirect causes of the event in order to establish

the root causes. The causes may be one or several of the following: technical issues, human behaviour, organizational culture, process, procedure, equipment, man–machine interface, environment, or latent weaknesses in defence. There should also be a thorough analysis of the actual and potential consequences and highlighting of remaining lines of defence.

The search for corrective and preventive actions to maintain plant safety and avoid recurrence of similar failures will take into account not only the direct and root causes, but also the potential consequences, by examining the efficiency of the remaining lines of defence. Preventive actions can also be applied to other situations or other plants. The need for honesty, objectivity and comprehensive reporting of incidents and the use of this information must be stressed. The data that needs to be collected on precursors and symptoms of problems can be further clarified in training sessions and by involvement of staff in the development of improved reporting systems.

Participation of the personnel or team involved in the event is essential, especially in the case of human error, and they should be encouraged to propose corrective and preventive measures. It must be clearly stated by management that safety culture is not necessarily a 'zero error' culture, but rather a learning process that relies for improvement on openness and experience feedback.

5.5. ABILITY TO LEARN

The enhancement of nuclear safety relies on both actions taken in response to failures (reactive prevention) and the ability of organizations to identify the nature and causes of developing problems and to apply effective interventions to meet them (proactive prevention). A more proactive approach to safety management can be achieved through processes that will promote improved performance over time. Organizations using such processes are known as **learning organizations** and are characterized by their willingness to seek international exchanges of information. The ability to learn is central to an organization's ability to improve.

Improvement over time can be achieved through a learning process, which involves the organizations's ability to recognize and diagnose problems, to formulate and implement solutions, and to monitor the effects of the solutions and make adjustments as required by experience. The organization's ability to handle issues such as plant design, construction, modifications, operating experience, incident investigations, and periodic safety reviews is dependent upon the efficiency with which the steps in the learning process are carried out so that improvement over time can be made. Furthermore, organizations can learn when they can adapt to changes in external or internal operating contingencies, and thus be more efficient or effective. A sense of ownership at all levels of the organization is to be encouraged. Staff are more likely to respond to changes in which they have participated.

Teaching institutions and professional associations can contribute significantly to supporting the learning process.

5.6. THE ROLE OF TRAINING IN PROMOTING A POSITIVE SAFETY CULTURE

Training can make an important contribution to developing safety awareness and skills. Training needs should be identified using job/task analysis and by referring to other sources such as risk and hazard assessments. Trainers should also regularly visit plants and work areas to observe the performance of employees in order to improve understanding of specific training needs.

Training is commonly provided when a person joins an organization or periodically to refresh skills but is not always given when changing a job. Safety training for senior managers should reflect the demands of their job and will differ in some aspects from the training given to more junior managers.

Although safety training increases knowledge and skills, it may not change employees' beliefs, values, attitudes and behaviour, which may impede the transfer of the new knowledge or skill to the workplace. Trainers can counter this difficulty by recognizing the need to encourage a change in the attitude and behaviour of trainees in addition to imparting new knowledge and skills. Trainers can play a significant role in promoting a positive safety culture since they serve as both teachers and as agents for culture change. To undertake this dual role successfully, trainers may themselves require additional training.

Comprehensive and integrated safety training is visible evidence of an organization's dedication to the goal of ensuring the safety of employees and others affected by the organization's activities. Trainees, including new employees, will be strongly influenced by the attitude and behaviour of trainers towards safety, and therefore safety trainers have a special responsibility for setting a good example.

5.7. EMPLOYEES' CONTRIBUTION TO IMPROVING SAFETY PERFORMANCE

All employees have a primary responsibility to contribute to their personal safety and to that of their fellow employees. Many organizations have found by experience that this contribution is best facilitated by encouraging employee involvement since individuals tend to take a personal interest in matters related to their personal safety. Examples of employee involvement in safety are given below.

5.7.1. Safety improvement teams

Groups of individuals, who may represent various functions, meet to find a solution to some safety related problem. This is particularly effective for improving safety in work that requires different groups to interface. Safety improvement teams are used mainly to resolve local organizational rather than technical problems.

5.7.2. Safety committees and safety meetings

Many organizations encourage regular safety meetings at the departmental or sub-group level or by committees. The committee usually comprises nominated representatives from both management and workforce. The safety committee or safety meeting reviews safety performance in its area of responsibility and discusses actions for improvement. Communication with equivalent safety groups in other areas is encouraged so that new ideas and practices can be shared. In some organizations the safety committee members or safety meeting participants take the initiative in arranging visits to external organizations to observe and learn about new approaches to safety. The safety committee is usually chaired by a manager, although in some organizations the chairmanship rotates and is assumed by a non-managerial person. The acceptability of this will depend on organizational and national culture.

5.7.3. Safety conferences

Some organizations hold safety conferences which serve as a forum for representatives from all levels of the organization to meet and discuss safety performance. The conference may be focused on a particular safety theme. External speakers may be invited to share their experiences and broaden the perspective of the participants. External speakers may include representatives of the regulatory bodies. An annual conference often combines presentations and lectures with group work aimed at producing action plans for improving safety. Conferences may devote a day to discuss the importance of safety and to recognize selected employees' contributions to safety.

5.8. ACTIVE INVOLVEMENT OF CONTRACTORS

All contractors involved in design, engineering, manufacturing, construction, operation, maintenance or other areas can contribute to the improvement of safety and should therefore participate in the enhancement of plant quality and safety. The policy of relationships with contractors falls within the scope of safety culture development to ensure that the primary responsibility of the utility or plant regarding safety and

monitoring is not diluted and to foster the quality factor in the contractors' activities. Emphasis must be placed on the quality and safety of work done by the contractor, who must be aware of the standards required. Contractors should receive the same attention and training in safety culture as utility staff. The relationship with suppliers can also be important, and should be fostered in the same way.

This partnership between contractors and the utility or plant is mutually beneficial for several reasons, including the following:

- Training in safety and quality should be provided to the contractor. Experience has shown that the involvement of contractors in work preparation, risk analysis and experience feedback is beneficial both to the quality of work (e.g. in reducing the duration of the outage of the facility) and to the development of skills.
- Multiyear contracts extending two or three years into the future enable investment in training, quality and dosimetry to be optimized. This may be implemented through the concept of 'best quality bidder' and accompanied by an assessment of the contractor's performances in quality, industrial safety and radiological protection. This approach would encourage greater convergence of the safety culture of both vendor and contractor.

5.9. COMMUNICATION OF SAFETY ISSUES TO THE PUBLIC

In many countries nuclear power is a controversial subject and it is important to maintain public confidence in its safety. Communication of information on safety performance to external groups can assist in developing this confidence. However, the information must be prepared and disseminated by competent staff in order to minimize misinterpretation.

Some organizations hold routine meetings, often referred to as 'local liaison meetings', with representatives of their local community and local government to share information about activities and performance. Sub-groups can be formed to deal with environmental and emergency planning issues. The meetings often include representatives from the regulatory bodies in order to assure the local community that there is an independent perspective.

In addition to local liaison meetings, some organizations publish regular newsletters containing information on safety related matters. The background, consequences and corrective actions applicable to any significant safety abnormality can be included. In some instances where a newsletter is used as a channel of communication, the information is picked up by the wider media (newspapers, radio, television) to report on events at the nuclear installation. This practice can result in a more factual and less emotional reporting of an abnormality.

Larger scale installations can benefit by providing tours for visitors. This creates a sense of openness and offers an opportunity to provide visitors with factual information. Very large installations can construct exhibition centres to demonstrate models of nuclear processes. Some models operate interactively and attract the interest of young people. In some countries, nuclear organizations hold regular news conferences with media representatives.

5.10. SELF-EVALUATION PROCESSES

Organizations committed to the achievement of high standards of safety performance use self-evaluation processes as a 'feedback loop' to maintain and develop their ability to manage safety. Self-evaluation processes allow organizations to assess their safety performance by internal reference to key performance indicators and by external comparison with the performance of other organizations.

Self-assessment, self-inspection or checking are important aspects of any self-evaluation programme and each manager or supervisor should be encouraged to develop and implement a self-evaluation programme in their area of responsibility. Some organizations provide specific training for employees who are responsible for self-evaluation in order to ensure that the task is conducted to an acceptable standard. Some organizations provide a wider range of their workforce with self-checking training to encourage employees to assume individual responsibility for their personal safety and that of their colleagues. Such training can assist in identifying unsafe acts or conditions.

Independent evaluations and audits should be conducted by competent people independent of the area or activities being audited. This can be achieved by using either external consultants or employees from different sections, departments or sites to audit their colleagues. Those with auditing responsibilities will generally require specific training in this task to ensure competence.

Review and audit activities are commonly used in the nuclear industry. Those which focus merely on compliance can create a negative image of audits in the eyes of employees and can create difficulties for auditors in their work. Some organizations have changed the role of audits from the exclusive identification of non-compliances to include the identification of improvement opportunities. Auditors, by the nature of their work, have the opportunity to observe 'best practices' in an organization, and audits can be used as a means of disseminating information about best practices to all parts of the organization. Judgement of what constitutes best practice is subjective to a degree and the inclusion of this supplementary requirement may present difficulties for the traditional quality assurance audit.

A feature of many successful audits is a pre-audit meeting between the auditors and the auditees to discuss and agree the scope and programme. This involvement by the auditees does much to ensure that the auditors' work is perceived positively.

5.11. INTEGRATED SAFETY EVALUATIONS

Safety issues need a multidisciplinary approach, with the participation of different specialists and professional groups. It is essential that these issues are not dealt with one by one, but in an integrated manner. This will require the work to be organized in a way that will allow an integrated approach, for example in the planning and implementation of a major plant modification or in the investigation of an incident. These areas usually require consideration to be given to technical problems, human factors and organizational aspects in a co-ordinated and integrated manner. The need for an integrated approach to safety evaluations applies to industry, nuclear installations and regulatory agencies.

More generally, the integration of knowledge of the human factors into the routine day to day safety work may also provide a fruitful means of improving safety performance.

5.12. SAFETY PERFORMANCE INDICATORS

Traditionally, most organizations record the number of accidents and safety related events. Whilst providing important trend information, these indicators are of a passive nature and their exclusive use can be demotivating to the workforce. Some organizations use indicators of a more positive nature to complement the traditional passive indicators. Positive safety indicators include:

- Percentage of employees who have received safety refresher training during the previous month/quarter;
- Percentage of safety improvement proposals implemented during the previous month/quarter;
- Percentage of improvement teams involved in determining solutions to safety related problems;
- Percentage of communication briefs that include safety information;
- Number of safety inspections conducted by senior managers/managers/supervisors during the previous week/month (a safety inspection may be combined with a housekeeping inspection);
- Percentage of employees' suggestions relating to safety improvement;
- Percentage of routine organizational meetings with safety on the agenda.

This list is not comprehensive and is illustrative only. The value of positive safety indicators is that they serve as a mechanism for awarding recognition to employees who are endeavouring to improve safety by thought, action or

commitment. Recognition for achievement is a powerful motivating force to encourage continued improvement.

5.13. REGULATORY APPROACH AND IMPLICATIONS FOR SAFETY CULTURE

There is considerable international diversity in the regulatory approach to safety with regard to where emphasis should be placed. The regulator has options in dealing with the regulation of human and organizational factors.

One option is a compliance based approach, in which very explicit standards and requirements are applied uniformly to all nuclear facilities or activities and which result in a standard approach. However, this approach may be less effective or even inappropriate for the area of organization and safety culture.

Another option is to focus on outcomes — to establish safety performance indicators and to devote regulatory energies to tracking indicators and launching investigations when the indicators show a deteriorating or unacceptable level of performance. However, the problems arising in this approach are that it is very difficult to develop predictive indicators, and that the indicators which can be developed are often either too easy to manipulate or not sensitive enough to developing problems to allow early intervention.

An additional option, referred to as a process based approach to regulation, takes specific account of the fact that the safe operation of nuclear facilities depends on the effectiveness of the organizational processes established to operate, maintain, modify and improve a facility. In brief, this approach focuses on the organizational systems that the facility has developed to ensure continuous safe operation from the perspective of the facility's internal logic. Process based regulation recognizes that the design of organizational processes must remain flexible in order to allow the facility to create processes that are internally consistent, adapted to its history, culture and business strategy, and that allocate resources in the most rational way. A process based approach attempts to allow this flexibility while forcing the facility to think very carefully about the logic of its processes, to demonstrate to the regulator that a very rigorous approach has been taken to the design, implementation and ongoing evaluation of its key processes and that the facility is alert to opportunities to improve its systems.

These three approaches can be combined as they are not mutually exclusive.

Effective processes can take many different forms but they must be explicit, predictable, logical, implementable and must include a basis for self-assessment. The advantage of process based regulation for the areas of organization and safety culture is that assessments focusing on the logic of key organizational processes, and the care that the utility or plant takes in implementing and self-assessing these processes,

allow a degree of flexibility but are just as rigorous as prescriptive approaches which concentrate on compliance.

Irrespective of which regulatory approach is adopted, organizations committed to continuous safety improvements will benefit from an open and frank dialogue with the regulatory body, especially when the dialogue focuses more on achieving fundamental safety objectives than on mere formal compliance with detailed rules and regulations. Experience has shown that such dialogue will promote an enquiring and learning attitude, which is a key element in enhancing safety culture. In other words, the regulatory approach adopted may significantly influence the possibilities of fostering continuous improvement on the part of the utility or plant.

In practice, an optimal combination of all these suggested regulatory approaches may be the most effective. The optimum regulatory approach will depend upon the influence of the national culture.

5.14. INFLUENCE OF THE REGULATORY BODY

In the interests of promoting safety culture in organizations under its jurisdiction, the regulatory body should consider the following:

- Allowing some flexibility, within the constraints of national legislation, for organizations to manage for safety and develop aims and goals that exceed legal requirements.
- Targeting inspection effort to areas of risk and recognizing that some plants may have effective safety management systems. At these plants, sufficient inspections of control processes and selective inspections of consequences to the plant may be adequate as a regulatory tool.
- Not seeking to allocate blame in the investigation of incidents, and avoiding inappropriate punitive action for reporting incidents.
- Showing the reasoning behind regulatory controls, e.g. by publishing them.
- Establishing predictability and stability in the regulatory process.
- Trying to agree on appropriate technical ground rules for safety cases and assessment methodologies.
- Having regular dialogue with organizations and encouraging openness in dealings.
- Training inspectors to communicate with the public on nuclear safety issues in a comprehensible manner.
- Training inspectors in safety management (including safety culture) and human factors.
- Encouraging inspectors to interact with workers at the facility and to be visible to them.

5.15. INTERACTION WITH REGULATORS

The statutory duties of the regulators necessitate frequent contact with those who design, construct, operate, maintain and decommission nuclear installations. In addition to this formal interface, some organizations hold regular meetings with regulators to inform them of general plans and activities. These meetings keep the regulator informed of progress in work areas which, although outside their immediate area of statutory involvement, may be of interest. The meetings can also give the regulator a broader perspective, promoting additional confidence in the total safety framework and organization that supports good safety performance. Questions relating to safety culture can often be discussed at such meetings. It may be that several regulators have jurisdiction over a nuclear installation and the meeting can offer a convenient opportunity for the representatives from different regulatory bodies to interface with each other and the organization.

6. ASSESSING PROGRESS IN THE DEVELOPMENT OF SAFETY CULTURE

No composite measure of safety culture exists. The multifaceted nature of culture makes it unlikely that such a measure will ever be found. Changes are usually slow and often imperceptible, but history demonstrates that cultural changes can be discerned over finite periods of time, and the same should be true of safety culture. To assess progress in the development of safety culture we may have to abandon the search for a single composite measure and concentrate on identifying the range of indicators that reflect the individual sub-components of culture. The basic range would comprise measures for observable behaviour, conscious attitudes and perceptions or beliefs. Examples of methods that have been applied to measure these key components are shown in Fig. 3 [9] and are discussed in more detail below.

6.1. BEHAVIOURAL MEASURES

This is the easiest cultural component in which to detect change as it is observable. The observation may be of general activities or of a specific individual or group. It must be conducted carefully to minimize any influence on the behaviour, otherwise the conclusions may be erroneous. The use of a person familiar to those observed should minimize any influence but runs the risk of a biased view. Conversely, using a third party unfamiliar to those observed can ensure an unbiased viewpoint but increases the likelihood that the behaviour observed may not be typical.
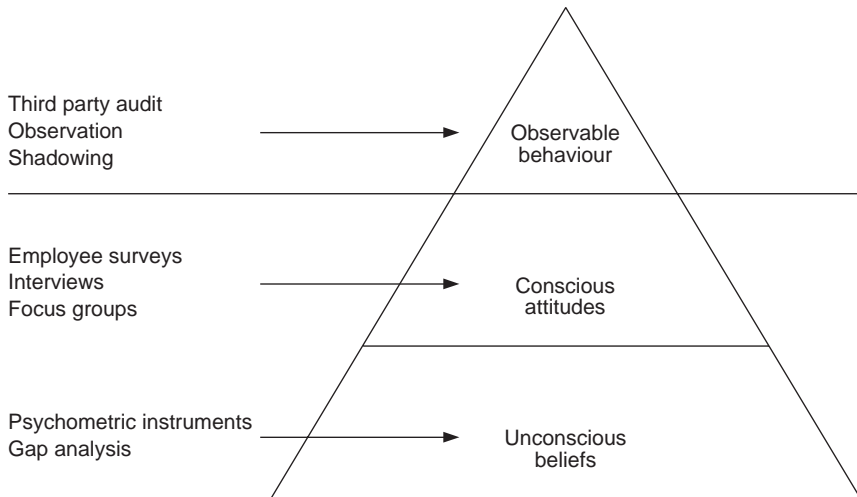
FIG. 3. Methods for measuring key components of safety culture (after SCHEIN in Ref. [9], Ch. 7, Fig. 7.2).

An in depth behavioural evaluation may require the use of a trained and skilled third party. The evaluator should be given some lead-in time to become familiar with those to be evaluated in order to ensure that behaviour is not unduly distorted by the evaluator's presence. Changes in behaviour will only be revealed by a series of observations or evaluations over a period of time. The results of these observations will reveal a trend, which can be used as a basis for measuring behavioural change.

6.2. ATTITUDINAL MEASURES

Employee attitude surveys are the most common method for obtaining information at this cultural level. The preparation of an employee survey requires persons skilled in attitude measurement. Analysis and interpretation of the results require equally high skills. Some organizations have employed the services of the human behavioural science or psychology department of their local academic institution. Before conducting any large scale employee survey it is worthwhile carrying out a small scale trial to test the usefulness of the survey. The trial may include interviewing small groups of employees to test the practical implementation of the survey. The results of an employee survey can provide useful information that allows management to target areas for more effective safety improvement action. The survey questions can explore not only the personal attitude of the individual but also his or her perception of the attitude of their supervisor, other line managers and their peers. Repeated use of the same attitude surveys over time and the same population

can provide useful information about trends in attitudes. The results of an attitude survey can be compared with the results of behavioural observation to identify correlations.

6.3. PERCEPTION OR BELIEF MEASURES

It is very difficult to measure change in perception or belief, particularly since many of them may be at the subconscious level. An indication that a subconscious belief may be having an important influence is the presence of a significant inconsistency between observable behaviour and conscious attitude. To measure beliefs requires psychometric techniques of an advanced nature and the interpretation of results can be difficult. Normally, behavioural observation and attitudinal surveys should provide ample information for measuring cultural change.

6.4. OVERALL ASSESSMENT OF SAFETY CULTURE

The information accumulated from the behavioural observations and attitudinal or belief surveys can give a valuable indication of whether safety culture is developing successfully. The information can also be used to confirm the effectiveness of specific management actions in relation to safety. This is in addition to the more tangible evidence of a maturing safety culture, namely sustained improved safety performance. Sustained improved safety culture can be achieved with appropriate training and deployment of existing resources.

Before listing some specific organizational indicators of a progressive safety culture, the influence of major environmental and internal organizational factors on an organization's safety culture is discussed below. The influence can be assessed by a general evaluation model developed for the purpose.

6.4.1. General evaluation model

Figure 4 illustrates a general model that provides a framework for a high level screening evaluation of safety culture. The model identifies factors that can significantly influence safety culture. The potential benefit of the model is that it prompts consideration of the various influences on safety culture and can highlight areas that warrant more detailed consideration. Although the model is primarily qualitative, it can serve as a basis for a simple screening matrix that provides a quantitative dimension. An explanation of how a screening matrix could be used is summarized in Appendix IV. The matrix can be used to evaluate generally the

FIG. 4. General evaluation model.

synergistic influence of the various factors that could affect the successful development of safety culture in an organization.

6.4.2. Specific organizational indicators of a progressive safety culture

Safety culture does not exist in isolation and is influenced by the prevailing organizational climate or culture. It is important that the organizational culture be supportive of safety and, particularly, that it should encourage the appropriate behaviour, attitudes and values on the part of employees. Some organizational indicators of progressive safety culture are:

- Widespread employee commitment to good safety performance, including visible leadership by top management;

- Good safety performance, considered to be a goal in itself that is important to the organization, and not merely intended to comply with regulatory requirements;
- Investigation of the fundamental causes of events or near misses to learn lessons rather than to allocate blame;
- Effective communication of safety information including safety performance trends;
- No blame attached to employees who voluntarily report mistakes;
- Commitment to continuous evaluation and improvement of safety performance;
- Co-ordinated and regular audit programme;
- Managerial awareness of safety culture issues;
- Employee involvement in safety improvement activities;
- Primary organizational goals include safety and are not focused on cost or financial targets only;
- Adequate allocation of financial and other resources to support safety;
- Positive efforts made to learn from safety performance of external organizations;
- Safety performance measures include measurement of the effectiveness of activities on processes that affect safety, and not just measurement of the results of these activities or processes.

The above indicators reflect, in the words of INSAG-4, the intangible attitudes of personal dedication, safety thinking and a questioning attitude. The indicators are the tangible manifestation of a progressive safety culture

7. DETECTION OF INCIPIENT WEAKNESSES IN SAFETY CULTURE

While the previous part of this report offered practical suggestions for the development or improvement of safety culture in an organization, this section deals with indicators of a weakening safety culture. There is often a delay between the development of weaknesses and an event involving significant safety consequences. Alertness to the early warning signs allows remedial actions to be taken in sufficient time to avoid adverse safety consequences.

Regulators have an obvious and legitimate interest in maintaining safety culture, and whilst it may not be practicable or appropriate for them to prescribe a safety culture, they have an important role to play in encouraging organizations to identify, understand and apply positive steps to improving safety culture. Currently, most regulatory regimes are geared to negative feedback; hence this report can be of

value to regulators in focusing attention on the practices that develop strong safety culture. However, it is important that regulators also be alert to incipient weaknesses in safety culture and this section provides some guidance on symptoms to look for when carrying out their regulatory duties.

7.1. SYMPTOMS OF A WEAKENED SAFETY CULTURE

Regulators, in particular, should pay attention to the symptoms listed below when inspecting plants and other facilities belonging to an organization. Some symptoms are associated with the information provided to the regulators by the organization. The management of an organization should pay particular attention to monitoring for these symptoms in their organization's self-assessment process. The symptoms are categorized into organizational, regulatory, employee and technology issues. In some cases, suggestions are made on how to make symptoms more transparent.

7.1.1. Organizational issues

7.1.1.1. Pressure from external environment

Many organizations are subjected to increasing economic and market pressures that are forcing them to significantly reduce their cost base, often through downsizing their workforce. In some regions of the world major political and social changes have affected organizations both directly and indirectly. These changes create uncertainty in organizations that inevitably affect personal behaviour and attitude. Organizational goals and priorities can change significantly and there is a potential for safety standards and performance to be adversely affected. All those involved in the management or the regulation of safety should pay attention to how significant corporate change processes are being managed in order to ensure that the principles of good safety are not being jeopardized.

7.1.1.2. Inadequate resolution of problems

Symptoms of inadequate resolution of problems are repeated crises, significant accumulations of corrective actions, lack of effective managerial prioritization of remedial actions, and failure to address the root causes of problems. Inadequate resolution of problems can result in an increasingly overloaded and underresourced situation that causes a highly ritualized response to problems. The response often includes repeated calls for demonstrably defective procedures to be rewritten, training to be improved or employees to "take more care". In practice, however, few if any

effective remedial measures are ever taken. Design and equipment modifications also become stalled because attention is being given to 'fire fighting' problems rather than to addressing root causes. The constant barrage of problems may provoke a sense of hopelessness in employees who perceive that their individual efforts are ineffective. The frustrations of management in this situation may appear as an increased tendency to apportion blame to those individuals who seem to be the source of their problems.

7.1.1.3. Organizational insularity

Organizational insularity can cause safety culture to deteriorate simply because managers come to believe that their safety performance is satisfactory and therefore become complacent. Managers have no benchmarks or learning opportunities. Insularity can be internal to an organization. Plants and facilities belonging to the same utility often create and display very different organizational and operational styles and identities. Whilst this can assist in promoting a feeling of corporate identity, *esprit de corps* and individualism useful in building morale, it has undesirable elements in its influence on safety culture.

Regulators need to review the organization and operation of each plant and compare aspects such as interaction with other plants, interchanges of staff and information, and collective problem solving. A lack of communication and interaction is not healthy, and the regulator should be alert for signs of plants "not talking to each other". Small differences in style, approach or local adjustment are acceptable but the aim should be for a consistent and open attitude to prevail across all the plants at a utility. It may not, however, be immediately obvious to the regulator or utility management that such large differences exist, and it is in both their interests to review and rectify any shortcomings between sites or plants. It is easier for the regulator to deal with a standardized approach, and it makes economic sense for utilities to function as a family and profit from the pooling of ideas and resources.

This is an area that warrants further investigation by the regulators in order to ensure that an open and interactive organizational style prevails on a regular basis between the plants under their jurisdiction.

7.1.1.4. Openness

Open and honest communication between regulator and representatives of an organization is essential if the regulator is to be able to assess and evaluate the safety culture. Difficulties in obtaining information may be a sign that there is a weakness in the safety culture. An organization striving to improve and develop its safety culture should be willing to share its experience with others as well as using the experience to improve its own safety. With deregulation and increased competition there may be a tendency to restrict information on commercial grounds. This should

not be allowed to escalate and undermine the open relationship between regulator and organization. An increase in requests for information to be treated as commercially confidential may be an early sign that barriers to mutually beneficial exchange of information and opportunities for shared learning are being erected which could ultimately degrade the safety culture. This restriction may also extend to the openness of the organization to participate in and contribute to international exchanges and initiatives.

7.1.2. Regulatory issues

7.1.2.1. Corrective actions

One of the most obvious signs that safety culture is starting to weaken is evidence of a significant accumulation of corrective actions that have not been addressed. The existence of an effective programme for self-assessment, root cause analysis and corrective action is a positive indication of a good safety culture. Measuring the number of open corrective actions and the period of time for which the actions have been open is a good indicator of general managerial effectiveness in planning and organizing work, allocating priorities and monitoring the progress of implementation. This is particularly important when the corrective actions are safety related.

Many organizations maintain databases of corrective actions and compile an index to indicate the status of corrective actions. Appendix V is an example of one possible index that takes account of both the number of corrective actions and the period of time they have remained open.

7.1.2.2. Patterns of problems

Part of the ongoing monitoring of compliance and plant status checks normally carried out by the regulator is the collection of information from varied sources. By arranging this information into predetermined categories it is possible to create a profile or pattern of similar situations from which preliminary conclusions can be drawn. The range of categories depends on the system available for information to be reported and analysed. However, it should be comparatively simple to create a list of safety culture attributes based on, for instance, INSAG-4, against which reported or observed occurrences can be recorded. Such a collection can then be arranged into areas of recurrence or patterns of problem areas with which to begin further investigations into the causes.

Repetition of problems usually indicates that the root cause was not identified correctly and that whatever corrective action may have been implemented was not adequate. Information can be collected from formal or informal sources and where possible should be corroborated or cross-checked to validate its accuracy.

This data collection and analysis method can be used to produce 'trended' information to indicate levels of reported performance by sections, groups or departments of the plant. Whilst they are not true indicators of performance, trends are guides that can alert the regulator to areas of concern on the basis of information originating from the plant.

7.1.2.3. Procedural inadequacies

Documentation is the lifeblood of an organization, and regulatory requirements demand that it be acceptable in quality and content. It is also required that safety documentation be complied with, and this must therefore be up to date and reflect the actual situation. Normal quality assurance audits and checks ought to cover these requirements, but they are usually not performed often enough to monitor the day to day status of review and revision.

An important element of safety culture is that employees should have confidence in procedures and use them correctly. However, it is essential that the regulator understands the system of regular documentation review and that any deterioration is detected at an early stage. Failure to detect and rectify 'out of normal' situations regarding procedures, etc., will lead to plant employees ignoring instructions, losing confidence in documented requirements and probably taking unilateral and unsafe actions. The slippage of review dates and revision issues contributes strongly to poor safety culture and can also indicate weaknesses in other areas such as management, configuration control, resourcing and safety decision making. It also influences morale, as the employees often perceive that if documentation is neglected then other areas of concern are also suffering.

Regulators should therefore monitor frequently not only the quality of presentation, format and availability of documentation but also insist on a list of review dates, current status reports and delays. This list can then be checked on site by random inspections of procedures, etc., to verify what has been revised and whether the reporting and review system is working. A large number of documents that have exceeded their review dates indicates a significant weakness in documentation management and requires urgent regulatory intervention.

7.1.2.4. Quality of analysis of problems and changes

Regulators have to be sure that any analysis carried out at the plant follows a systematic, auditable system which will ensure that the correct methods are used, validation performed and the correct solutions defined. Too often the process is circumvented owing to inadequate identification of the problem, lack of resources and knowledge, or time constraints, which can lead to inappropriate actions.

Unless the regulator carries out the initial analysis, which is both undesirable and impractical, it is often difficult for the regulator to determine the effectiveness of the analysis system.

Prior to approval of plant modifications, the regulator usually demands the presentation of a safety justification and this should be drawn up in accordance with predetermined requirements set out by the regulator. Typically, these should include the philosophy, statement of the problem, proposed courses of action, justification and an independent review by the utility. A root cause analysis must be undertaken to ensure that the real cause of the problem is identified. Evidence of adequacy of this analysis can be readily checked by the regulator by monitoring the recurrence of similar problems.

The establishment of a review and analysis group at the utility with the correct level of experience and qualifications will inspire confidence in the analysis process. However, it is important that the regulator checks regularly that this group remains in place. Training in and demonstration of root cause analysis should also be demanded by the regulator. To monitor accuracy, the regulator should make regular checks on the composition of the group and random examination of the root cause analyses carried out by the group.

It may also be possible at multisite utilities for the regulator to cross-check submissions from plants on the same or similar submissions to identify any anomalies which may indicate a serious mismatch in review and analysis techniques.

In all cases the emphasis must be on systematic and conservative assumptions which can be related to risk and the accepted safety criteria. The fundamental principles of safety culture — prudent and rigorous approach, questioning attitude and communications — underpin the need for all safety case submissions and root cause analyses to be carried out with due regard for the possible consequences.

Whereas sufficient attention may be devoted to technical plant modifications, the same is not always true for changes in organizational systems. Yet it is the latter that may have very serious consequences for the ability of the organization to develop a sound safety culture.

High quality in analysis usually also requires an integrated approach, i.e. a broader view of safety and recognition of the need for integrated analyses with the involvement of different specialists. To be more proactive, the analyses performed must also include a long term perspective.

7.1.2.5. Lack or failure of independent nuclear safety reviews

For all safety related proposals and modifications, independent nuclear safety assessments should be undertaken by persons other than those who carried out the

original work. In a healthy safety culture, these assessments will always have been fully documented and checked for methodological, calculational and technical accuracy and validity, using approved procedures. As well as providing evidence that a safety culture is continuing to produce documentation to an approved regulatory standard, regulators and licensees will wish to satisfy themselves that there is a continuing commitment to the production of high quality independent safety documentation, that all necessary checks are being made on a regular basis, that assessments are consistent with the level of change being contemplated, and that reviewers are fully conversant with the implications of the proposals. Regulators and licensees should also satisfy themselves that necessary actions are being taken to provide assurance that the proposals will work in practice.

7.1.2.6. Reality mismatch

A well developed safety culture will always be consistent with the nature of the safety case and the state of the plant. What this means in practice is that the state and configuration of the plant will always match the assertions of the safety case, and the condition of the plant will always support and enhance the requirements of the safety case. In other words, the state, configuration and condition of the plant must at all times be fully consistent with the claims that are being made in the safety case and that the claims required in support of the safety case must never make demands on plant or personnel which are unrealistic or unreasonable. A well developed safety culture will prompt plant management to make such consistency checks for themselves, whereas a less well developed safety culture will usually result in regulators having to insist that such checks are made. Suitable checks can be made on a room by room, system by system or function by function basis, as appropriate to the claims made in the safety case. Whichever means are used, it is essential that the provisions of the safety case are at all times fully reflected in the reality of the plant and personnel characteristics, and if licensees are seen to be inattentive to such matters, regulators may have to make such checks themselves. If this were to become necessary, it would be indicative of at least three basic shortcomings in the licensees' safety culture. First, the regulator would have to be concerned that the licensee was not making the necessary cross-checks; this, amongst other things, could indicate a lack of commitment. Secondly, such inattention would indicate that communication and co-operation within an operating organization were not properly developed. Thirdly, such a situation would not only place an undue burden upon a regulator, but would tend to indicate that the licensee did not possess a learning culture, which would then be a major concern.

7.1.2.7. Violations

Non-compliances (violations) tend to be recorded by most licensees in varying degrees, in relation to breaches of operating rules and operating instructions. Such reports can be of variable quality and detail but all should be notifiable to the relevant regulatory bodies. Not only do violations provide a rich insight into the operational performance and compliance characteristics of any organization as well as a fertile ground for investigation into general and specific problem areas, but they also serve to indicate whether a licensee is radically different to others operating similar plant. Whilst recognizing that there will, of necessity, be some important differences between the reporting levels and criteria existing between nations it is possible, nevertheless, for a licensee to benchmark itself in relation to others in a similar class, e.g. those operating similar plant of similar age. Such benchmarking can provide valuable insight into the relative success with which a licensee is managing its affairs and is indicative of the extent to which its safety culture is keeping up with the evolution of other comparable organizations. For example, if a licensee had plant broadly similar in design, age and operating regime to another licensee's installations, and which, even after allowing for reporting level differences, experienced a disproportionately high incidence of non-compliances compared to its counterparts elsewhere, this would be a matter for investigation by both licensee and regulator. As a minimum, such an investigation would need to account for the apparent differences between apparently comparable installations. This would indicate, first of all, the presence of a learning culture, and therefore a potentially strong safety culture at work. In addition, it would provide the basic raw material for the necessary corrective actions that would be expected to flow from such an investigation, thereby satisfying the requirement for continuous improvement and a desire to remain at the forefront of the nuclear community.

7.1.2.8. Repeated requests for dispensation from regulatory requirements

Requests for dispensation from existing regulatory requirements can be made, particularly prior to restart after a planned outage. Frequent requests should trigger a review of the adequacy of the regulatory requirement, or questioning whether production priorities are being overemphasized to the possible detriment of safety. The latter would be a sign of a weakening safety culture. When requests for dispensations are made at the last minute the regulator is placed in the unenviable position of having to prevent the resumption of production, with the associated economic consequences, instead of focusing on the organizations' inadequate planning and work implementation. The latter are signs of weaknesses in the organizational culture which clearly have consequences for safety.

7.1.3. Employee issues

7.1.3.1. Excessive hours of work

A significant factor in the degradation of personal performance is fatigue. Safety culture relies on optimum output in the areas of attention, questioning attitude, diligence and fitness for duty. However, all these are adversely affected when an individual is tired and stressed. Working hours must be formulated and regulated to allow people to perform their allotted duties within reasonable time-scales without imposing undue pressures which can induce unsafe and undesirable consequences. Transition from normal to additional working hours is an accepted part of industrial life, but excessive and sustained overtime can lead to safety problems and is unfortunately all too frequently sought by the worker. Regulators can check the hours worked by staff, either permanent or contractors, in order to monitor the acceptability of overtime and to identify cases of excessive or sustained attendance hours.

Many incidents have included the influence of overtired and stressed individuals as a contributing cause and this area needs to be identified and analysed by the regulator as a category in occurrence trending. Persistent abuse of overtime and the continued reuse of staff on call-outs or replacement work would indicate to the regulator that resource levels and planning of work require investigation. The potential for excessive working hours is particularly acute in outage periods and, when combined with the attendant pressures of meeting deadlines and the physical stresses often experienced under outage conditions, can lead to a serious degradation of safety culture.

7.1.3.2. Number of persons not completing adequate training

Training plays an integral role in the safety culture of an organization, and the regulator would want to be assured that adequate attention is being paid to the quality and applicability of training programmes. These aspects are checked by submissions from the operating organization, and by examination and acceptance of the training required by the regulator. However, the attendance and performance of staff at training sessions needs continuous monitoring. Regular checks on the status of training hours and the results of training are easy to undertake by testing and, when added to the profiles obtained from analysing other safety culture areas, can provide additional indication of the commitment level of staff and management. This information, when correlated with the results of occurrence analysis, particularly if groups or departments are highlighted, can provide supporting evidence to the regulator that further investigation and targeted corrective action are needed in the training area.

7.1.3.3. Failure to use suitably qualified and experienced persons

All nuclear plant operations should be carried out by suitably qualified and experienced persons. Whilst this is a basic requirement, and even a licence condition for many operating regimes, it obviously cannot always be achieved in practice. Such failure tends to show itself in those incident and accident event reports that conclude that further training/retraining of personnel is required. Suitably qualified and experienced persons can be readily identified and recruited by careful attention to the definition of the needs of a given job. This proactive approach includes identification of the principal duties and responsibilities of the job holder, the attributes required for the tasks to be performed, and the preparation of a profile outlining the characteristics required of the incumbent in order to carry out the duties effectively. Poor safety cultures would tend not to have job profiles available, nor would they make the necessary attributes explicit. Good safety cultures would not only have all the basic systems in place but would seek to use incident feedback, amongst other things, to identify any personnel deficiencies, and incorporate any such identified features into their selection and recruitment procedures for future application, as appropriate. The presence of unsuitable and inexperienced personnel becomes readily apparent when checks are made regarding knowledge and experience requirements against the basic skill, knowledge and task capability that are available within a workforce. Such checks can be made by means of skills and job task analysis. The implementation of an effective 'systematic approach to training' (SAT) regime would indicate a strong enhancement of safety culture in the training area and would make a significant impact on the next paragraph's applicability to an operating organization.

7.1.3.4. Understanding of job descriptions

Typically in poor safety cultures, some individuals are not fully aware of the total requirements, responsibilities and accountabilities of their job. This can arise either because job descriptions have not been properly prepared in the first instance or because individuals have not been properly briefed on their employer's expectations. In either case, there is obviously the potential for a significant mismatch between the expectations of the employer and the employee. To check that this is not a safety culture concern, the licensee should produce the necessary safety components of the relevant job descriptions. The regulator should then require evidence that there is a one to one correspondence between the job holders' understanding of their job responsibilities, and the licensee should be able to produce evidence that the job holders actually understand the requirements of their jobs as defined by the licensee. In the first instance, such confirmation could take the form of a simple written affirmation that the job holders have received, agreed and understood the job descriptions, and that the licensee is confident that the job holders understand the job

descriptions and the general requirements. This would probably need to be followed up by further confirmatory checks. For example, wherever possible, key job holders would be asked to outline their jobs and indicate their competence, skills, knowledge, background and experience, which would all be evaluated against the job descriptions prepared. Where necessary, further checks would then be made at the discretion of the regulator by seeking confirmation of the suitability of both job descriptions and job holders as evaluated by additional external agencies, such as the operators of similar plant and/or recruitment/training specialists.

7.1.3.5. *Employment of contractors*

An emerging trend in plant maintenance and support is the increased employment of contractors to replace traditionally plant based personnel. Whilst this policy has financial benefits for the utility, it often comes at the expense of safety, either directly as a result of lower standards or indirectly through the effects on permanent plant employees.

Control and direction of contractor employees can often fall short of that expected from permanent plant employees. Regulators can monitor the situation by regular checks on contractor behaviour, analysis of reported contractor performance, on site inspection and review of contractor records.

Trending and analysis of occurrences or problems may reveal contractor involvement and shortcomings. However, the regulator needs to be aware at an early stage of the utility's intention to employ contractors. Examination of the contract specifications and conditions prior to contract award may allow the regulator to determine the adequacy of safety, supervisory and training provisions and consequently to require appropriate amendments. One of the problems associated with employment of contractors is the effect on regular employees who may feel threatened, insecure or resentful, all of which may adversely affect their safety performance.

Any changes to contractor policy or adverse performance attributable to contractor involvement needs to be identified at the earliest stages by the regulator so that remedial action can be taken swiftly.

7.1.4. Technology issues: plant conditions

Plant conditions provide a useful and valuable insight into the general health of an organization's safety culture. It has long been recognized that poor housekeeping standards are an indicator of behaviour and attitudes which are not likely to be conducive to the development of a sound safety culture. Other indications are lack of attention to alarms or non-repair of malfunctioning equipment, overdue maintenance work or poor information recording and archiving systems. These deficiencies are

prevalent when there is inadequate managerial and supervisory attention to safety matters and often reflect the absence of an effective self-assessment and self-inspection regime. Such deficiencies damage the credibility of any claimed organizational commitment to safety.

7.2. REVITALIZING A WEAKENED SAFETY CULTURE

Early detection of problems will lead to early diagnosis and the application of effective remedial measures. Senior management must be seen to be committed to stabilizing the situation by demonstrating leadership and taking responsibility for the problems. It is essential to regain effective control of the safety mission and implement effective remedial action when faced with a weakening safety culture. Making inroads into outstanding corrective actions can lead to early feelings of success and resumption of control. Management may have to emphasize that safety takes priority over production objectives. Introducing a safety performance measurement system based on the indicators of a progressive safety culture (see Section 6.4.2) can help refocus an organization's safety efforts in the right direction.

8. CONCLUDING REMARKS

There is no consistent and visible prescriptive formula for developing a strong safety culture. However, a prerequisite is genuine and consistent commitment by the top management of an organization to improving safety. Provided this commitment exists, the best recommendation is to do something tangible and visible to improve safety, preferably involving employees from the outset.

The choice of practices for developing an improved safety culture should take account of the existing national and organizational culture in order to ensure effective implementation.

The importance of the learning process has been emphasized in this report. A mechanism is necessary to ensure that international experience of practices to develop a strong safety culture is shared on a regular and frequent basis.

The maintenance and improvement of a safety culture is a process of continuous evolution. Indicators are available to assess positive progress in this evolution and to detect a weakening safety culture.

Use should be made of the publications and services associated with safety culture that are available from the IAEA.

Whilst it may not be possible to legislate or regulate all the attributes of safety culture, the role of the regulatory body is very important in establishing and fostering a safety culture attitude in the facilities under its jurisdiction.

Appendix I

**PRACTICES USED FOR
DEVELOPING AN IMPROVED SAFETY CULTURE THAT ARE NOT
SPECIFICALLY MENTIONED IN INSAG-4**

SYSTEMS AND PROCESSES

- Use of electronic information systems that make information and data widely and easily available.
- Efforts to improve job satisfaction.
- Strong technical and engineering support in the pursuit of improved safety.

ORGANIZATIONAL CULTURE

- Doing what is right, not because it is required.
- Respect for nuclear technology.
- Broad view of safety — including radiological, industrial, environmental and nuclear aspects.

LEADERSHIP

- Listen to understand.
- View training as an investment and not a cost.

Appendix II

**KEY QUESTIONS FOR USE IN DISCUSSIONS WHEN TRYING
TO INCREASE AWARENESS OF SAFETY CULTURE**

- What does 'safety culture' mean?
- What are the top priorities and the most important principles and actions?
- What key practices exemplify a safety culture?
- How does safety culture connect with the purpose, productivity and viability of the organization and why is this connection important?
- What can we do to have a more effective safety culture?
- How is safety culture lived out in an organization?
- How do we achieve a set of shared attitudes, values and behaviour which support a safety culture?
- How do we assess changes in safety culture?
- How does regulatory/governmental strategy affect safety culture?

Note: A list of more detailed questions can be found in INSAG-4 [3].

Appendix III

CHARACTERISTICS OF A GOOD FACILITATOR

- Respected by colleagues, respects them, and has their confidence.
- Motivated, willing to be challenged and to learn.
- Exemplifies organizational values.
- Exhibits strong personal commitment to the organization's vision.
- Open, sincere, willing to value the viewpoint of others.
- A high quality performer in normal work.
- Demonstrated facilitation experience preferred.
- Demonstrated ability to be effective in ambiguous situations.
- Good presentation and skillful public speaking, good presence.
- Demonstrates flexibility and sense of humour.
- Willing to spend personal time and energy to succeed in this task.
- Has knowledge of business/organization/employee relations.
- Willing to travel if necessary to facilitate groups.
- Possesses a sense of personal security and courage in facing challenges and taking risks.
- Demonstrates willingness and capability to learn about 'human and organizational dynamics' and 'change' in order to help self and others.

Notes: No single facilitator will have all these characteristics.

Those designated to fulfil the facilitator role must receive training.

In some organizations the manager will be the facilitator.

Many of the above characteristics are those required of a leader.

Appendix IV

SAFETY CULTURE SCREENING MATRIX

IV.1. RATING OF FACTORS WITH A POTENTIALLY HIGH LEVEL IMPACT ON SAFETY CULTURE

The following is a guide to rating an influencing factor. The guide is indicative only and should be supplemented by personal judgement based on experience and observation.

Influencing factor	Tendency	Rating criteria
Business environment	Positive	• Regarded as a successful and profitable business • Stable or growing market share
	Negative	• Unprofitable business • Market share under threat because of competition
Regulatory environment	Positive	• Well established and mature regulatory framework • Experienced regulators
	Negative	• Recently deregulated • Inexperienced regulators
Organizational environment	Positive	• Experienced in managing change • Good communications • Well defined goals • Employee participation • Leadership visible
	Negative	• Inexperienced in managing change • Poor communications • Lack of employee involvement • No visible senior level commitment to safety
Organization history	Positive	• Long term (>20 years) experience in nuclear industry • No recent takeover or reorganization • Internationally recognized
	Negative	• Limited experience of nuclear industry • Recent major reorganization or takeover • Recent attempts to change organizational culture

Influencing factor	Tendency	Rating criteria
Worker characteristics	Positive	• Flexible • Competence based training • Experienced in teamwork • Reasonable educational background • Local pool of skilled labour
	Negative	• Inflexible • Classroom based training only • Inexperienced in teamwork • Limited educational background • Low morale
Technology characteristics	Positive	• Mature technology • Safety features incorporated in design • Limited modification required • Good ergonomics • Fault tolerant
	Negative	• Immature technology • Obsolete technology • Poor design from safety perspective • Significant ongoing modification • Poor ergonomics • Not fault tolerant • Significant consequences if fault occurs
National culture	Positive	• Ethos of personal responsibility • Not status conscious • Questioning attitude
	Negative	• Hierarchical orientation • Unquestioning attitude • Overly sensitive to criticism
Sociopolitical environment	Positive	• Stable • Adequate funding • Mature institutions • Cohesive society • Respect for law
	Negative	• Volatile • Immature constitutions • Fragmented society • Recent experience of major change • Severe governmental budget restraints

IV.2. SCORING CRITERIA

Score	Criteria
5	All positive tendencies strongly evident
4	All positive tendencies evident to some degree
3	Majority of tendencies positive
2	Majority of tendencies negative
1	Majority of tendencies negative with at least one strongly evident
0	All tendencies strongly negative

IV.3. SCREENING MATRIX

Influencing factor	Weight	Rating	Score
Business environment	× 2		
Regulatory environment	× 2		
Organizational environment	× 3		
Organizational history	× 1		
Worker characteristics	× 3		
Technology characteristics	× 2		
National culture	× 2		
Sociopolitical environment	× 1		
Total score			

IV.4. EVALUATION

Total score	General evaluation
> 60	Satisfactory
30–60	Likelihood of some incipient weaknesses
< 30	Significant potential for latent weaknesses

Appendix V

INDEX OF CORRECTIVE ACTIONS

The index allows the status of corrective actions to be tracked relative to the status at the base date when the index is 100. The underpinning quantity index and time index are calculated using 'time open' and 'number of corrective actions' at the base reference date as weighting factors.

$$\text{Corrective action index} = 100 \times \sqrt{\text{quantity index} \times \text{time index}}$$

where:

$$\text{Quantity index} = \frac{\sum_i To_i \times Q_i}{\sum_i To_i \times Qo_i}$$

$$\text{Time index} = \frac{\sum_i Qo_i \times T_i}{\sum_i Qo_i \times To_i}$$

$\sum_i$ indicates sum over all corrective action databases;

To_i is the average time for which corrective action in database i has been open at base reference date;

T_i is the average time for which corrective action in database i has been open at time of future measurement;

Qo_i is the number of corrective actions open in database i at base reference date;

Q_i is the number of corrective actions open at time of future measurement.

EXAMPLE ILLUSTRATING USE OF CORRECTIVE ACTION INDEX

The following example is based on an organization comprising two divisions. Each division has its own corrective action database that records each outstanding corrective action and the length of time it has been open. The first month is the base month.

Month	Division A		Division B	
	Number of corrective actions open	Average time open (days)	Number of corrective actions open	Average time open (days)
1 (base)	10	30	20	45
2	10	45	20	60
3	5	45	10	60
4	5	30	10	45
5	15	20	25	25

The detailed calculation of the quantity index, the time index and the overall corrective action index is illustrated for the second month.

$$\text{Quantity index} \; = \; \frac{30 \times 10 + 45 \times 20}{30 \times 10 + 45 \times 20} \; = 1$$

$$\text{Time index} \; = \; \frac{10 \times 45 + 20 \times 60}{10 \times 30 + 20 \times 45} \; = 1.375$$

$$\text{Corrective action index} = 100 \times \sqrt{\text{quantity index} \times \text{time index}}$$

$$= 100 \times \sqrt{1 \times 1.375}$$
$$= 117$$

Repeating the calculations for the other months gives the following results:

Month	Quantity index	Time index	Corrective action index
1	1	1	100
2	1	1.375	117
3	0.5	1.375	83
4	0.5	1	71
5	1.314	0.583	88

REFERENCES

[1]   INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident, Safety Series No. 75-INSAG-1, IAEA, Vienna (1986).

[2]   INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Basic Safety Principles for Nuclear Power Plants, Safety Series No. 75-INSAG-3, IAEA, Vienna (1988).

[3]   INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Safety Culture, Safety Series No. 75-INSAG-4, IAEA, Vienna (1991).

[4]   INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on Nuclear Safety, Legal Series No. 16, IAEA, Vienna (1994).

[5]   INTERNATIONAL ATOMIC ENERGY AGENCY, The Safety of Nuclear Installations, Safety Series No. 110, IAEA, Vienna (1993).

[6]   INTERNATIONAL ATOMIC ENERGY AGENCY, Establishing a National System for Radioactive Waste Management, Safety Series No. 111-S-1, IAEA, Vienna (1995).

[7]   FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

[8]   KOLB, D., Experiential Learning, Prentice-Hall, Englewood Cliffs, NJ (1984).

[9]   WALTERS, M., Building the Responsive Organization: Using Employee Surveys to Manage Change, McGraw-Hill, New York (1994).

BIBLIOGRAPHY

ADVISORY COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS (ACSNI), Organizing for Safety, Human Factors Study Group Third Report, Health and Safety Executive, London (1993).

BRIANT, V.S., GERMANN, R.P., "Cultivating management awareness of human performance issues", Proc. 5th IEEE Conf. on Human Factors and Power Plants, Monterey, 1992, pp. 472–476.

DAHLGREN, K., OLSON, J., "Organizational factors and nuclear power plant safety: A process oriented approach", Proc. Conf. on Probabilistic Structure Analysis Method (PSAM-II), San Diego, 1994, Plenum Press, New York and London (1994).

DEBES, M., "The safety culture policy in EDS nuclear power plants: a key for safety and performance", Proc. Int. Topical Mtg on Safety Culture in Nuclear Installations, Vienna, 1995, Austria Section, Am. Nucl. Soc., Österreichisches Forschungszentrum Seibersdorf GmbH (1995) 839.

GERMANN, R.P., Organizational culture and nuclear safety, Trans. Am. Nucl. Soc. **62** (1990) 482.

HOEGBERG, L., "Safety culture as an element of contact and co-operation between utilities, research institutions and safety authorities", presented at ICSA Seminar on Safety Culture in Nuclear Power Plants, Bern, 1994.

INTERNATIONAL ATOMIC ENERGY AGENCY, Management for Excellence in Nuclear Power Plant Performance, Technical Reports Series No. 369, IAEA, Vienna (1994).

— Experience with Strengthening Safety Culture in Nuclear Power Plants, IAEA-TECDOC-821, Vienna (1995).

— ASCOT Guidelines, IAEA-TECDOC-860, Vienna (1996).

LEE, T., Seeking a safety culture, Atom **429** (1993) 20.

LONG, R.L., "Nuclear safety culture — the way to the future", Panel Discussion, Proc. Int. Topical Mtg on Safety Culture in Nuclear Installations, Vienna, 1995, Austria Section, Am. Nucl. Soc., Österreichisches Forschungszentrum Seibersdorf GmbH (1995).

MERRY, M.W., RYCRAFT, H.S., "Development and formation of a safety culture", ibid., p. 361.

CONTRIBUTORS TO DRAFTING AND REVIEW

Bacs, J.	Paks Nuclear Power Plant, Hungary
Briant, V.S.	General Public Utilities Nuclear Corporation, United States of America
Carnino, A.	International Atomic Energy Agency
Chung, J.-H.	Ministry of Science and Technology, Republic of Korea
Dahlgren, K.	Swedish Nuclear Power Inspectorate, Sweden
Debes, M.	Electricité de France, France
Evans, M.C.	British Nuclear Fuels plc, United Kingdom
Friedmann, P.	Siemens AG, Germany
Gardner, P.H.	Nuclear Installations Inspectorate, United Kingdom
Hall, A.C.	Council for Nuclear Safety, South Africa
Higashi, A.	International Atomic Energy Agency
Hoffman, D.R.	Excel Services Corporation, United States of America
Koutaniemi, P.	Finnish Centre for Radiation and Nuclear Safety (STUK), Finland
Merry, M.W.	British Nuclear Fuels plc, United Kingdom
Meyer, P.J.	Siemens AG, Germany
Noguchi, Y.	Chubu Electric Power Company, Japan
Palacios, E.	Comisión Nacional de Energía Atómica, Argentina
Pu, J.	Daya Bay Nuclear Power Station, China

Rapoport, H.   Nucleoeléctrica Argentina S.A., Argentina

Srinivasan, G.R.   Nuclear Power Corporation, India

Swaton, E.   International Atomic Energy Agency

Vámos, G.   Paks Nuclear Power Plant, Hungary

Williams, J.C.   Nuclear Safety Directorate, United Kingdom

Zhong, W.   International Atomic Energy Agency