

BASIC PROFESSIONAL TRAINING COURSE

Module **XXI**

Management system, leadership and safety culture



IAEA

International Atomic Energy Agency

Background

In 1991, the General Conference (GC) in its resolution RES/552 requested the Director General to prepare 'a comprehensive proposal for education and training in both radiation protection and in nuclear safety' for consideration by the following GC in 1992. In 1992, the proposal was made by the Secretariat and after considering this proposal the General Conference requested the Director General to prepare a report on a possible programme of activities on education and training in radiological protection and nuclear safety in its resolution RES1584.

In response to this request and as a first step, the Secretariat prepared a Standard Syllabus for the Post-graduate Educational Course in Radiation Protection. Subsequently, planning of specialised training courses and workshops in different areas of Standard Syllabus were also made. A similar approach was taken to develop basic professional training in nuclear safety. In January 1997, Programme Performance Assessment System (PPAS) recommended the preparation of a standard syllabus for nuclear safety based on Agency Safety Standard Series Documents and any other internationally accepted practices. A draft Standard Syllabus for Basic Professional Training Course in Nuclear Safety (BPTC) was prepared by a group of consultants in November 1997 and the syllabus was finalised in July 1998 in the second consultants meeting.

The Basic Professional Training Course on Nuclear Safety was offered for the first time at the end of 1999, in English, in Saclay, France, in cooperation with Institut National des Sciences et Techniques Nucleaires/Commissariat a l'Energie Atomique (INSTN/CEA). In 2000, the course was offered in Spanish, in Brazil to Latin American countries and, in English, as a national training course in Romania, with six and four weeks duration, respectively. In 2001, the course was offered at Argonne National Laboratory in the USA for participants from Asian countries. In 2001 and 2002, the course was offered in Saclay, France for participants from Europe. Since then the BPTC has been used all over the world and part of it has been translated into various languages. In particular, it is held on a regular basis in Korea for the Asian region and in Argentina for the Latin American region.

In 2015 the Basic Professional Training Course was updated to the current IAEA nuclear safety standards. The update includes a BPTC text book, BPTC e-book and 2 "train the trainers" packages, one package for a three month course and one package is for a one month course. The "train the trainers" packages include transparencies, questions and case studies to complement the BPTC.

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Editorial Note

The update and the review of the BPTC was completed with the collaboration of the ICJT Nuclear Training Centre, Jožef Stefan Institute, Slovenia and IAEA technical experts.

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1 INTEGRATED MANAGEMENT SYSTEM

Learning objectives:

After completing this chapter, the trainee will be able to:

1. *Describe the concept of an integrated management system.*
2. *Describe what an organization needs to consider when an implementing integrated management system.*
3. *Describe the major differences between the IAEA Safety Standard GS-R-3 and ISO 9001:2000.*
4. *Describe the major differences between the IAEA Safety Standard GS-R-3 and ASME NQA-1-2008.*

The fundamental safety objective is to protect people and the environment against harmful effects of ionizing radiation. To ensure this objective is achieved, we need leadership for safety to shape a strong safety culture based on an integrated management system.

Safety culture shapes the environment in which people work and thus influences their behaviour and attitudes to safety. An organization with a strong safety culture will be recognizable by having an effective safety management system in place. An organization with a strong safety culture will also achieve a good safety performance. The management of safety needs to take into account the particular legislative requirements in the respective country, as well as the culture of the organization. By the culture of the organization is understood to be the matrix of shared values, attitudes and patterns of behaviour within the organization, or in simple terms »the way we do things round here«.

It is important to point out at the very beginning that the term »safety management system« does not imply that safety is managed separately from other business activities.

Safety and production depend upon the same management principles and therefore go hand in hand with each other. We will always find that organizations with a strong safety culture also achieve high availability. Safety is an integral component of the way the whole organization is managed and must have the involvement and active participation of all staff.

We must not forget the fundamental principle that safety is the responsibility of the operating organization (licence). To discharge this responsibility, the operating organization needs to establish an effective safety management system. However, it needs to be developed in such a way as to comply with the national legislation and requirements of the relevant regulatory body. Its overall objective remains to be the protection of individuals, the public and the

environment.

Safety is the responsibility of the operating organization.

1.1 IAEA Safety Standards for Integrated Management Systems

The Fundamental Safety Principles document SF – 1 [1] provides the basis for all IAEA Safety Requirements. Under the current arrangements, there are 13 different IAEA Safety Requirements divided into general and specific areas. One of those is the Safety Requirement for “Management Systems for Facilities and Activities” GS-R-3 [2]. The requirements are expressed by with the wording “shall” which means that the standards must be met by the IAEA Member States. GS-R-3 is broken down into two guides, “Application of the Management System for Facilities and Activities” GS-G-3.1 [3] and “The Management System for Nuclear Facilities” GS-G-3.5 [4]. While the requirements state WHAT has to be met, the guides pronounce recommendations on HOW to achieve the requirements set in GS-R-3 and are expressed as “should” statements in these documents.

For an overview of the structure of the IAEA standards for integrated management systems see Figure 1.1 below.

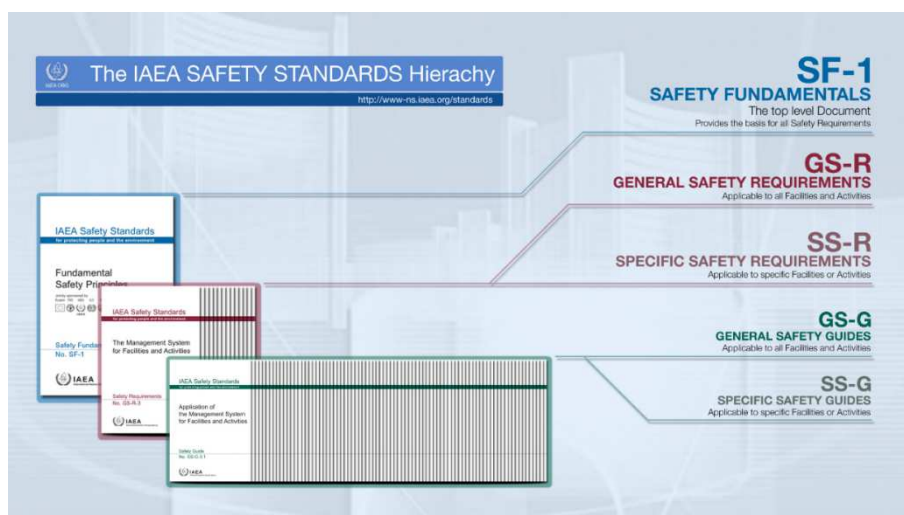


Figure 1.1: IAEA Safety Standards for Integrated Management Systems.

Integrated management systems have evolved from a series of measures applied to improve the quality of work over the centuries. When the first specialised craftsmen started manufacturing tools and equipment, the only principle of quality was simple: *caveat emptor* (let the buyer beware). Throughout history more and more stringent

measures have been introduced to ensure that the quality of work was adequate, from individual control of own work as part of a craftsman's code of honour, via foremen controlling a group's work during the industrial revolution, to full time inspectors being employed during World War I. The systematic approach to quality commenced in industrial manufacturing during the 1930s, continued throughout World War II and the post-war period, in particular in connection with the rebuilding of the Japanese and German economies and is still being improved upon today. As part of this evolution, different concepts have been introduced such as quality control (QC), quality assurance (QA), quality management (QM) and integrated management systems. The first quality system approaches were based on statistical principles. The 1950's the concept of quality was expanded to acknowledge the importance of management. This was for example stated in the fourteen principles introduced by Deming.

The difference between QC and QA is primarily the approach to when the quality of the product shall be assessed. QC focuses on testing of products to ensure defects are identified and rectified. QA focuses on preventing defective products through a process of improvement and stabilisation of the production and associated processes. QA, however, does not eliminate the need for QC, as frequent testing is necessary to ensure that the product is of an appropriate quality. QC is therefore seen as an integral part of the QA process.

The difference between QC and QA:

- QC focuses on testing of products,
- QA focuses on preventing defective products.

QM introduces another aspect to the quality circle, that of managing quality. QM emphasise not only product control but also how this is achieved. Thus, QA and QC are integral parts of QM. With the increased focus on QM, the ISO 9000 series were introduced to support and structure the process required to ensure high-class quality management. ISO 9001 is the basic quality management system standard. The first version of the standard was published in 1987 and several revisions have been made since its introduction. The standard specifies requirements for a quality management system that can be used for internal application by organizations, or for certification, or for contractual purposes. It focuses on the effectiveness of the quality management system in meeting customer requirements. The standard does not address requirements specific to other parts of the management system such as for example safety management. The ISO 9001 standard is based on a process approach, meaning that the various activities linked within the organisation as well as the interaction between those activities, must be known and understood by the organisation and constitute the basis of the management system.

As part of the quality evolution, the need to document the quality process has existed. This has been done in management systems that

describe, e.g. the workflow, work processes and other organisational factors involved. However, these have often been developed as a single system without their connections and dependency on other systems within the organisation. Integrated management systems attempt to integrate all the systems in an organisation into one so that all work processes and organisational factors can be seen as a whole. Thus it integrates safety, health, environmental, security, quality and economic elements [2].

1.2 History and evolution of IAEA safety standards for management systems

Quality Assurance was identified as one of the five areas of the Nuclear Safety Standard (NUSS) programme for the development of Safety Standards in the 1970s. The other four areas were Governmental organization for regulation of NPPs, Siting, Design and Operation, thus recognizing the relevance of quality assurance standards in the four areas of nuclear, radiation, waste and transport safety.

The primary IAEA document on the subject was the Code of Practice on Quality Assurance with 14 Safety Guides.

In past years many misconceptions about the usefulness and importance of the quality assurance programme have developed, as illustrated by N. Redman in Fig.1.2 below.

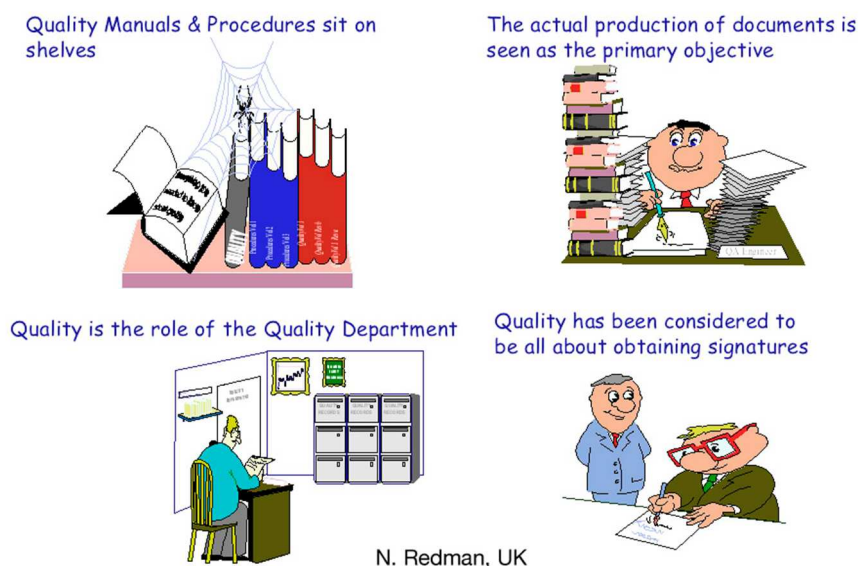


Figure 1.2: Some misconceptions about QA.

The above mentioned Code and Guides in the subject area of Quality Assurance were recently revised into a new Safety Series “Management System Facilities and Activities”, published in 2006.

The term “Management System” has been adopted in the revised series of documents instead of the term Quality Assurance/Quality Assurance Programme. This development integrates all aspects of managing a nuclear facility, including the Safety, Health, Environmental and Quality Assurance requirements into one coherent system.

1.3 Integrated Management Systems

The management developments needed to achieve the different objectives pursued by any organization have to adjust to changes over time. The aim of any organization is to deliver products and/or services that comply with all applicable requirements and satisfy all stakeholders. There are requirements, for example, regarding safety in the nuclear field that are paramount, and cannot be compromised. The achievement of all requirements and satisfaction of all the stakeholders is necessary for the survival and success of an organization.

Organizational models, concepts and tools have developed to include human factors and cultural issues and more integrated management approaches that complement the old traditional classical approach to achieving results that were based on inspection and verification checks. Products must be made and activities must be carried out in a safe manner, though on the other hand it must be recognized that all organizations only remain in business if they make a profit.

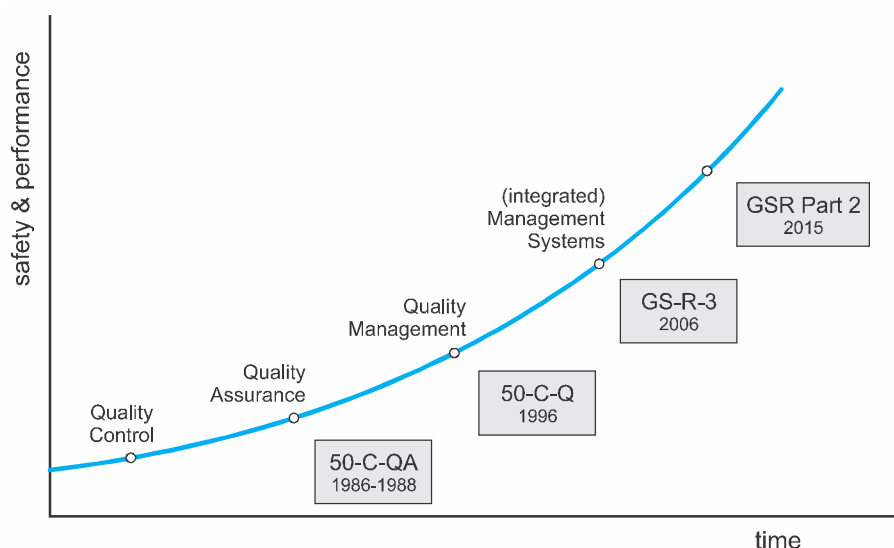


Figure 1.3: Evolution of approaches to improve safety and performance. Publication of GSR Part 2 is expected in 2015.

Technological innovations have radically altered the relationship between systems and humans and therefore the way of managing the

whole organization. Issues related to complex activities and multiple objectives involve people operating at different levels in the organization. The operating processes are modified by the introduction of new management practices and new requirements. The daily practices and the results achieved by the organization, the organizational culture and the management processes are deeply interrelated. The way of managing the organization has had to evolve accordingly to accommodate these changes and to ensure that the employees understand what has to be done to meet all requirements.

The model illustrated above in Fig. 1.3 represents evolution over the last century regarding the approaches applied by organizations in order to achieve good safety standards and performance. The reality is undoubtedly more detailed and complex. Many initiatives have often been introduced in parallel and new initiatives have co-existed with former initiatives. The important message that the model delivers is that the activity of managing an organization and surviving has been evolving to continually strive for higher levels of performance and safety and that this trend is ongoing. Some of the key management approaches of the model are marked on Fig. 1.3.

Quality Control separated conforming products from non-conforming ones at the end of the process. It mostly consisted of some type of inspection/measurement for acceptance or non-acceptance.

Quality Assurance took measures to systematically prevent non-conformance by using established procedures and documentation to demonstrate that quality was implemented throughout the production process. The Quality Assurance approach has also evolved from a compliance approach to one with a more performance-based focus.

Quality Management introduced consideration of everyone involved within the process and the concept of internal customer and supplier. This was a relevant development bringing attention to the organization being essentially about people and recognition of the organizational culture issue. Business excellence models appeared.

Management System integration was the development where the organization became increasingly aware that other stakeholders, apart from just customers and employees, had to be addressed while conducting business. Organizations put increasing attention on issues such as safety, health, quality, environment, finance, security, human resources, cultural aspects, etc., and aimed to manage holistically by using an integrated Management System aimed at meeting the sum of their objectives. Integrating the Management Systems leads to a coherent, harmonious and optimal way of delivering the vision of top management and the goals and objectives of the organization and of ensuring that safety is not compromised, which is the main goal of integration.

The model also suggests that an integrated Management System is not the final stage or solution in this evolutionary progress. The continuing path and need for higher levels of performance and safety will further develop. It is therefore important to remain flexible in order to be able to dynamically adjust the increasingly changing and challenging demands.

1.4 Current Status of Safety Standards on the Integrated Management System

The set of Safety Standards establish requirements and provide guidance for implementing Management Systems that integrate safety, health, security, environmental and quality objectives (Figure 1.4). These documents are GS-R-3, GS-G-3.1 and GS-G-3.5 which replaced the IAEA 50-C-Q Code on Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations, as well as the related 14 Safety Guides contained in the Safety Series No.50-C/SG-Q. The IAEA Code 50-C-Q and developments within the International Organization for Standardization (ISO) in the ISO 9001:2000 and ISO14001:1996 publications were considered in developing this comprehensive, integrated set of Management System requirements. Member States experience in developing, implementing and improving Management Systems was also taken into account.



Figure 1.4: Management Systems integrate safety, health, security, environmental and quality objectives.

The aim of the set of Safety Standards is to provide requirements and guidance for implementing an effective Management System that:

- Integrates all aspect of managing nuclear installations and activities including the safety, health, quality and environmental requirements in a coherent manner,
- Describes the planned and systematic actions necessary to provide adequate confidence that all these requirements can be satisfied, and supports the enhancement and improvement of safety culture.

This integration aims to ensure that economic, environmental, health, security and quality matters are not considered separately to safety matters, to avoid any potential negative impact on safety. The three main documents in the IAEA Safety Standards that relate to management systems are:

- Safety Requirements GS-R-3 which specifies the Management System requirements for all nuclear installations and activities, incorporating the Code 50-C-Q and other relevant international standards.
- Safety Guide GS-G-3.1 which provides thematic guidance for each of the requirements contained in GS-R-3 and is applicable to all nuclear facilities and activities. GS-G-3.1 includes all of the relevant guidance material that was contained in Safety Guides 50-SG-Q1 to Q7, as well as new material.
- Safety Guide GS-G-3.5 which provides specific guidance for Management Systems for nuclear facilities. It includes all of the relevant guidance material that was contained in Safety Guides 50-SG-Q8- Q14, as well as new material (Fig.1.5).

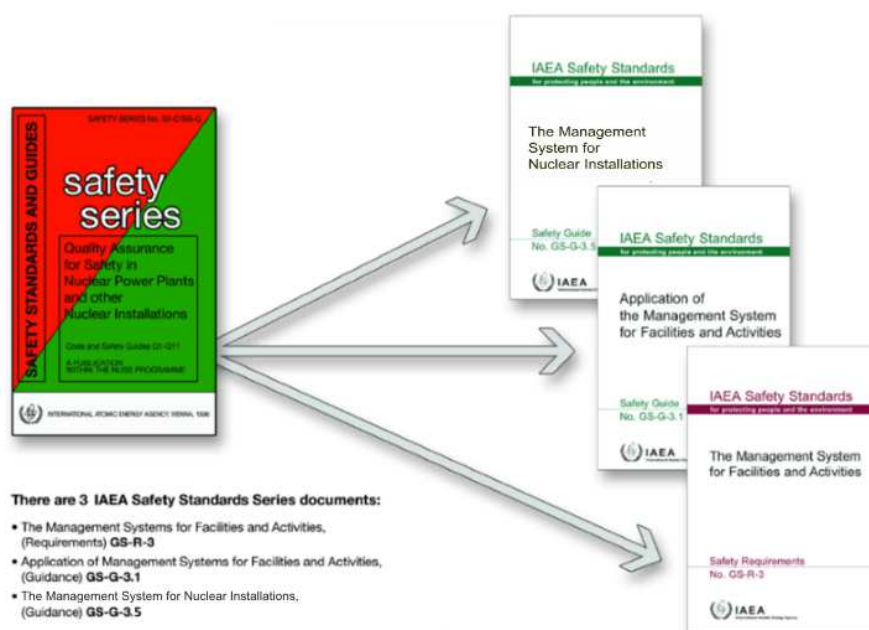


Figure 1.5: Link between the Quality Assurance and the Safety Management documents.

1.5 What an integrated management system consist of

An integrated management system is a management system that integrates all of an organisation's systems and processes in to one complete framework, enabling the organisation to work as a single unit with unified objectives.

With an integrated system in place, the organisation becomes a unified

whole, each function aligned behind a single goal: improving the performance of the entire organisation. An integrated system provides a clear, holistic picture of all aspects of the organisation, how they affect each other, and their associated risks. There is less duplication, and it becomes easier to adopt new systems in the future.

An integrated management system allows the management team to create a single structure that can help to effectively and efficiently deliver the organisation's objectives, from managing employees' needs and encouraging best practice, to minimizing risks and maximizing resources.

An integrated management system enhances safety by:

- Bringing together in a coherent manner all the requirements for managing the organisation.
- Describing the planned and systematic actions necessary to provide adequate confidence that all these requirements are satisfied.
- Ensuring that health, environmental, security, quality and economic requirements are not considered separately from safety requirements, to help preclude their possible negative impact on safety.

The IAEA Safety Requirements [2] specify that safety shall be paramount within the management system, overriding all other demands and that the management system shall be understandable to those who use it, and that it include the following:

- The policy statements of the organisation.
- A description of the management system.
- A description of the structure of the organisation.
- A description of functional responsibilities, accountabilities, levels of authority and interactions of those managing, performing and assessing work.
- A description of the processes and supporting information that explain how work is to be prepared, reviewed, carried out, recorded, assessed and improved.

Other aspects that may be included are commitment, leadership, as well as risk evaluation and risk management.

All these factors are fundamental to managing the inherent risks in an organisation and ensuring that safety is the first priority. The knowledge that the structure of the organisation, the work processes and the roles, responsibility and accountability are clearly defined are preconditions for establishing a strong safety culture where management and workers can develop an understanding of what behaviour is required and then behave accordingly.

1.6 Integrated Management Systems

Basic principles

A robust and effective management system should support the enhancement and improvement of safety culture and the achievement of high levels of safety performance and give the fundamental safety objective an overriding priority. The management system should therefore be designed with these purposes in mind and should be implemented in such a way that it is known, understood and followed by all individuals. [2]

One aspect of importance is that the management system shall be binding for all individuals. Different levels of compliance in the organisation, e.g. headquarters vs. production unit, or operations vs. maintenance, can have severe negative consequences since it can be interpreted as a status marker, such as “we don’t need to follow the management system” or “we know better” attitudes can develop. It is therefore a good idea to develop a uniform approach in handling deviations and when and how sanctions should be applied.

The management system shall be binding for all individuals.

The management system should specify all work delegated to external organisations, as well as the lines of communication and the interfaces between internal and external organisations [2]. This is essential to maintain an overview of the information exchange that happens in an organisation and to prevent informal communication taking over and decisions being made outside the agreed framework.

The management system should assign responsibility for achieving the organisation’s objectives and should empower individuals in the organisation to perform their assigned tasks. Managers should be responsible for achieving safety and quality in the final outputs of work under their responsibility within the organisation. Individuals should take responsibility for quality and safety while carrying out the work that is assigned to them. In order to discharge this responsibility, individuals should be technically competent in using the appropriate hardware, equipment, tools and measuring devices and should have a clear understanding of the work processes [2].

The management system should ensure that a review of the controls that affect work, such as the training of individuals and the work package that accompanies it, is conducted prior to restarting work after interruptions [2]. It is often in such situations that safety can be compromised, as the desire to restart production and get back online becomes the main focus of the personnel involved.

It is important that an organisation has a common language so that personnel communicate effectively and understand what is meant by

the terms used. Misunderstandings can impact on both safety and performance, as well as generate divisions in an organisation. In GS-R-3 the following is stated, “The management system should provide a common vocabulary consistent with the work being performed. All key terms used in the management system should be defined and should become an integral part of the training programme to ensure that communications and understanding are consistent throughout the organisation”.

Common language and common understanding in an organisation are very important.

The ever-present trade-off between safety and production must be managed in such a way that the responsibility and authority to stop unsatisfactory work should be assigned in such a manner that planning, scheduling and other considerations do not override safety requirements. Everybody has the right and obligation to stop work if it is considered unsafe and not be punished for doing so. A common approach in nuclear organisation is the usage of the STAR-principle: Stop Think Act Review/Report. The management system should provide a framework for a working environment in which staff can raise safety issues without fear of harassment, intimidation, retaliation or discrimination.

The actions of all managers have a strong influence on the safety culture within the organisation.

As mentioned earlier, the actions of all managers (senior management, managers and supervisors or team leaders) have a strong influence on the safety culture within the organisation. The managers need to be role models and promote good working practices. When managers identify poor work practices it is essential that they intervene. The management systems play a key role in this aspect. The expected behaviour of both managers and co-workers needs to be defined and communicated. If this is not formalised the risk is that managers avoid intervening and a culture of acceptance of non-safe behaviour is created. A good practice is to reinforce managers' involvement in the day-to-day work of co-workers by carrying out management tours. There are other good tools developed by WANO and INPO, such as task observation, coaching etc. However, it is important that managers and team leaders have suitable tools to conduct the required observations and tours. The organisation should provide training in leadership for safety and formalise the routines required to establish and maintain a presence in the workplace. The effect should also be systematically evaluated. Many organisations have attempted to introduce such measures but without support for the managers and team leaders, the impact has been limited or detrimental because personnel perceived the initiative as one for surveillance of their work practices rather than a behavioural safety intervention.

Managers and supervisors should encourage and welcome the reporting by other individuals of potential safety concerns, incidents and near-misses, and accident precursors, and should respond to valid concerns promptly and in a positive manner [2]. Learning from experience is one of the most valuable tools and all reporting should be taken seriously. Many hazards are well known in organisations and when accidents happen, it often doesn't come as a great surprise as many warning signs have been seen in advance. Unfortunately personnel grow accustomed to such warning signs and learn to ignore them after a while.

Contractors should give the same high priority to safety, especially when they are working inside a facility. It is important for the organisation to clearly define their safety expectations to contractors and to follow-up safety behaviour to ensure that different safety standards are not accepted within the facility.

When defining the framework of expected behaviour, it is recommended to involve the workforce. If this is done part of the implementation will be embedded in the process. Part of the framework needs to consist of the consequences of violation of the requirements. Such strategies should involve the balanced use of appropriate incentives and sanctions. To be effective, these strategies should be well understood and should be applied consistently and fairly throughout the organisation. For a strategy to work it has to be perceived as just and fair.

The organisation should develop a management system that is appropriate to the stage in the lifetime and the maturity of the nuclear facility or activity [8]. The management system evolves continually and should be adapted to the organisation's current needs, not those of the past or the future. The importance of the management system and its application to the working culture should be communicated and understood by all individuals. However, irrespectively of how good the management system is, it is only as good as its application.

Finally some examples of the expected benefits of an integrated management system:

- Increased focus on safety,
- Integration of the strategies and policies of the organization,
- Implementation of continual improvement in all areas,
- Creates synergy, consistency and decreases bureaucracy, more user-friendly and simpler management system,
- Faster reaction to change and challenges,
- Easier compliance, less violations, greater staff participation and responsibility,
- Removal of barriers between organizational units.

Grading the application of the management system

The application of management system requirements is normally graded in such a way as to deploy appropriate resources, on the basis of consideration of:

- The significance and complexity of each product or activity;
- The hazards and the magnitude of the potential impact (risk) associated with the safety, health, environmental, security, quality and economic elements of each product or activity;
- The possible consequences if a product fails or an activity is carried out incorrectly.

Grading the application of the management system requirements should enable valuable resources and attention to be targeted on the products or activities of greater significance. This can result in minimizing total costs while improving safety [3].

Examples of areas for grading:

- Type and content of training;
- Level of detail and degree of review and approval of instructions;
- Need for and level of detail of inspection plans;
- Degree of in-process reviews and controls;
- Requirements for traceability of material;
- Type and level of detail in procurement documents;
- Type of assessment;
- Records to be generated and retained.

One example of grading that has a direct relation to safety is to grade the work procedures and instructions. Good practice is to divide them into three levels:

1. Procedures work whose performance is critical to safety requiring to be signed off step-by-step,
2. Procedures that explain how the work should be performed and contains a checklist,
3. Generic procedures that give guidance how to perform the work task.

Grading helps the organisation to balance the focus so that the safety-critical aspect will receive the attention which is needed. It also helps to avoid using the same process category for all types of work performance and overloading the organisation.

Documentation of the management system

The management system formalises the activities in the organisation by setting them down in a set of documents. It is important that their vocabulary that is coherent, makes sense, and is clear, unambiguous and readily understandable. Each document should be written in a manner appropriate to the level of expertise of its users, and in a manner that reflects the correct way of working (i.e. 'user-friendly'). The involvement of the end-user is recommended [2].

The organisation should aim to have a management system that reflects actual external and internal requirements. This means that the management system should be flexible enough to accommodate changes in policy involving strategic aims, safety, health, environmental, security, quality and economic considerations. It is also important to have a process in place for continuous improvements and updates of the management system.

Management responsibility

Keeping an up-to-date and well-functioning management system requires both attention and resources. Understanding the importance of the management system and its role as the structural spine of the organisation is imperative amongst management since inadequate management systems often are major contributors to accidents and incidents. To avoid such events, the management shall demonstrate its commitment to the establishment, implementation, assessment and continual improvement of the management system as, well as providing adequate resources to carry out these activities.

The five major recurrent issues in accidents and incidents are leadership, communication, operational attitudes and behaviour, risk management and oversight.

Senior management has a significant role in making the management system work and must develop both individual and institutional values and behavioural expectations for the organisation on how to support the implementation and maintenance of the management system. Senior management are expected to lead the way and illustrate through their words and actions the importance of the management system. They must also ensure that it is clear when, how and by whom decisions are made within the management system.

Managers at all levels have an obligation to communicate the importance of implementing the management system in all work situations and to follow-up compliance to ensure that it doesn't become a dead letter. It is important to make sure that the management system becomes a tool, appreciated and utilised by the workforce and not irrelevant documentation of hypothetical work practices that do not reflect reality.

Allowing unsuitably qualified personnel to work on safety-related jobs can have severe consequences both in terms of accident risks and with respect to sending a wrong signal from management about what is being prioritised, safety or production. Management should ensure that the workforce have been provided with adequate training, resources and direction so that work can be performed safely and effectively. This training should be given before the work is started and only personnel who have the qualifications to complete the work shall be permitted to do so. This is critical for safe work performance.

Well qualified workers must work on safety-critical jobs.

Managers are responsible for matching the competence needed for the work task with the person's actual competence. Formalised processes for competence assurance should be part of the management system.

Policies for the safety, health, environment, security, quality, and economic aspects need to be developed, implemented and evaluated. Senior management are responsible for these policies and their implementation.

Ownership of work should be encouraged and managers should examine samples of work practices and related information on a regular basis to identify areas needing improvement. They should also encourage each individual under their supervision to look for more efficient and effective ways of accomplishing assigned tasks.

Resource management

Senior management has a significant role in making sure that adequate resources are available to meet the organisations goals and to operate in a safe manner. The managers are responsible for resource allocation. To allocate resources in a rational manner, the following is needed:

- an overview of the organisation's activities and costs,
- forecasts,
- planning,
- control over the actual status,
- follow-up processes,
- an overview of safety performance.

Financial resources are not the only resources to be managed. Human resource management ensures that personnel have the right competence and are under continuous educational development. Judgement about whether work is organised in the most efficient way is also part of resource management. Adaptation to new research and technologies may also be needed, but with a conservative approach.

It is good practice when improving the organisation's effectiveness and efficiency to involve the personnel who are performing the activities. They are often the experts on how the work can be improved.

Process implementation

The *processes of the management system* that are needed to achieve the goals, provide the means to meet all requirements and deliver the products of the organization need to be identified, and their development needs to be planned, implemented, assessed and continuously improved [2].

What is a *process*, and what are *inputs* and *outputs*?

A process is an integrated set of activities that uses resources to transform inputs into outputs.

A system exists whenever several processes are interconnected using such input-output relationships.

Processes are interconnected because the output from one process becomes the input for another process. In effect, processes are connected by means of such input-output relationships.

A central feature of an integrated management system is that it describes the processes required for the organisation to achieve its goals and meet the requirements identified.

These processes are essential for understanding how the organisation is managed and how work is to be conducted. However, in many organisations awareness of what the processes contain is limited, since these have evolved over time and are rarely documented adequately. It is not infrequent in organisational fusions or divisions that internal dependencies and work processes are only identified when it is too late, thus requiring several adjustments to become online and working efficiently again.

Before developing processes, it needs to be emphasised that the aim of process implementation is firstly to reinforce safety and secondly to improve efficiency. The processes must be developed so that they reflect the interfaces between different individuals or groups and ensure effective communication and the clear assignment of responsibilities. Each process must ensure that the following are achieved:

- Process requirements, such as applicable regulatory, statutory, legal, safety, health, environmental, security, quality and economic requirements are specified and addressed,
- Hazards and risks are identified, together with mitigating actions,
- Interaction with interfacing processes are identified,
- Process inputs, flow and outputs are identified,
- Process measurement criteria are established.

One critical aspect of process descriptions is to ensure the process reflects reality and not an ideal world.

A frequently seen mistake is that process descriptions become too advanced and incorporate too many different elements and thereby become too complicated for actual use. Involvement of operators in

the process description is the easiest way to prevent complicating matters to an unnecessary extent.

Some examples

Safety culture and the management system are the tools available within an organisation to be able to create and implement processes which support safety as the most important goal in nuclear facilities.

Different work teams may have different goals and work processes to reach those goals and therefore the safety concept can have a slightly different meaning in different parts of the organisation – and thus different cultures emerge. This means that within an organisation several cultures might exist simultaneously.

Such differences clearly exist between a strictly rule-governed facility as compared to a part of the organisation which works on development and innovation. These processes can co-exist within the same organisation. In the nuclear area this could be the case in nuclear waste management organisations which may conduct daily operations in a strictly rule-based framework and simultaneously perform advanced research and analyses concerning the principles and methods of long term nuclear waste storage in a framework based on research and innovation.

A good safety culture is based on the co-existence of rule-based processes and research and innovation processes.

In these cases good safety culture is based on the co-existence of rule-based processes and research and innovation processes. This must be based on features in the management system defining and giving guidance on how to adhere to the strictly rule-based processes in one part of the organisation and to the research and development process within the other part of the organisation. In this case the risk management system must clearly define and govern all these processes. Also, practices must be implemented to ensure the employees know and understand of their own culture and also to make them understand the reason for the difference between cultures. This is done to create a safety awareness within the company as well as an understanding of why there are and must be differences. In such cases it is very important that the management recognizes the cultural differences, and designs and implements risk management activities to support the different processes. If these issues are not addressed there is a risk of severe negative consequences when the practice of the innovative processes influences the rule-based processes in such a way that each employee can choose what rules and procedures to follow, as well as being able to make his own individual interpretations of rules and procedures.

For the senior management leadership and lower level management strict enforcement of measures to uphold the different kinds of risk

management processes is very important for the processes to co-exist successfully.

Process management

Managing the processes of the organisation effectively is critical to its success. Certain preconditions must be met for this purpose. The following should be determined as a minimum:

- Core processes the output of which is critical to the success of the facility or activity;
- Supporting processes which provide the infrastructure necessary for the core processes (e.g. procurement training);
- Management processes which ensure the operation of the entire management system [3].

The organisational process must be identified on the basis of a review of working practices that includes:

- What work is done, who carries it out and how it is performed;
- What resources are needed to carry out the work;
- The constraints and requirements that affect the work.

A logical hierarchy must be used to describe the processes involved. Interdependencies must be described to ensure that the organisational processes are as comprehensive as possible.

Generic management system processes

There are several management system processes that must be developed to make sure the system functions to enhance safety and performance. A brief introduction to each follows [2].

Control of documents is a prerequisite for a management system to function. All individuals involved in preparing, revising, reviewing or approving documents must be competent to carry out the assessments and have access to appropriate information on which they can base their decisions. It is a good idea to use a mixture of personnel to ensure that managerial, administrative and technical aspects are taken into account. Changes to documents must be reviewed and recorded systematically for traceability and shall be subject to approval.

Control of products must be carried out systematically through a process of testing, verification and validation before the acceptance, implementation or operational use of the products. Specifications and requirements for products shall be in accordance with established standards. The organisation shall confirm that products meet the required standard and ensure they perform satisfactorily in service.

Control of records in the process documentation is a must. All records shall be readable, complete, identifiable and easily retrievable. The media used to control the records is important as changes to databases or archives happen when necessary or as a result of the availability of new technology. The risk is that organisations end up with several

databases as transfer of documents is too complicated or new names must be assigned to every file, which makes their actual application difficult and cumbersome.

Purchasing requirements must be developed and specified in procurement documents. These specifications can include everything from technical requirements, via security clearances to safety culture training. Suppliers of products should be audited on a regular basis to see if their management system is adequate and implemented.

Communication is also essential for a successful organisation. Information relevant to safety, health, environmental, security, quality and economic goals shall be communicated to all personnel in the organisation for the purpose of keeping employees informed.

Communication with regard to the management system must be kept at the level that is relevant for the personnel involved. A mistake many organisations make is to expect close knowledge of the management system in the whole work force, which is both unrealistic and can also be destructive. It is more important to know and understand exactly what is relevant for the individual than the grander scheme of things.

Organisational change shall be evaluated and classified according to their importance to safety. Each change shall be justified. This can be done using a risk analysis that emphasises the consequences for the personnel involved, not for the structure of the organisation. It is critical to ask the important question: “What is in it for me”, as this often is the dominating concern amongst the work force.

Many organisations are reorganised as part of changes in the economic climate where downsizing is a frequent result. Changes shall therefore be planned, controlled, monitored, tracked, recorded and most importantly communicated to ensure that safety is not compromised. Changes made without explanations and the opportunity for managers and personnel to make sense of the alterations will often be met by mistrust and uncertainty and have a negative impact on the safety culture.

Measurement, assessment and improvements

An integrated management system does not improve if left to its own devices. Thus, measurement and assessment should be part of the organisational learning process in order to identify areas needing improvement. This is not just the role of managers but all personnel should be involved in the process, irrespective of the complexity of the tasks they have to perform.

Complacency is one of the highest risks and an organisation can never rest on its laurels. The senior management has to remain vigilant and be self-critical even in moments of success. This is easier said than

done, as human nature prefers to enjoy successes rather than focus on failures.

Since human nature prefers to focus on positive experiences, it is necessary to assess the state of the organisation systematically to avoid complacency and reduce tendencies towards denial. In addition to the early detection of deterioration, an assessment of weaknesses in the management system could also be used to identify potential enhancements of safety and performance and to learn from both internal and external experience.

The relationship between the activities of measurement, assessment and improvement are shown graphically in Figure 1.6. Independent assessments include internal audits, external audits, surveys and reviews, checks, inspections and tests. Self-assessment should be conducted at all levels in the organisation to assess performance and safety culture. Senior management should carry out management system reviews in order to determine their suitability, adequacy, effectiveness and efficiency in achieving objectives and improving performance.

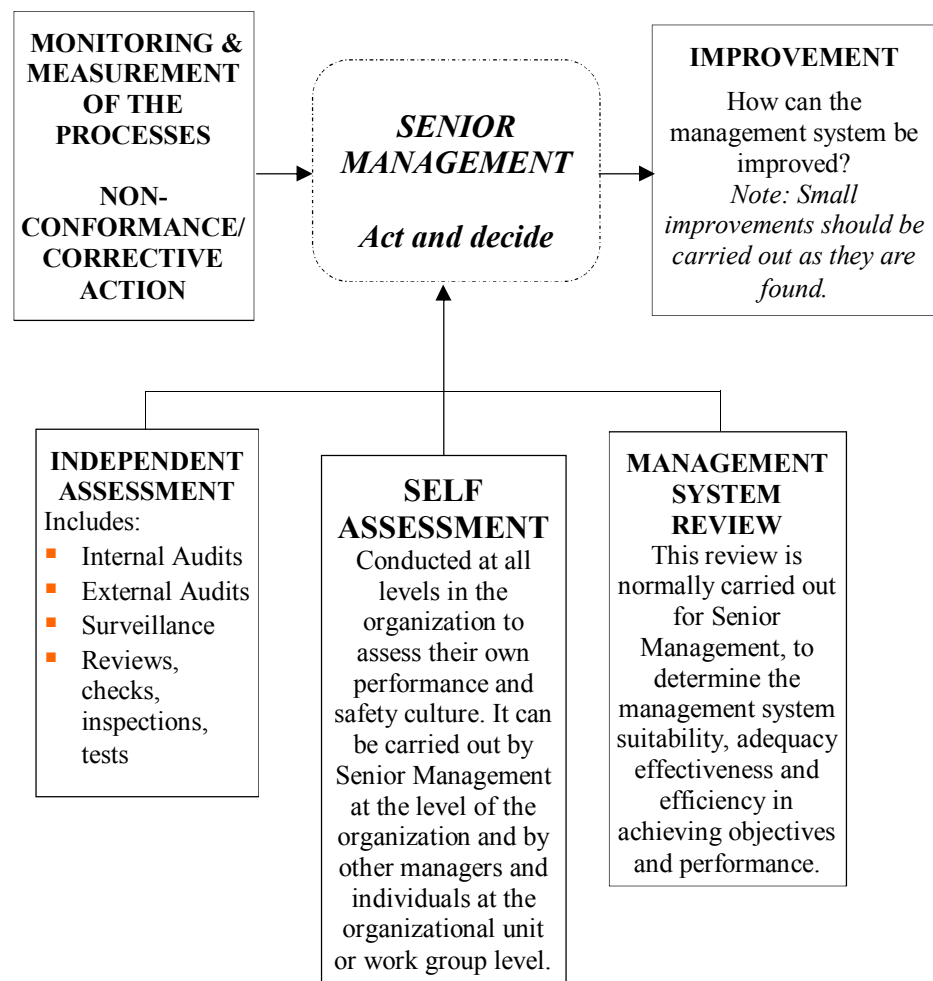


Figure 1.6: Illustration of the different types of assessments and how

they are all related to senior management.

Monitoring and measurement

The management system should ensure that standards of performance are established. These should be directly related to the product produced by the organisation and based on the objectives set by senior management. The level should be adapted to the organisation's needs and be logical and applicable. Grand visions and associated objectives can have a detrimental effect as the standards of performance become too distant from reality and personnel can as a consequence lose their belief in the system and its usefulness.

Once the standards have been established, performance should be measured against them at regular intervals to ascertain whether or not improvements in the quality of the product or process are necessary. Key performance indicators should be used and other appropriate methods of measurements, e.g. audits and surveys, should be developed.

Independent assessment includes internal audits, external audits, surveillance and reviews, checks, inspections and tests. Self-assessment should be conducted at all levels in the organization to assess performance and safety culture. At the organizational level it can be carried out by senior management. At the unit or work group level other managers or individuals can carry it out. The management system review is carried out for senior management to determine the suitability, adequacy, effectiveness and efficiency of the management system in achieving objectives and improving performance.

Self-assessment of the management system

Self-assessment focuses on how to identify, correct and prevent management problems and should go beyond such matters as conformance to regulations, product standards or established procedures. Issues that can be evaluated include:

- The validity of the plans and goals of the organisation,
- Comparison of present performance with management expectations,
- Individual and organisational expectations,
- Opportunities for enhancing safety,
- Safety trends,
- Effective use of human resources,
- Motivation, trust, communication and shared values,
- Safety culture.

The results from self-assessments (and independent assessments) shall be turned into corrective actions.

Together with independent assessments, self-assessments should be used to make overall assessments of the organisation's performance

and to identify improvement potentials.

To help self-assessment, a questioning attitude should be encouraged and means of reporting established to allow individuals to communicate their observations of potential risks or other types of deviations. Punishment or intimidation must be avoided as these often lead to defensive attitudes where the party involved stops reporting, whereby the organisation loses the opportunity for improvement.

The quality of the self-assessments depends on the degree of openness in the organisation. Self-assessments will be more honest and will identify more issues of concern the more open the organisation is.

Various methods of self-assessment can be applied. Some examples follow:

- Workspace inspections or observations and routine communication with individuals, including informal interviews, to determine whether expectations are understood;
- Observation programmes in which weaknesses in performance are documented for further action;
- Review, analysis and trending of important safety and performance data;
- Reviews of new corrective action reports;
- Benchmarking across the organisation;
- Periodic reviews of performance by senior management.

Self-assessments use historical information available in the organisation such as completed and uncompleted corrective actions, performance trends, lessons learned, and other operating experience. Current performance indicators should be assessed during the self-assessment. A final input to self-assessments can be reports from previous self-assessments and inspections. These are useful as indicators for where attention should be directed.

Self-assessments should be conducted on a regular basis but also when trends or other situational characteristics indicate a need. The methods applied should vary to help create as comprehensive a picture as possible.

Independent assessments of the management systems

The difference between self-assessments and independent assessments is that independent assessments involve an independent party, who looks at the management system from the outside.

Independent assessments, being external peer reviews or internal audits, reduce the risk of “home blindness”.

Independent assessments can include reviewing, checking, inspecting, testing, internal audits, audits performed by external organisations or internal, dedicated units which perform internal

audits and observations. Independent assessments should focus on new or emerging management concerns and performance problems and emphasise safety issues. Using a combination of assessment methods is recommended as to get as objective picture of the situation as possible. The results must be verified against standards and/or requirements when possible.

Apart from external peer reviews such as IAEA OSART or WANO Peer Reviews, two of the most effective methods for independent assessments within organizations are internal audits and observations. These will be presented in further detail here.

Internal audits must be conducted systematically on a regular basis. The goal is not solely to determine if the organisation complies with requirements but to identify the improvement potential for enhancing safety and performance. Internal audits must also be prompted by significant changes in the management system or associated processes, or by weaknesses in performance or in safety. One shortcoming of internal audits is that if the culture does not encourage openness, the answers provided could be “economical with the truth” resulting in deviations and observations that do not correspond with reality. It is therefore advisable to combine internal audits with observations.

Observation of work performances is one of the best methods for assessing and reporting on a specific area or an ongoing activity. It is flexible and less formal than an audit and can be performed in a relatively short period of time. It is important to communicate the purpose of the observations to all the personnel observed, as failure to do so can lead to those observed perceiving the experience as very unpleasant and therefore become negative about the outcome.

A single instance of observation is not sufficient to assess the effectiveness of the management system. It is therefore a good idea to carry out observations on a regular basis, perhaps even introduce a formal behavioural safety scheme that includes observations as an element.

It is important that the personnel performing the internal audits and observations have the qualifications to do so and understand the complexities of the organisation. If not, it is easy to draw the wrong conclusions.

Management system reviews

It is important that the management system is kept alive and up-to-date. Senior management must therefore develop activities to review the management system in a process that extends over the whole organisation. The frequency of reviews should be determined by the needs of the organisation.

Review inputs must provide data for identifying the potential for improvements in the performance and safety of the organisation. These can take the different forms but include some of the following [3]:

- The safety status and the organisation's objectives and the results of improvement activities;
- The status of actions from past management system reviews;
- The performance of the organisation in achieving its objectives, plans and goals;
- The results of assessments of all types;
- Feedback on the satisfaction of interested parties;
- Advances in technology, research and development;
- Results from benchmarking activities;
- The performance of suppliers;
- New opportunities for improvement;
- The control of process and product non-conformances;
- The status of activities in strategic partnerships;
- Other factors that may impact the organisation, such as financial, social or environmental conditions;
- Relevant statutory and regulatory changes.

The outputs of reviews should be used to improve the management system and see the outcome as an opportunity to improve both the safety and performance of the organisation.

The schedule of reviews must facilitate the timely provision of data for strategic planning in the organisation. Selected outputs should be communicated to personnel to demonstrate how the process of improving the management system works and that it is worthwhile to contribute.

Non-conformance, corrective and preventive actions

Non-conformance

The cause of non-conformance must be detected and remedial actions taken to prevent its recurrence [2]. Non-conformances can be seen as violations to be punished or deviations to be learned from. The latter is by far the preferred solution as non-conformances provide excellent opportunities to evaluate the present status of the system.

Senior management should encourage the development of a culture in which individuals have the opportunity to report non-conforming processes without fear of negative consequences and ensure the provision of tools and methods to report the non-conformances. These reports should proceed through the management system and follow a predefined process of handling the issues raised. Ideally the individuals who see deviations should be obliged to report them; however, this may be easier said than done. Reporting one's own behaviour, if it deviates from the procedure, may not be acceptable

since human error is unacceptable in some cultures. The reporting system shall be developed so that it fits in with the present organisational culture to allow for the best possible problem solving. If required it could be made confidential.

Adequate resources must be made available to allow for thorough investigations by qualified technical, administrative or managerial personnel of non-conformances to gain a complete understanding of the problems involved. Safety considerations must have first priority over cost and schedule considerations in the classification and analysis of non-conformances. If the non-conformances compromise safety, it may be that the activities have to be temporarily postponed until the problem has been rectified.

Corrective actions

Non-conformances must be corrected as soon as possible, especially if they are related to safety. Senior management should support the corrective action process by encouraging the effective identification and correction of non-conformances. How non-conformances are reported and evaluated depends on the organisation's size and product and can vary widely, but irrespective of that it is important to have a system for grading and prioritisation of corrective actions. A lack of such a system often leads to the easy corrective actions being quickly implemented first, while the more difficult ones take a longer time or are left on the shelf. The grading can be done systematically by using risk matrixes to ensure that the appropriate time and resources are assigned to the task.

One important aspect of a successful corrective action process is feedback to the individual who reported the non-conformances.

Personnel and managers should report whether the reports on corrective actions are taken seriously and used to promote safety and enhanced performance. If no feedback is forthcoming, reporting will be reduced, as the process may be perceived as pointless. Many good reporting systems have faltered on this obstacle.

Corrective actions must be subject to approval, prioritised and completed in a timely manner on the basis of their significance. Deviations shall only be accepted if more urgent safety matters require the attention of the manager responsible. Accountability shall be assigned and dates shall be followed-up to ensure completion on time.

It is worthwhile to trend non-conformances in order to see how they develop over time. The trend analyses must be reviewed, summarised and presented to senior management on a regular basis to ensure that this knowledge and understanding is registered at the highest level.

Preventive actions

The purpose of preventive actions is to prevent the potential causes of non-conformances from occurring and to maintain safety and performance. Preventive actions should focus on proactive steps to reduce the probability of deviations as identified in risk analyses. Preventive actions could include:

- Changing the organisational structure;
- Retraining and requalifying personnel;
- Improving safety culture;
- Improving the management system;
- Changing or modifying documents;
- Issuing new documents.

The focus must be on those preventive actions that have the greatest effect and such are often found at the management level. They are more difficult to implement but will have a wider impact.

Improvement

A strategic objective of an organisation is the continual improvement of processes in order to enhance the organisation's safety and performance. Improvement can be achieved at different levels:

- ***At the working level***, by introducing small incremental improvement activities conducted within existing processes by those directly involved from day to day;
- ***At the process level***, where each individual responsible for the process is in charge of improvement;
- ***At the organisational level***, through significant improvement projects throughout the organisation (at the level of the management system) which lead either to the revision and improvement of existing processes or to the implementation of new processes. These projects are usually carried out by cross-functional teams and are distinct from routine operations.

Improvements should be made systematically based on the quality cycle:

- experience review,
- analysis,
- identification and evaluation of possible solutions, and
- evaluation of effects.

Thereafter the solution can be implemented. The new solution should also be evaluated when it is in place and has become part of everyday working life.

If the solution is successful, the organisation should consider standardising it and applying it across the organisation.

1.7 Major differences and correlations between GS-R-3 and ISO 9001:2008

Introduction

The IAEA GS-R-3 is intended to help an organization establish, implement, assess and continually improve a management system that integrates safety, health, environmental, security, quality and economic elements, to foster a strong safety culture and improve safety performance in all the activities of the organization. In IAEA GS-R-3 safety is of primary importance, overriding all other demands.

ISO 9001:2008 allows an organization to demonstrate its ability to meet customer and applicable regulatory requirements, in addition to its own organizational requirements, and to enhance customer satisfaction. ISO 9001:2008 does not include requirements specific to other management systems, such as those particular to environmental management, occupational health and safety management, financial management or risk management.

Management Principles in both standards

Both IAEA GS-R-3 and ISO 9001:2008 are based on the following common management principles that reflect good management practices:

- Safety focus (GS-R-3) and customer focus (ISO);
- Leadership;
- Involvement of people;
- Process approach;
- System approach to management;
- Continual improvement;
- Factual approach to decision making;
- Mutually beneficial supplier-customer relationships.

IAEA GS-R-3 is based on the principle of an integrated management system, which includes all factors affecting the activities and safety performance of an organization. Safety culture and human performance are important management principles in IAEA GS-R-3; they are part of the focus of the standard. Risk management is another important management principle included in IAEA GS-R-3.

IAEA GS-R-3 requires proactive strategic thinking and planning, integrating all goals, strategies and objectives, while the emphasis of ISO 9001:2008 is on the operational level of product and 'quality management' requirements. Consequently, the scope of application and integration of management principles is much larger in IAEA GS-R-3 than in ISO 9001:2008.

ISO 9001:2008 has no requirement to integrate safety, health, environmental, security, quality and economic elements of the management system to ensure that safety is properly taken into account in all activities of the organization.

Focus and Structure of both standards

IAEA GS-R-3 is a safety standard, while ISO 9001:2008 is not. IAEA GS-R-3 is a standard specific to the nuclear industry and its focus is on achieving and enhancing safety. It establishes requirements designed to achieve and enhance safety, while enhancing the satisfaction of interested parties. IAEA GS-R-3 is applicable to the establishment, implementation, assessment and continual improvement of management systems for:

- Nuclear facilities;
- Activities using sources of ionizing radiation;
- Radioactive waste management;
- The transport of radioactive material;
- Radiation protection activities;
- Any other practices or circumstances in which people may be exposed to radiation from naturally occurring or artificial sources.

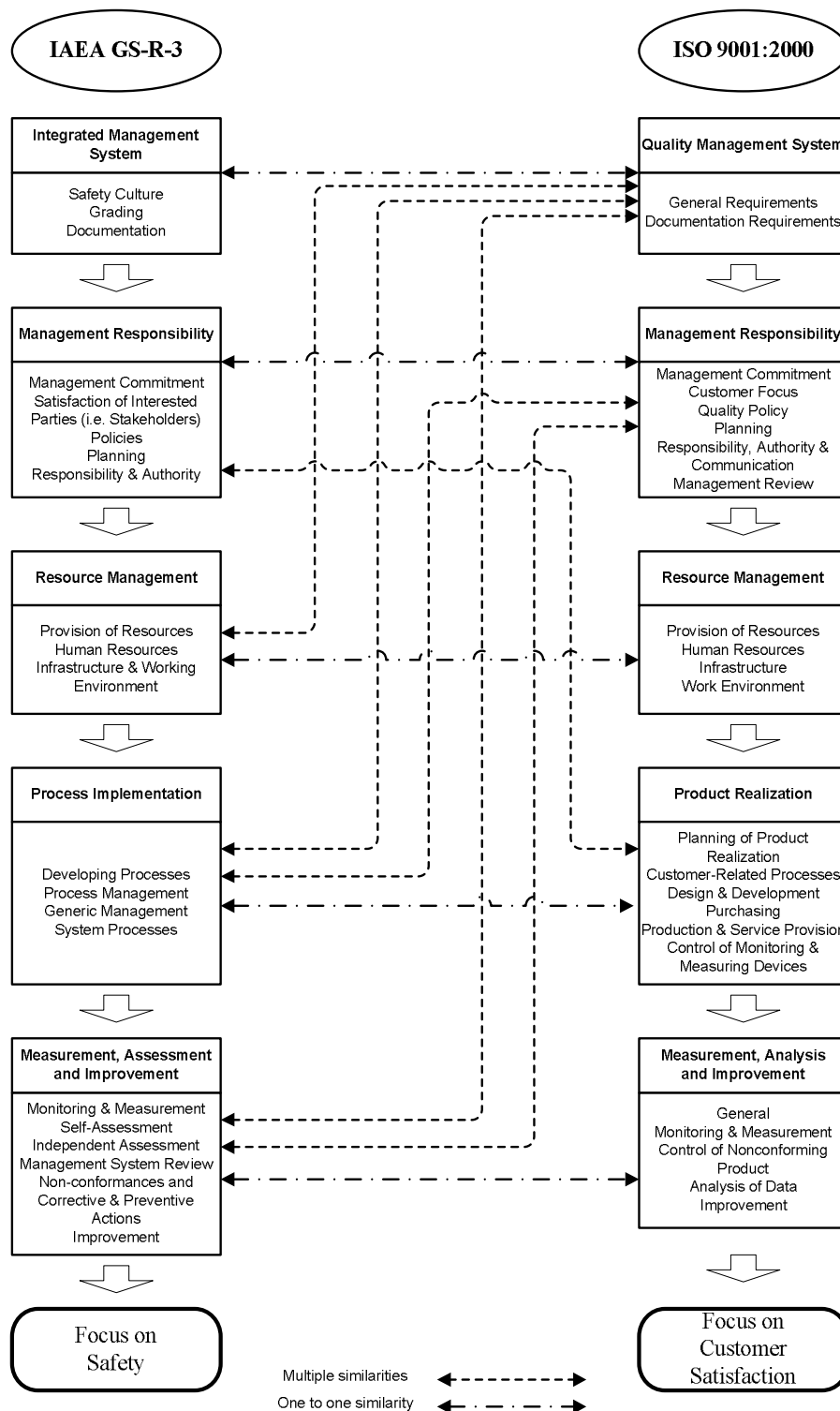


Figure 1.7: Similarities in structure between the IAEA GS-R-3 and ISO 9001:2008.

The ISO 9001:2008 is a general quality management system standard applicable to any organization. Its focus is on providing a product that meets customer and applicable regulatory requirements, and enhancing customer satisfaction. It focuses on the effectiveness of the quality management system in meeting these objectives, not on

enhancing safety. ISO 9001:2008 states that it does not include requirements specific to other management systems, such as those particular to environmental management, occupational health and safety management, financial management or risk management. It specifies requirements designed to demonstrate an organization's ability to consistently provide a product that meets customer and applicable regulatory requirements, and to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and ensuring conformity to customer and applicable regulatory requirements.

There are similarities in structure between IAEA GS-R-3 and ISO 9001:2008, in spite of the differences in focus and overall objective. The requirements in both standards have been structured in terms of the following main categories (Fig. 1.7):

- Management system;
- Management responsibility;
- Resource management;
- Process implementation or product realization;
- Measurement, assessment or analysis, and improvement.

With the publication of GSR Part 2 expected in 2015, which will supersede GS-R-3, some of the above may change.

1.8 Major differences and correlations between GS-R-3 and ASME NQA-1-2008

Introduction

ASME NQA-1-2008, Quality Assurance Requirements for Nuclear Facility Applications, is a national standard developed by the American Society of Mechanical Engineers (ASME) that specifies requirements for a Quality Assurance Programme. ASME NQA-1-2008 defines requirements for an organization to establish, implement and assess a quality assurance (QA) programme to achieve nuclear safety. ASME NQA-1-2008 reflects industrial experience and current understanding of QA requirements for the safe, reliable, and efficient utilization of nuclear energy, and management and processing of radioactive materials [5].

IAEA GS-R-3 defines requirements for an organization to establish, implement, assess and continually improve a management system that integrates safety, health, environmental, security, quality and economic elements to ensure that safety is not compromised. It fosters a strong safety culture and improved safety performance in all the activities of the organization.

Scope and Approach of both standards

IAEA GS-R-3 and ASME NQA-1-2008 apply to the lifecycle of nuclear facilities and activities, including siting, design, construction, commissioning, operation, and decommissioning. IAEA GS-R-3 and

ASME NQA-1-2008 foster the application of requirements in a manner that is consistent with the relative importance of the item or activity.

IAEA GS-R-3 adopts an integrated management system approach to be applied to all activities within the organization. IAEA GS-R-3 requires the integration of safety, health, environmental, security, quality and economic elements of the management system to ensure that safety is properly taken into account in all activities. It specifies requirements designed to achieve and enhance safety, while enhancing the satisfaction of interested parties. A management system based on IAEA GS-R-3 includes safety culture, human performance, a process approach to the achievement of objectives and continual improvement of the management system and its processes.

The ASME NQA-1-2008 approach applies quality assurance requirements to activities that could affect the quality of nuclear material applications, structures, systems and components of nuclear facilities. Quality assurance requirements are used to develop a Quality Assurance Programme necessary to achieve, safe, reliable and efficient utilization of nuclear energy, and management and processing of radioactive material.

ASME NQA-1 was originally developed to implement quality assurance requirements for nuclear power plant design and construction in the USA. ASME NQA-1-2008 now applies expanded quality assurance requirements to a range of nuclear facilities to address new technologies and safety issues. ASME NQA-1-2008 does not require an integrated management system approach as required by IAEA GS-R-3.

1.9 Questions

1. Describe the concept of an integrated management system.
2. Describe what an organization needs to consider when an implementing integrated management system.

2 LEADERSHIP

Learning objectives:

After completing this chapter, the trainee will be able to:

1. *Describe the key challenges related to leadership.*
2. *Describe how to develop leadership strategies.*
3. *Name various leadership practices.*

There is a difference between management and leadership. It can be stated simply that **‘management’ is a function and ‘leadership’ is a relationship**. Management ensures that work is completed in accordance with requirements, plans and resources. It is through leadership that individuals may be influenced and motivated, and organisations changed. Managers should also act as leaders.

Good leadership, which addresses the interaction between managers and employees, as well as all social interactions in the organisation, is needed. Everyone knows how it feels to be treated with disrespect by managers and how it affects the work situation. This aspect can be sensitive if an individual, for example, dares to report a safety deviation, or to uphold a questioning attitude. The core of leadership is the quality of the interaction between the leader and his/her followers.

Leadership has everything to do with the impact that one individual has on others and the environment created as a result. Leaders need to manage issues, systems and resources through the application of expectations, rules, rewards and corrective actions. In addition, it involves leading individuals and teams, and introducing change through serving as a role model and through providing inspiration, challenges and support. By doing this, leaders establish healthy human relations and a strong safety culture [6].

Leaders who are trustworthy, fair, encouraging and motivating, and who work on team building create a healthy atmosphere and strong safety culture in an organization.

Their staff respond by adhering to organizational goals, professional development, helping and supporting each other and being active members of a team. Such organizations as a consequence produce better overall results than organizations without strong leadership.

There are, however, a few **challenges related to leadership** that need to be overcome, such as [6]:

- Lack of clarity about the difference between management and leadership and the importance of both in developing healthy organizational and safety cultures;
- Ensuring leadership continuity throughout all phases of a project in order to maintain the safety focus;

- Constraints set by governments, owners or corporate bodies, which may emphasize business and economic concerns and have little understanding for nuclear safety issues.

During all phases of a project, leaders need to develop a **dynamic leadership** that can adapt to a changing environment and help all individuals within the organization to understand their role in nuclear safety. Such dynamic leadership is developed when leaders [6]:

- Demonstrate nuclear safety awareness and expect safety accountability from all workers;
- Facilitate learning, the sharing of ideas and collaboration, and create an overall sense of competency, so that people willingly engage to achieve results and meet expectations;
- Recognize and resolve issues that can compromise safety while considering the reasons for their appearance. This includes promoting integration of information and people, and recognizing patterns that indicate breakdowns in communication and collaboration;
- Build organizational capacity through continuous investment in development of the knowledge and skills of the workforce. Leaders demonstrate an approach focused on learning and coaching;
- Acknowledge human fallibility and foster learning for teams and individuals;
- Demonstrate a willingness and ability to allow opposite views to surface irrespective of the position of the speaker in the organization. Leaders who are dictatorial, egocentric, irritable and uncommunicative constrain employee engagement and motivation, which in turn creates an unhealthy organizational culture;
- Demonstrate awareness and willingness to promptly and strongly act when political, commercial or other interests undermine nuclear safety.

For developing leadership capabilities in an organization it is necessary to establish a **leadership development plan** to ensure that effective leadership will be present throughout the entire duration of a project. To achieve this, we need to define the suitability requirements for different organizational levels and select individuals with “natural strengths” in those areas to increase the likelihood of effective performance. Such “natural strengths” can mean, among other things, individuals who are able to provide vision for new directions and engage others, anticipate the need for change and promote new ways of doing things, inspire involvement and commitment to accomplish more, challenge others to be innovative and build the capacity of others through coaching and mentoring.

Good leaders need to establish **leadership practices** that will support an open, proactive, safety minded environment. Such practices might include among others the following examples [6]:

- Use experience and anecdotes to share values and convey the importance of safety in a memorable way;
- Pay attention to breakdowns in human interactions and use mediation techniques to ensure collaboration between people;
- Use active listening and open ended questions to help individuals think things through for themselves;
- Monitor organizational effectiveness to uncover where sharing, learning, cooperation, or contributions to nuclear safety are not taking place;
- Establish acceptable behaviour and results, and make sure they are known to everyone involved;
- Use individual development plans;
- Establish relationships and have crucial dialogue before problems arise.

Although the IAEA promotes the concept where managers are leaders, as one cannot manage without leadership and one cannot lead without management skills, some literature sources make such a distinction between them as presented below in the example.

The Bristow Group is a provider of helicopter services for the oil and gas industry, operating more than 400 helicopters in more than 20 countries, flying over 300 000 hours per year in a variety of environments. A basic idea of the Bristow Group is the separation of ‘management’ and ‘leadership’, where management deals with strategy, goals and tasks, while leadership deals with culture, teamwork and co-workers (see Fig. 2.1) [7].

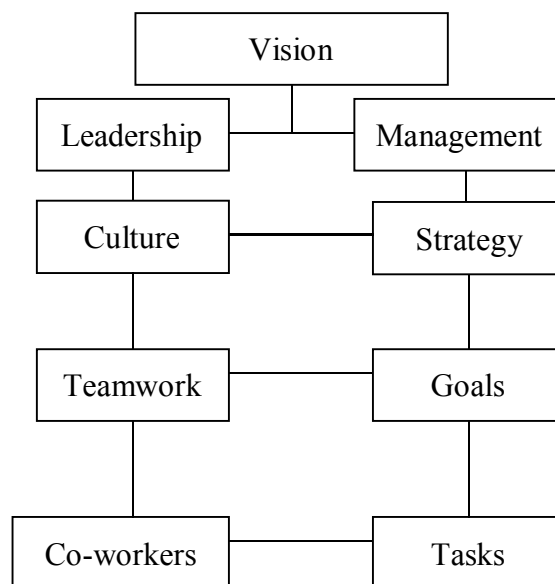


Figure 2.1: Relationship between management and leadership.

Bristow published a document to show how they expect leaders in the Group to behave [7]:

- Lead through example according to the Group’s core values;

- Build trust and confidence in the staff you work with;
- Keep people informed;
- Take responsibility for your actions and hold others responsible for theirs.

The above are only the basic elements of leadership challenges and practices. Apart from reference [6] which was frequently cited above and which focuses on leadership and safety culture in the pre-operational phase of an NPP project, and the main documents on the subject as mentioned earlier (GS-G-3.1 and GS-G-3.5), the following additional IAEA safety standards publications provide further useful information on leadership, organization and safety culture:

- IAEA Safety Standards Series NS-G-2.4 *The Operating Organization for Nuclear Power Plants* [8]. This document deals with the organisation of at an NPP site that will bring together a strong safety culture and good plant performance.
- IAEA Safety Standards Series NS-G-2.8 *Recruitment, Qualification and Training of Personnel for Nuclear Power Plants* [9]. This document describes the need in an operating organization for a sufficient number of well qualified staff to carry out safe plant operation.

Some important elements of leadership will also be discussed in the next Chapter on safety culture.

Good leadership and a strong safety culture go hand in hand.

2.1 Questions

1. What are the key challenges related to leadership?
2. Name a few examples of leadership practices.

3 SAFETY CULTURE

Learning objectives:

After completing this chapter, the trainee will be able to:

1. *Define safety culture as proposed in INSAG-4 and adopted by the entire nuclear community.*
2. *Describe safety culture shortcomings during the TMI-2 and Chernobyl accidents.*
3. *Describe the general concept of culture.*
4. *Define prerequisites for a strong safety culture.*
5. *Define symptoms of a weakening safety culture.*
6. *Describe methods for the assessment of safety culture.*

3.1 The emergence of safety culture and the nuclear safety industry

Safety culture is today the most important “*non-technical*”, overall safety framework in the nuclear industry.

Safety culture is used as a holistic concept to address all activities that take place in a nuclear facility, activities which are related to human behaviour.

Safety culture issues have not always been considered to be important. The origin and emergence of the safety culture concept can be traced to the two major accidents which occurred in the nuclear industry.

The term safety culture was first introduced by IAEA International Nuclear Safety Advisory Group INSAG-1 in 1986 following the Chernobyl accident. The intention was to denote that management and organisational factors are important to safety and that problems in those areas could be significant contributing causes to the accident.

However, the importance of management and organisational issues to nuclear facility safety first clearly surfaced in relation to the aftermath of the accident in 1979 at Unit 2 of the Three Mile Island (TMI) plant in the USA. The US Nuclear Regulatory Commission’s (NRC) investigation revealed that “The one theme that runs through the conclusions we have reached is that the principal deficiencies in commercial reactor safety today are not hardware problems, they are management problems.” [10] The report also stated that “*The NRC, for its part, has virtually ignored the critical areas of operator training, human factors engineering, utility management and technical qualifications.*” Thus the investigation showed that these important areas so far had been neglected in nuclear safety work both from the industry as well as the regulator perspective.

The findings of the investigation capture the basis for much of the NRC's agenda for the years to come, as well as for the industry's agenda to improve plant operations. The NRC's post-TMI action plan included a large number of issues under the general heading of human factors. The major categories included operator qualifications and training, staffing levels and working conditions, the man-machine interface, emergency operating procedures, human reliability, and organisational and management effectiveness. Thus, the human factors area in nuclear power received major attention in the United States as well as in the rest of the world. Independent of the initiative that the NRC undertook, the industry saw the need to improve the quality of nuclear operations with regard to the human factor. The Institute of Nuclear Power Operations (INPO) was established by the electric utilities that owned and operated nuclear power plants to foster excellence in plant operations.

After the Chernobyl accident analysts were surprised by the number of faulty decisions made during the course of events leading to this major accident. Questions were asked related to why operators were unable to identify and communicate the problems to high-ranking decision makers during the event and how the operators could accept running the plant against the rules and regulations, and also what general attitude towards safety could have influenced decision-making and behaviour. However, the safety culture concept was not introduced until after the Chernobyl accident.

The IAEA International Nuclear Safety Advisory Group (INSAG) wrote in their INSAG-1 report [11] that *"A vital conclusion drawn from this behaviour is the importance of placing complete authority and responsibility for the safety of the plant on a senior member of the operational staff of the plant. Of equal importance, formal procedures must be properly reviewed and approved and must be supplemented by the creation and maintenance of a "nuclear safety culture"."* The concept of the term safety culture was now formally introduced in the nuclear safety area.

Work in INSAG-1 was followed by INSAG-3 [12] explaining that safety culture is a very general term including the personal dedication and accountability of all individuals engaged in any activity which has a bearing on safety in nuclear power plants. INSAG-4 [13] developed the concept in more detail and defined safety culture as:

"... 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".

It also stated that safety culture involves both attitudes and structures, both the organisation and the individual, and requires that safety issues are appropriately matched with resources and actions. This

definition received great attention across the international nuclear community.

It was now clearly recognized that management, organisation and attitudes influence safety. Organisations and in particular their management form prerequisites or boundaries to human actions in the form of shared attitudes and values. The direction of research and practice were that organisations should develop a good safety culture in order to create safe and reliable organisations. This was adopted as a regulatory requirement in the nuclear domain and has spread gradually to other areas of industry such as aviation, offshore oil and gas exploitation, the chemical industry and the transport sector. Research was directed towards finding the characteristics of a good safety culture, as well as finding the means to assess, identify and develop such a culture.

Although “*the nuclear safety culture*” concept was mentioned in the report published in 1986 (INSAG-1), the causes of the Chernobyl accident were initially attributed to operator error and also to the inherent instability of this type of reactor. However this explanation was extensively questioned and debated. G. Medvedev (a senior nuclear engineer and the chief engineer at the time of the plant's construction) wrote in his book “*The truth about Chernobyl*” [14] in 1990 that: “*The mere fact that the operators were carrying out an experiment that had not been approved by higher officials indicates that something was wrong with the chain of command. The State Committee on Safety in the Atomic Power Industry is permanently represented at the Chernobyl station. Yet the engineers and experts in that office were not informed about the programme. In part, the tragedy was the product of administrative anarchy or the attempt to keep everything secret.*”

In 1993 the IAEA International Nuclear Safety Advisory Group (INSAG) published an additional report, INSAG-7 [15] that reviewed “*that part of the INSAG-1 report in which primary attention is given to the reasons for the accident*”. Most of the accusations against staff for breach of regulations were acknowledged to be erroneous, based on incorrect information obtained in August 1986. This report reflected another view of the reasons for the accident. This report paid close attention to the inadequate (at the moment of the accident) “*culture of safety*” at all levels. Weaknesses in the safety culture were inherent not only at the operational stage but also, and to no lesser extent, during activities at other stages in the lifetime of nuclear power plants (including design, engineering, construction, manufacture and regulation). The poor quality of operating procedures and instructions, and their conflicting character, put a heavy burden on the operating crew, including the Chief Engineer. “*The accident can be said to have flowed from a deficient safety culture, not only at the Chernobyl plant, but throughout the Soviet design, operating and regulatory organisations for nuclear power that existed at that time.*”

To summarize, the new information on the causes of the accident highlighted a number of broader problems contributing to the accident. These include:

- A plant which fell well short of the safety standards in effect when it was designed, and even incorporated unsafe features;
- Inadequate safety analysis;
- Insufficient attention to an independent safety review;
- Operating procedures not always backed by safety analysis;
- Inadequate and ineffective exchange of important safety information both between operators and between operators and designers;
- Inadequate understanding by operators of the safety aspects of their plant;
- Insufficient respect on the part of the operators to the formal requirements of operational and test procedures;
- An insufficiently effective regulatory regime that was unable to counter pressures for production;
- A general lack of safety culture in nuclear matters, at the national level as well as locally.

The problems above can be summarized as related to safety culture. The development of the safety culture concept after the Chernobyl accident led to the understanding that safety culture and its implementation concerns not only operators but also managers, organisations and nations.

Implementation of safety culture is not only the concern of operators but also managers, organisations and nations.

This was a starting point for a major effort on safety culture within the nuclear industry.

3.2 The Concept of Culture

In order to understand safety culture, it is necessary to have an insight into the concept of culture. The first step is to obtain an appreciation of culture in its broadest sense.

If you were asked to describe your own culture, what would you say? Probably you would say that it is simple to act upon, but describing one's own culture is actually not an easy task. Our own culture emerges with distance and when confronted by another. Or in the words of the French philosopher, Jean Baudrillard, "To open our eyes to the absurdity of our own customs is the charm and benefit of travel". Culture serves as a lens through which we perceive the world. Culture distorts how we see the world and how the world sees us. We tend to use our own culture as a reference point to evaluate others.

Culture is to society what memory is to individuals. Culture includes traditions that reflect “what has worked in the past”. It also encompasses the way people have learned to look at their environment and themselves, and their unstated assumptions about the way the world is and the way people should act.

The biggest danger in trying to understand culture is to oversimplify it in our minds. It is tempting to say that culture is just “the way we do things around here”, or “our basic values”, or “our rituals”, and so on. These are all manifestations of culture, but none is culture at the level that culture matters. A better way to think about culture is to realize that it exists at several “levels” and that we must endeavour to understand these different levels, but especially the deeper levels.

The levels of culture go from the very visible to the tacit and invisible. The following diagram in Fig. 3.1 shows a multilevel model of culture that was developed by the scientist Edgar Schein [16].

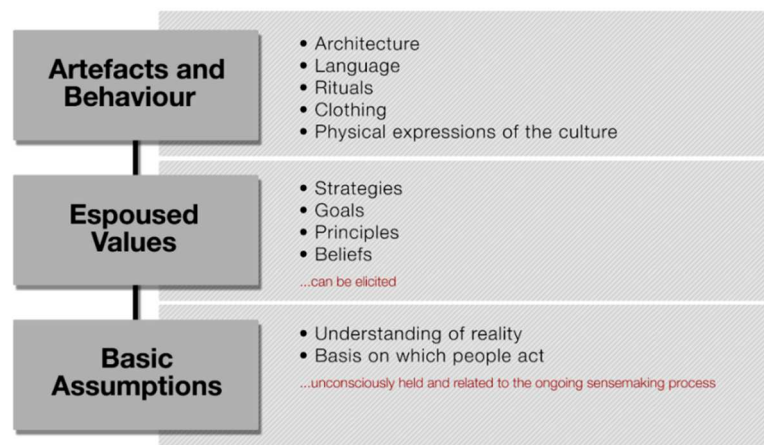


Figure 3.1: Multilevel model of culture.

Artefacts

The easiest level to observe is that of artefacts: what you see, hear and feel. Entering an organisation, the most obvious artefact is the architecture and design of the building.

Is the space where people work open, partitioned by half walls or in private offices? Other aspects of layout, such as the number of executive dining rooms and washrooms, or reserved parking spaces also indicate the importance attached to hierarchy and status. These may be reinforced by artefacts such as cars, and office furniture that send clear messages regarding ranking order.

At the level of artefacts, culture is very clear and has immediate emotional impact. But you do not really know why each an organisation is constructed as it is, or why people are behaving as they are. It is difficult to decipher what is going on. You have to move to

the next level of culture.

Espoused values

Espoused values are those values that are adopted and supported by a person or organisation. Information about espoused values can be obtained by asking questions about the things that you observe or feel. Espoused values are those values that people say that they support. Values are preferred states about the way things should be. Examples of espoused values often quoted in organisations are equality of opportunity, teamwork, empowering employees, safety as a priority etc. These values are common to many organisations, even those having completely different physical layouts and working styles. Should you spend a longer time in an organisation you will often become aware of inconsistencies between some of the espoused values and the visible behaviour. For example, an organisation may espouse “teamwork” as a value but has a reward system that is highly competitive and individualistic. It may espouse “safety is a priority” but employees take risks to meet production targets. What these inconsistencies tell you is that a deeper level of thought and perception is driving behaviour. The deeper levels may or may not be consistent with the values espoused by the organisation. If you are to understand the culture, you must find out what is going on at the deeper level, and establish what the basic assumptions are.

Basic assumptions

These lie at the deepest level of culture. They are fundamental beliefs that are so taken for granted that most people in a cultural group subscribe to them but not in a conscious way. To understand any culture you must dig out these basic assumptions that are operating. These basic assumptions will reflect many of the deeper assumptions of the national culture but are not exclusively determined by it. The basic assumptions can shortly be described as the understanding of reality. In the case of an organisation they will also reflect its history, the values, beliefs and assumptions of the founders and the key leaders who have made it successful.

An example of a basic assumption is the underlying belief about human nature. Are people basically good or evil? Some religions take as their point of departure the idea that people are basically evil (original sin) and can only be redeemed through certain acts of religious faith. People are expected to sin, to confess, to ask forgiveness, and to repent. Other assumes that people are basically good, and that they live and work to fulfil their human potential. Hard work and perseverance are seen as ways of achieving these ends. In management this translates into beliefs about workers: Theory X and Theory Y. In Theory X, workers are assumed to be lazy, to need constant direction and supervision because they will try to get away with as much as possible. In Theory Y, workers are assumed to be self-directed, to be willing to take initiatives and to do what has to be done without external control. Thus assumptions about human nature

determine the willingness to delegate and the nature of control systems. The popular idea of empowerment depends very much on the assumption that people are self-directed and self-controlled.

Other basic assumptions deal with fundamental aspects of life - the nature of time and space; human activities; the nature of truth and how one discovers it; the correct way for the individual and the group to relate to each other; the relative importance of work, family and self-development; the proper role of men and women; and the nature of the family.

Basic assumptions are rarely discussed or confronted and hence are extremely difficult to change. To learn something new in the realm of basic assumptions requires us to consciously resurrect, re-examine and possibly change some of the more stable parts of our cognitive structure, a process involving double-loop learning. Such learning is intrinsically difficult because the re-examination of basic assumptions temporarily destabilizes our cognitive and interpersonal world, releasing deep feelings of anxiety. Rather than tolerating such anxiety, we tend to want to interpret the events around us as consistent with our basic assumptions, even if we have to distort our interpretation. It is in this psychological process that culture has its ultimate power.

Any group culture can be studied at these three levels - the level of artefacts, the level of espoused values, and the level of basic assumptions. If one does not find out the pattern of basic assumptions that may be operating, one will not know how to interpret the artefacts correctly or how much credence to give to the articulated values. In other words, the essence of a culture lies in the pattern of basic assumptions, and once one understands these, one can understand the other more superficial levels of culture, and deal appropriately with them.

One should also be aware of that not all aspects of a culture are visible to the observer. Like the well-known iceberg analogy, the major part of the iceberg is under water and not visible (Fig. 3.2). Analogous to the iceberg culture is mostly below the surface. Above the surface we find the visible aspects of culture; artefacts, people's actions, language use etc. Below the surface we find:

- Norms,
- Values,
- Fundamental assumptions about reality.

Because the aspects of culture that are below the surface are not directly observable we make inferences and interpretations of them based on the part we can observe, i.e. what's above the surface.

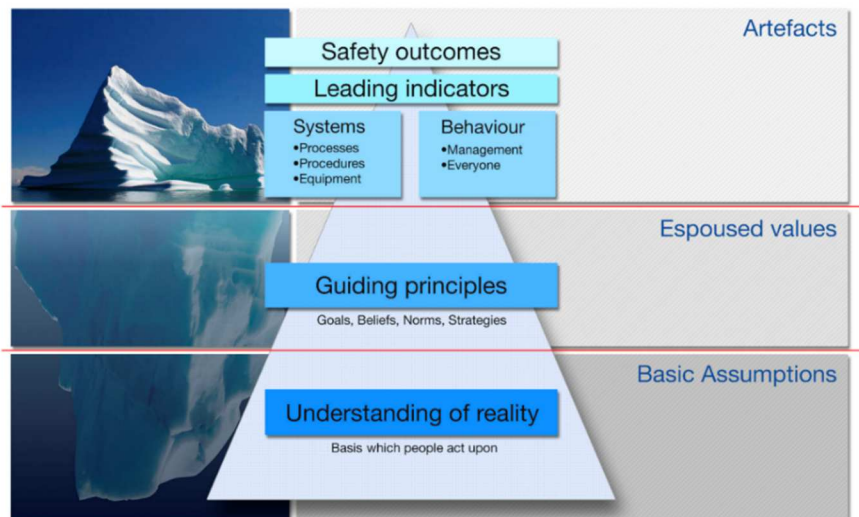


Figure 3.2: The iceberg as a metaphor of culture.

3.3 Models of safety culture

The first complete definition of safety culture was presented in the document INSAG-4. There safety culture was defined as:

“... that assembly of characteristics and attitude in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receives the attention warranted by their significance”.

It was pointed out that safety culture has two general components. The first is the necessary framework within an organization and is the responsibility of managers. The second is the attitude of individuals at all levels in responding to and benefiting from the framework. Fig. 3.3 illustrates this concept and shows the desired responses at the organizational levels of policy, management and the individual. The policy level establishes the necessary framework for the organization. Management shapes the working environment and fosters attitudes conducive to achieving good safety performance. At the individual level, a questioning attitude, a rigorous and prudent approach, and good communication are emphasized [17].

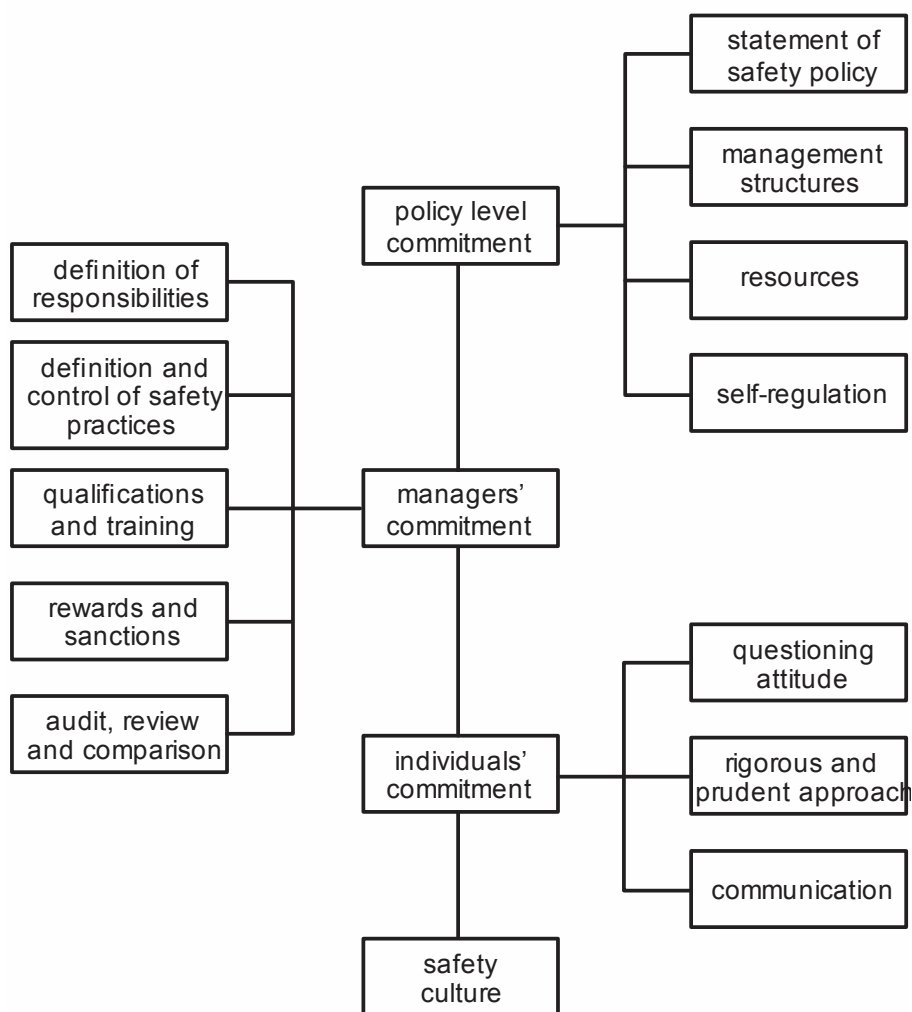


Figure 3.3: Safety Culture as defined in INSAG-4.

Report INSAG-15 on “Key Practical Issues in Strengthening Safety Culture” [17] identifies 7 such key issues. These are:

- **Commitment:** Commitment means not only providing leadership but also developing, in partnership with staff and their representatives, the means of translating the safety goals of the organization into day to day reality.
- **Use of procedures:** Management systems require clearly written procedures that are fit for purpose in controlling all aspects of nuclear safety. However there should be a balance in the number and extent of procedures. They should be in place for work which needs to be controlled and this must be clearly communicated to the operators who will use these procedures so that they understand the importance of their being strictly followed. If this is not the case, if procedures are not valued, a culture of shortcuts or “work-around” can develop. In some instances, as for example in severe accident conditions, procedures might not be the best solution as uncertainties of how an event will develop are too great, in which case guidance is the preferred solution instead of procedures.

- **Conservative decision making:** This relates to a questioning attitude and a rigorous and prudent approach. Individuals or teams should be required to stop and review any safety related work before taking actions. Such a culture should be reinforced by management by praising staff if they stop work or do not approve modifications because there is reasonable doubt about the safety implications.
- **A reporting culture:** Failures and “near misses” are considered as opportunities to learn by organizations with a sound safety culture. This is however strictly connected with the development of a “blame-free” environment, where individuals are assured that their reporting will be valued. In addition all reported events need to be promptly investigated to determine the real root causes and feedback be given to the reporting individual or group. The regulator should also acknowledge such culture if or when the number of reported events significantly increases. This should not be viewed as a concern by regulators if they understand the reasons, but as a positive sign of individual responsibility.
- **Identification of latent weaknesses/ challenging unsafe acts and conditions:** Almost all incidents and accidents start as a result of an unintentionally unsafe act which in combination with a latent weakness in the system results in an undesirable condition. Such latent weaknesses can be deficiencies in design, procedures or training. It is therefore important that operators be encouraged to challenge potentially unsafe practices and identify latent weaknesses wherever and whenever they encounter them.
- **The learning organization:** If an organization is not searching for improvements and new ideas by means of benchmarking and seeking out best practices, there is a danger that it will slip backwards. A learning organization is capable of tapping into the ideas, energy and concerns of staff at all levels in the organization.
- **Underpinning issues; communication, clear priorities and organization:** Apart from the above specific issues there are three prerequisites which underpin all of them. The first one is clear communication about safety issues, the second is of ensuring that a sense of reality is retained about what can be achieved and on what timescales, and the third of achieving and maintaining clarity about the organizational structure and accountability for what is to be done.

It should be pointed out that the INSAG-4 model of safety culture is not the only one that has been developed, even though it is the one which is widely accepted throughout the nuclear community. As an example of other models let us mention here the simple model of safety culture developed by Skriver, consisting of three interacting elements: Risk management, understanding and behaviour [18]. To make sure that the organisation has a good safety culture all three elements have to be considered. This model can be used as a basis for

change and for working towards a better safety culture (see Fig. 3.4).

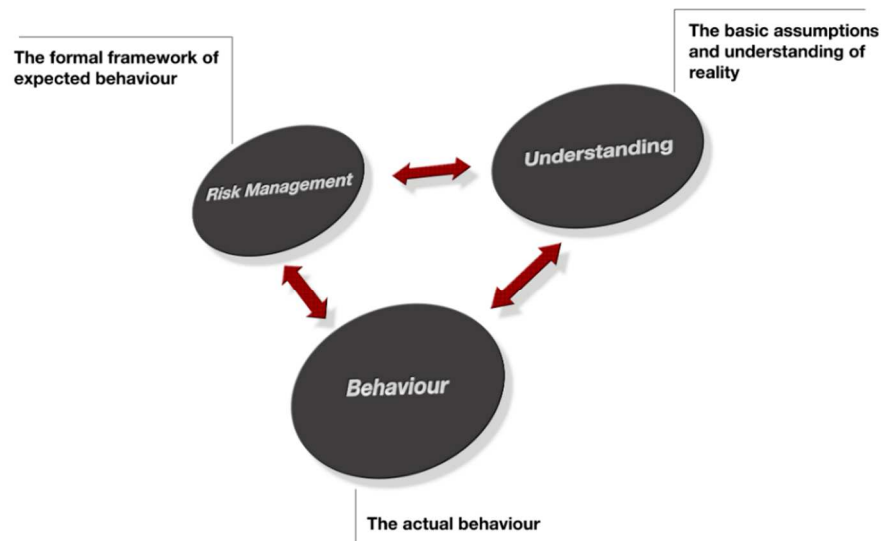


Figure 3.4: Skriver's safety culture model.

Risk management is the framework of expected behaviour within the organisation. The framework formally consists of legislations and regulations written as rules, policies, procedures etc. in the management system. External legal requirements and internal rules made within the organisation create demands on the risk management of the organisation. Risk management includes governing documents and guidelines on how the organisation and its employees should act in relation to safety.

Understanding is related to the basic assumption and understanding of reality, understanding of the situation, the work environment, and systems such as the technical as well as the management system. Understanding influences attitude and finally behaviour. Understanding also embraces overall knowledge and competence. The core of safety culture is a clear understanding how the individual affects safety and the responsibility to act in a safe proactive manner. This includes top managers, managers and co-workers.

Behaviour means actual actions taken and how one behaves in relation to safety. It is about how management and employees take care of safety issues in their daily work, in decisions that are made and how one prioritizes. Senior management, for example, must through its own behaviour show that safety issues are important and that reporting of deviations is essential by giving feedback and encouraging reporting. The key to safety is correct behaviour, and to achieve results in safety work behaviour has to be changed.

Each element above is important per se but in order to change and improve the safety culture of an organisation one has to work with all

three elements together. The character of the risk management in an organisation affects the attitudes of the employees towards following existing rules and instructions. The understanding of and attitudes to safety issues and the risk management system by staff influences their behaviour. A positive attitude towards an action tends to lead to the action being repeated with higher quality. The risk management system has to be designed in a way that corresponds to the activity of the organisation. If the rules are difficult to follow in practice they will not control behaviour. Thus the different elements of the model act together and to achieve a change all three have to be considered as a whole.

Before considering a multilevel view of safety culture, let us consider what are the attributes that constitute a good foundation for safety in an organisation. These are the attributes that you would look for when assessing safety in an organisation, to assure yourself that the approach to safety is coherent and comprehensive.

3.4 Prerequisites for a strong safety culture

The IAEA describes five main characteristics of a strong safety culture, as depicted in Fig. 3.5 below.



Figure 3.5: Characteristics of safety culture.

The IAEA five safety culture characteristics are broken down into 37 attributes [3]. The idea is to give guidance on which main activities contribute to upholding a strong and sustainable safety culture. The characteristics and attributes are not the culture itself, but can be expressions of the culture.

Safety is a clearly recognized value:

- The high priority given to safety is shown in documentation,

communications and decision-making. This should not just be a formality where safety is mentioned as a high priority, but nothing is done to improve it;

- Safety is a primary consideration in the allocation of resources;
- The strategic business importance of safety is reflected in the business plan, e.g. contractors must be evaluated on both their price and safety record;
- Individuals are convinced that safety and production go hand in hand;
- A proactive and long-term approach to safety issues is shown in decision-making. Changing the safety culture is not a fast process and the organisation must be patient in awaiting results. Campaigns will only have a short term effect and should be treated as steps towards a better safety culture, not as the solution;
- Safety conscious behaviour is socially accepted and supported (both formally and informally).

Leadership for safety is clear:

- Senior management is clearly committed to safety. This commitment is shown in both words and actions;
- Commitment to safety is evident at all levels of management;
- There is visible leadership showing the involvement of management in safety related activities. Decisions are made higher up the hierarchy so that the burden is not placed on the worker;
- Leadership skills are systematically developed. Safety is an integral part of the leadership development;
- Management ensures that there are sufficient competent individuals and plans ahead for the future to ensure that human resources do not become a problem;
- Management seeks the active involvement of individuals in improving safety. Safety initiatives with clear stated objectives must be introduced to maintain a questioning attitude and combat complacency;
- Safety implications are considered in management change processes. Risk assessments must be made when changes are considered to have safety implications;
- Management shows a continual effort to strive for openness and good communication throughout the organisation;
- Management has the ability to resolve conflicts;
- Relationships between managers and individuals are built on trust. This must also include the relationship with contractors. Frequently contractors have a lower status than employees and are taken less seriously. This must be avoided as contractors often can contribute new observations as they have the experience from working at different sites and see different approaches to safety culture interventions.

Accountability for safety is clear:



- An appropriate relationship with the regulatory body exists that ensures that the accountability for safety remains with the licensee;
- Roles, responsibilities and accountability are clearly defined and understood;
- There is a high level of compliance with regulations and procedures;
- Management delegates responsibility with appropriate authority to enable clear accountabilities to be established;
- Responsibility for safety is evident at all organisational levels and for all individuals.

Safety is integrated into all activities:

- Trust permeates the organisation;
- Consideration of all types of safety, including industrial safety and environmental safety, and of security is evident;
- The quality of documentation and procedures is good and reflects reality, not utopia;
- The quality of processes, from planning to implementation and review, is good;
- Individuals have the necessary knowledge and understanding of the work processes and the know-how to apply these for their own work situation;
- Factors affecting work motivation and job satisfaction are considered. Management decisions are communicated to the entire workforce and evaluated from a “what is in it for me” perspective, as well as from an organisational perspective;
- Good working conditions exist with regard to time pressures, workload and stress. The working conditions are monitored and evaluated systematically and improved when required;
- There is cross-functional and interdisciplinary cooperation and teamwork;
- Housekeeping and material conditions reflect commitment to excellence. Adequate resources and interventions are applied for improvement.

Safety is learning driven:

- A questioning attitude prevails at all organisational levels. Active steps are taken to reduce complacency;
- Open reporting of deviations and errors is encouraged;
- Internal and external assessments, including self-assessments, are used;
- Organisational experience and operating experience (both internal and external to the facility) are used;
- Learning is facilitated through the ability to recognise and diagnose deviations, to formulate and implement solutions and to monitor the effects of corrective actions;
- Safety performance indicators are tracked, trended, evaluated and acted upon;
- There is systematic development of individual competences.

The IAEA safety culture characteristics and attributes have been developed to emphasise out key aspects and provide support for organisations to meet the requirements for nuclear facilities. The characteristics and attributes are useful for both regulators and licensees.

Attributes important for safety:

- safety is a recognized value,
- the presence and quality of the risk control systems,
- the presence and quality of safety management information system,
- review of safety management systems,
- every employee receives high quality integrated job and safety training,
- all employees are aware of their individual role in safety on a daily basis,
- the hierarchy of the organisation is constructed to emphasize safety.

The following are some practical examples of characteristics and attributes:

The first attribute “**safety is a clearly recognized value**” is evident when looking into the organisation’s strategic plans and action plans, if safety is integrated into all aspects of the organisation’s activities. There are measurable short, medium and long term safety objectives in these plans, and there is regular monitoring of progress in implementing the plans. Monitoring of safety by the senior management team demonstrates a vital aspect of good leadership. There should be regular reviews of the plans to confirm that they remain valid. Information about the progress and outcome of reviews should be communicated to all employees. Thus the existence of plans, objectives, monitoring, reviews, and the involvement of senior management are tangible evidence of safety leadership, which is important for developing a positive safety culture.

Another key attribute for safety is **the presence and quality of the organisation’s risk control systems**. If risk assessments have been conducted on all the organisation’s activities, and the appropriate control measures have been fully implemented, it is probable that safety is being actively controlled at the operational level. However, the extent to which risk assessments have been conducted can only be determined if such assessments and the appropriate control measures have been properly recorded. Thus, the presence and quality of recorded risk assessments that cover all the organisation’s activities provides an indication of a positive safety culture. The presence of a planned review schedule that fully involves the persons who actually undertake the operational activities also provides an indication of a positive approach to safety.

Another attribute is **the presence and quality of an organisation's safety management information system**. This provides the means by which the organisation can evaluate its ongoing safety activities. It also helps the organisation to measure its effectiveness in controlling safety, as well as producing the information required to enable errors or weaknesses to be corrected.

The extent to which an organisation's safety management systems are reviewed is also a key attribute. This can only be achieved by conducting regular, planned safety management system audits throughout the whole organisation. The frequency with which these are done provides an indication of a positive approach to safety. Conducting audits is one thing, the organisation also has to act upon and implement any recommendations in the audit report. Thus, the extent to which an organisation provides the necessary resources to deal with the findings of audits of processes or the safety management system also provides an indication that there is a solid foundation for safety.

Another key attribute is **the extent to which every employee receives high quality integrated job and safety training**. Giving people infrequent safety lectures in classrooms is insufficient. The evidence required is that a planned integrated series of safety training events (relevant to the participants) are being conducted on a rolling basis for all employees. In addition, the extent to which an organisation actually changes its systems and management practices to support the safety training provides further evidence of a positive approach.

Probably the most important indication of a good safety foundation in an organisation is **the extent to which all employees are aware of their individual role in safety on a daily basis**. If work is perceived as only routine where the risk awareness is usually low, and safety solely dependent on managers and safety specialists, it can be said that the organisation has failed to win people over to the safety effort. Conversely, when safety issues are identified and acted on by all employees as part of their normal working routine, the organisation can be said to have won over people's hearts and minds to the safety cause. That means that all employees understand why safety is important and all feel responsible for and "ownership" of the safety issues.

The position of senior safety staff in an organisation's hierarchy gives a visible indication of the importance attached to safety. If the senior safety staffs have direct and unimpeded access to the head of the organisation, it can be said that the organisation actively recognizes the important contribution that the safety function makes to the organisation.

All the above attributes play an important role in establishing a good

foundation for safety in an organisation. These attributes, individually or in totality do not constitute a safety culture, although they are an important part of it.

3.5 Weakening safety culture

Latent weaknesses

The scientist James Reason has done research on accidents and how they occur. According to Reason [19] accidents and incidents occur because of the existence of active errors and latent circumstances. An active error is an error committed by an operator in the system (pilot, air traffic controller, reactor operator etc.). Latent circumstances are for example bad design, malfunctioning leadership, manufacturing or maintenance errors, bad procedures, bad automation, deficiencies in training, and inadequate equipment. These circumstances can exist for many years before a combination of the current situation and active errors results in breaking the safety barriers of the system and causes an accident. Latent circumstances develop through strategic and other decisions by governments, regulators, manufacturers, designers and managers. The effects of these decisions are spread in the organisation and create a distinct culture which can lead to unsafe behaviour. For an accident to happen it requires an unusual situation when a number of “holes” in the safety barriers coincide. The “holes” are caused both by active errors and latent circumstances (Reason’s Swiss Cheese Model, see Fig. 3.6). It should be noted that the “holes” do not need to be large. Minor “holes” resulting from what is called “normalisation of deviances” can result in disaster. “Normalisation of deviances” is a phenomenon that occurs when you continue operations in spite of minor faults because nothing untoward has happened so far.

Latent circumstances include bad design, malfunctioning leadership, manufacturing or maintenance errors, bad procedures, bad automation, deficiencies in training, inadequate equipment, etc.

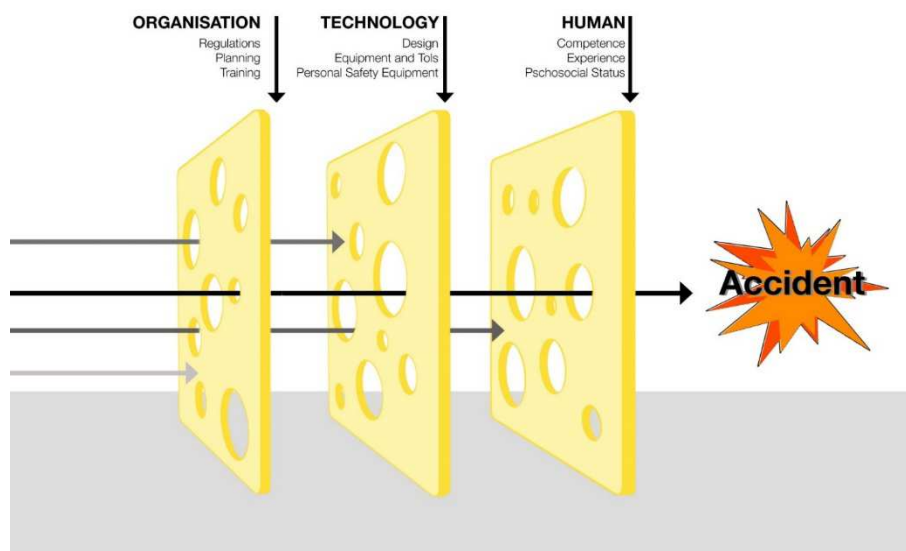


Figure 3.6: Reason's Swiss Cheese Model.

The recent research on severe accidents shows that the organisational factors are usually related to the safety culture. For example normalisation of deviations is a symptom of a declining safety culture. An organisation which has started to accept deviations has developed a culture where safety is not fully prioritized. In a perspective of safety culture Reason's Swiss Cheese Model can be used to show how important it is for the all members in a nuclear organisation to take responsibility for safety and be alert for deviations, especially smaller deviations, and take corrective actions. In all departments deviations occur, the important thing is to understand that each person in a high risk organisation has a safety responsibility to report and act. Managers cannot cover all areas of expertise in their departments and have full control. The organisation relies on the teamwork of all its organisation members to detect and work proactively with deviations.

Symptoms of a weakening safety culture

There is often a delay between the development of weaknesses in safety culture and the occurrence of an event involving a significant safety consequence. The weaknesses can interact to create a potentially unstable safety state that makes an organisation vulnerable to safety incidents. Within the nuclear industry there have been a number of severe events in different parts of the world that have been linked to a weakened safety culture. By being alert to the early warning signs, corrective action can be taken in sufficient time to avoid adverse safety consequences. Both the organisation (which could be a specific plant or utility) and its regulators must pay attention to signs of potential weakness. Some organisations that have encountered difficulties with their safety culture have previously been regarded as good performers by their industry peers. Good past performance is sometimes the first stage in the process of decline.

The following model has five stages of decline as presented in Table 3.1 [15], with each stage being more severe in its consequences than the previous stage. The model is reflective more of an organisation in secular decline rather than an organisation suddenly faced with a catastrophic event that could not be reasonably anticipated.

Table 3.1: Five stages of decline.

Stage	Name of stage	Characteristic of stage
1	Over-confidence	Good past performance leading to self-satisfaction.
2	Complacency	Occurrence of minor events that are subjected to minimum self-assessment, and delay in improvement programmes.
3	Denial	Number of minor events increases, with possibly a more significant event. These are treated as isolated events. Findings from audits are considered invalid. Root cause analysis not used.
4	Danger	Several potentially serious events occur but management and employees reject criticism from audits or regulator, by considering their views biased. The oversight function is afraid to confront management.
5	Collapse	Regulator intervenes to implement special evaluations. Management is overwhelmed and may need to be replaced. Major and very costly improvements need to be implemented.

The symptoms can be considered from both **the organisation's** and the **regulator's** perspective.

Organisation's perspective

The following symptoms are particularly relevant from the internal perspective of the organisation. Any self-assessment of safety culture should check for their presence. For some of the symptoms, it may be possible to develop indicators that will be of value in detecting adverse trends.

Lack of a systematic approach: this deficiency can affect all aspects of an organisation's activities. It makes an organisation prone to repeated crises, and some of these may have serious safety consequences. The presence of this deficiency is evidenced by unclear accountabilities, poor decision making processes, and lack of reliable

information and a generally limited understanding of the process. From the safety perspective, it is revealed in the weakness of risk assessment processes. Organisations that adopt a systematic approach do not assess their effectiveness solely on attaining goals, but also judge effectiveness by its ability to acquire inputs, process the inputs, channel the outputs, and maintain stability and balance. In the case of safety culture, a systematic approach would be indicated by the existence of improvement plans, clear goals and accountabilities, monitoring of progress and allocation of adequate resources. Another indication of a lack of a systematic approach is the absence of a process to manage change.

Procedures not properly taken care of: procedures that are not regularly reviewed and updated can become invalid, and possibly result in safety consequences. The preparation, issue and updating of procedures should be subject to quality control. Responsibilities for review should be clear. A positive sign is having the people who have to use the procedures involved in review and writing.

Incidents not analysed in-depth and lessons not learned: repetition of a problem usually indicates that the fundamental cause (or causes) of a problem has not been properly identified. A systematic in-depth analysis of incidents is necessary if lessons are to be learned and the root causes identified. Root cause analysis requires that both the direct and indirect causes of incidents be identified. The causes may be technical, human factor, organisational culture, process, procedure, equipment or environment. Past experience has shown that human factors and safety culture issues play a large part in many events that have safety consequences. A root cause analysis allows the complexity of events to be better understood. Repetition of events may also indicate that the organisation does not have a learning culture. A positive sign that attention is being given to the systematic analysis of events is that training is given to those employees who may have to use this skill.

Resource mismatch: resource mismatch may reveal itself in the form of excessive project slippage, excessive overtime worked by employees, lack of suitably qualified and experienced persons, increased use of contractors in key organisational roles for long periods of time, and repeated requests to regulators for dispensations from regulatory requirements. No allowance is made in the planning process for unanticipated problems, with the consequent lack of margins for completing work. When considering resource mismatch, attention must be given to both the quantity and quality of resources, and whether the mismatch is short or long term. Resource mismatch is often present after a period of organisational downsizing.

Number of violations increasing: violations (conscious deviations from rules, e.g. short cuts) provide an insight into the safety culture. All violations should be thoroughly investigated to establish the root

causes. Where violations are increasing, it may be a sign of an indifferent management environment, or of some organisational stress. Violations should not be confused with errors caused by slips or lapses. The latter are unintended deviations of action from intention.

Increasing backlog of corrective actions: a significant increase in the number of corrective actions that were not implemented within their planned time-scale is a sign that safety may not be given the priority that it warrants. The extent of the backlog is a good indicator of managerial effectiveness in planning, resource allocation, prioritizing and monitoring of work. Attention should be given to both the number of corrective actions that have exceeded their target date for implementation, and the magnitude of the delay.

Verification of readiness for operation or maintenance: incidents often occur at the start-up of a plant after a shutdown for maintenance, or when the plant is not properly prepared by operators for planned maintenance work. Incidents may be caused by a variety of factors: poor pre-work planning, inadequate risk assessment, poor communications or permit-to-work systems, inadequate training, or lack of suitably qualified and experienced staff. The existence of a systematic process for preparing plant for start-up, or for maintenance, is an indicator that attention is being paid to this important aspect of operations. Both operational and maintenance staff should be involved in any verification.

Employee safety concerns not dealt with promptly: employees will become frustrated and de-motivated if they perceive that their safety concerns are ignored, or if they have repeatedly had to raise these concerns before action is taken. They will gain the impression that safety is not important—a poor basis for developing a positive safety culture. The absence of communications between employees and senior managers can prevent safety concerns from being brought to the attention of those who have the authority to initiate remedial action. Senior managers who regularly visit plant are more likely to be aware of safety concerns. There should be a system to allow or encourage employees to raise safety concerns, and which promotes corrective actions.

Disproportionate focus on technical issues: this weakness would be revealed by insufficient attention to those aspects of work involving human factors. Problems would only be perceived as technical challenges with solutions designed to engineer out any human weaknesses. A positive indication that this weakness does not exist is the inclusion of human factors and cultural issues in employee training, particularly in the training of managers. Human factors should be an integral part of risk assessment.

Near miss reporting: the absence of a near miss reporting system does not necessarily indicate a weakening safety culture, but rather that the

organisation does not recognize the valuable information that can be obtained from this type of event. It may be that the organisation is in the early stages of developing a learning culture, or that employees still have the basic cultural assumption that those who commit errors will be punished. The existence of a near miss reporting system is a sign that an organisation has achieved a higher level of sophistication in its approach to safety.

Lack of self-assessment processes: the lack of self-assessment processes is a significant indicator of potential weakness in safety culture. Lacking such processes, an organisation will be blind to deficiencies in safety attitudes and behaviour, and will be ignorant of the root causes of many events. An organisation is unlikely to adopt a philosophy of “continuous improvement” if it does not undertake self-assessment.

Housekeeping: poor standards in housekeeping generally indicate a disinterested management and a poorly motivated workforce, who have little pride in their environment. These weaknesses usually extend into the safety culture. Housekeeping standards have proved to be a good indicator of the general ethos of an organisation.

Regulator perspective

People who come from outside the organisation more readily detect some symptoms.

The regulator is a very important observer of an organisation, and has a key role to play in detecting early signs of a declining safety culture. The following is a list of some symptoms that are best identified from an external perspective. This does not mean that people within an organisation are incapable of detecting these symptoms; it merely means that their involvement in the organisation may make them less conscious of the symptoms.

Failure of corporate memory: significant corporate change must be carefully managed to ensure that the principles of good safety are not jeopardized. Organisations facing economic pressures may try to reduce their costs by downsizing their workforce and eliminating systems or overly simplifying them. This can result in a loss of skill, experience and historical data. The existence of an effective process of managing change is a protection against this consequence. The importance of retaining corporate memory is especially important in the nuclear industry which will face decommissioning work extending over many decades, and which will involve a new generation of employees. An indication of this weakness is a lack of adequate records, and a disproportionate number of experienced people leaving the organisation. The re-hiring of some of these people as consultants is possible evidence that the corporate memory is weak, especially if they are repeatedly needed to cope with problems.

Low status of the Quality Assurance (QA) function: a common finding of investigations into organisations that have encountered serious safety problems is the low status of the QA function. QA employees are viewed in a negative light and perceived by other employees to be undertaking a policing role. QA findings are often ignored or not addressed in a timely manner. An indication of the status of the QA function can be obtained from employee surveys, and also by examining how QA findings are addressed.

Role of Headquarters (HQ): often the operational sites of an organisation are geographically separate from their HQ. This separateness can result in different organisational sub-cultures developing, with consequences for communications and relationships. At individual sites, corporate goals may be subordinated to local goals, and policies and standards not uniformly applied. Relationships can become disharmonious, and it is unlikely that a sound safety culture can develop in such a climate. There may be a lack of awareness of safety issues at the corporate level, and they may be ignored when making business decisions. It is important that people from both the sites and HQ interact on a frequent basis to share information about all issues that are affecting their work. Senior managers located at HQ should regularly visit the sites, and whilst visiting ensure that they meet a wide range of employees.

Lack of ownership: a responsible attitude to safety is unlikely to develop when there is a lack of ownership of safety. Lack of ownership usually indicates a lack of commitment. This is particularly serious when lack of ownership exists among senior managers, as this disinterest will percolate down the management chain in the organisation. At the operational level, it will be revealed by an abdication of safety responsibilities to safety specialists.

Isolationism: organisations or parts of organisations can become isolated because of geography or from the way an organisation is structured. In an isolated organisation, safety standards can become unrelated to modern standards, and the organisation increasingly operates in a self-referencing mode. Insularity can also be internal to an organisation if many sub-cultures exist and they do not communicate with each other. This inhibits learning from shared information and experience.

Lack of learning: an organisation seeking to develop its safety culture should be willing to share knowledge and experience with others, as well as using the experience of others to improve its own safety. A learning organisation will adopt this approach. The nuclear industry is an industry that has been keen to share experience internationally. Problems can arise when organisations become complacent and focus on the successes of the past, and are reluctant to invest in building new skills for the future.

Unwillingness to share or co-operate: this symptom is closely associated with the previous two weaknesses. The existence of sub-cultures can result in a strongly shared purpose that motivates employees in their local groups, but which creates communication barriers between groups. Co-operation can be inhibited as groups seek to protect their status, or competitive position. Safety culture requires openness in communications and co-operative relationships. It is unlikely to develop positively when these requirements are absent.

Failure to deal with the findings of independent external safety reviews: regulators or other external groups may carry out safety reviews. Ignoring the findings of these reviews could indicate that safety is not considered a priority issue, or that there is a reluctance to accept proposals for change that were not developed internally. This would indicate a potentially weak safety culture. A positive indication would be the existence of a process to monitor progress in implementing the findings of reviews. Information on progress would be shared with those responsible for carrying out the review.

Deficiencies in the regulatory body: regulators have an important role to play in assisting organisations develop a positive safety culture. Representatives of the regulatory body should be trained in safety culture issues, so that they are better able to evaluate the safety culture of an organisation. The existence of such training is an indication that the regulator is adopting a broad perspective in its regulatory duties. This will assist it in the development of soundly based regulatory strategies. Regulators will only be able to detect symptoms of a declining safety culture if they have the knowledge to do so.

The presence of a small number of the above symptoms should not be construed as indicating that an organisation has a poor safety culture. Not all the characteristics of a positive safety culture will develop at the same rate; some characteristics will be more challenging than others to develop. However, the presence of many of the symptoms should be a cause for concern, as they would indicate that the organisation's safety state is vulnerable to destabilisation. The destabilizing trigger may be what appears to be a relatively minor event. Many of the symptoms can interact in a synergistic way, increasing the overall impact of their combined effect. For example, where there is a resource mismatch, there may be inadequate verification of readiness for start-up, or maintenance of plant; the pressure of inadequate resources may result in a lack of a systematic approach with shortcuts taken, and procedures modified without proper consideration. The pressure on resources may result in a lack of co-operation between groups as they give priority to their own goals. It may also result in a disproportionate focus on technical issues, as there is no time available to consider the human factor aspects.

The presence of many of the symptoms is cause for concern.

An organisation that has developed a positive safety culture, and which has a good safety management system, will be less vulnerable to destabilisation when unanticipated events occur. A strong safety culture and good safety management system cannot eliminate the occurrence of unanticipated events, although it can significantly reduce the frequency of their occurrence.

What a strong safety culture creates is resilience to any destabilizing force.

3.6 Development of safety culture

As mentioned before culture takes a long time to develop and requires continuous efforts to be changed. Therefore a continuous, long-term and systematic approach is needed to achieve sustainable improvements of the safety culture. When working with cultural improvements it is necessary to involve the whole organisation, not only the managers. It is good practice to implement a long-term programme, to avoid ad-hoc activities that might cause more harm than constructive achievements.

The IAEA Safety Report Series No. 11 [20] describes the development of safety culture in an organization. It is recognized that there is a large diversity among organizations in their understanding of the concept of safety culture. This might be due to 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 shown by many examples.

The SRS#11 document suggests three stages of development of safety culture in an organization. Description of these stages can serve an organization to identify where it stands and where it aspires to go. An organization does not necessarily have to belong to one of these stages; it can also be in between two stages in which case it would obviously aspire to move to the higher stage. The following is a description of the three stages and their characteristics [20].

Stage I – Safety is based solely on rules and regulations

At this stage, the organization sees safety as an external requirement imposed by the national government or the regulatory body and not as an aspect of conduct that will help the organization to succeed. Mere compliance with rules and regulations is considered adequate.

In 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 with a very little collaboration.
- The decisions taken concentrate upon little more than the need to comply with rules.
- Individuals who make mistakes are blamed for their failure to comply with the rules and procedures.
- Conflicts are not resolved; departments 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 may be viewed as a necessary 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.
- People are rewarded for obedience and results, regardless of long term consequences.

Stage II – Good safety performance becomes an organizational goal

At this stage, the organization has a management that perceives safety performance to be important even in the absence of regulatory pressure. Although there is a 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, like other aspects of business, in terms of targets and goals. The organization begins to look for reasons why safety performance reaches a plateau and is willing to seek the advice of other organizations.

For such organization the following characteristics can be observed:

- 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 management functions as a team and co-ordinates 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 less apportioning of blame.
- Conflict is disturbing and is discouraged in the name of teamwork.
- Management applies management techniques such as management by objectives.

- The organization is open to learning from others, especially techniques and good practices.
- Safety is thought to imply higher costs and reduced production.
- The organization's relationship with regulators, customers, suppliers and contractors is distant rather than close.
- 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, but it is not understood why added controls do not yield the expected results in safety performance.

Stage III – Safety performance can always be improved

An organization at this stage has adopted the idea of continuous improvement in 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 both. Progress is made step by step and never stops. The organization asks how it can help other companies.

The following characteristics can be observed at this stage:

- The organization begins to act strategically with a focus on the longer term. It anticipates problems and acts proactively.
- Staff recognize the need for collaboration between departments and functions. They receive management support, recognition and the resources they need for collaborative work.
- 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.
- Learning from others both inside and outside the organization is valued. Time is made available and devoted to adopting such knowledge.
- Safety and production are seen as interdependent.
- Collaborative relationships are developed between the organization and regulators, suppliers, customers and contractors.

- People are respected and valued for their contributions.
- The relationship between management and employees is respectful and supportive.

The above described stages of an organization apply not only to large utilities but can also be used to shape the performance of smaller companies where safety is a crucial issue, such as for example medical radiography or research reactors.

3.7 Assessment of safety culture

There are two different main categories of assessments of safety culture; self-assessments and independent assessments. A team from the home organisation, preferably with a cross-functional team, conducts self-assessments [21]. An independent assessment is, as the name indicates, performed by a group of external experts, which can also be a regulatory body [22].

Assessing safety culture needs special training and skills; otherwise it can involve risks such as focusing on the wrong aspects of the culture or creating false beliefs about the culture.

Assessments involve different tools:

- Observations,
- Focus groups,
- Questionnaires,
- Interviews,
- Document reviews.

When assessing safety culture it is essential not only to rely on only one tool. A combination of the above mentioned tools is recommended. Another important factor is to address the whole organisation or a full representation of the organisation. The result of the assessment needs to be communicated to the whole organisation. Results that show weaknesses in the safety culture oblige the senior management to implement improvement activities. Senior management commitment determines the success of the outcome. In general managers' commitment and involvement, as stated in the IAEA safety culture attributes, are important contributors to a strong safety culture.

Finally the concept of safety culture consists of all activities needed to create a safe organisation. It includes culture, attitudes, equipment, training, education and other prerequisites that directly or indirectly influence safety in an organisation. Safety culture needs to be seen as something inherent in all aspects of the organisation. Sometimes safety culture is incorrectly treated as apart from the other activities of

the organisation.



Figure 3.7: Influence of safety culture.

Safety culture is, as mentioned, part of every activity in a nuclear organisation. If the safety culture is strong it influences, for example, the design of technical components, safety systems, strategies and management systems (see Fig. 3.7). If the safety culture is weak it will show in poor design, poor strategies to achieve good production results, lack of a systematic approach to work processes etc.

3.8 Questions

1. What is the INSAG-4 definition of safety culture?
2. Explain the framework and the response of individuals in the INSAG-4 concept of safety culture.
3. Describe the three levels model of culture developed by Edgar Schein.
4. Name a few prerequisites for a strong safety culture.
5. Describe Reason's Swiss Cheese Model for accident occurrence.
6. Name a few symptoms of a weakening safety culture.
7. Describe some of the characteristics of each stage in the three stage model of organizational culture.

4 REFERENCES

- [1] EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).
- [2] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, Safety Requirements No. GS-R-3, IAEA, Vienna (2006).
- [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities, Safety Guide No. GS-G-3.1, IAEA, Vienna (2006).
- [4] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Nuclear Installations, Safety Guide No. GS-G-3.5, IAEA, Vienna (2009).
- [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Management System Standards: Comparison between IAEA GS-R-3 and ASME NQA-1-2008 and NQA-1a-2009 Addenda, Safety Reports Series No. 70, IAEA, Vienna (2012).
- [6] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Culture in Pre-operational Phases of Nuclear Power Plant Projects, Safety Reports Series No. 74, IAEA, Vienna (2012).
- [7] Burman, R. & Evans, A., Target Zero: A Culture of Safety. Defence Aviation Safety Centre Journal. Stanmore, UK: MoD Aviation Regulatory & Safety Group (2008).
- [8] INTERNATIONAL ATOMIC ENERGY AGENCY, The Operating Organization for Nuclear Power Plants, Safety Guide No. NS-G-2.4, IAEA, Vienna (2001).
- [9] INTERNATIONAL ATOMIC ENERGY AGENCY, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants, Safety Standards Series No. NS-G-2.8, IAEA, Vienna (2002).
- [10] Rogovin, M. Three Mile Island – A Report to the Commissioners and the Public, vol. 1, January 1980.
- [11] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Summary Report on the Post-Accident Review on the Chernobyl Accident, Safety Series No. 75-INSAG-1, IAEA, Vienna (1986).
- [12] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Basic Safety Principles for Nuclear Power Plants, Safety Series No. 75-INSAG-3, Rev. 1, IAEA, Vienna (1999).
- [13] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Safety Culture, Safety Series No. 75-INSAG-4, IAEA,

- Vienna (1991).
- [14] Medvedev, G. (1989). *The Truth About Chernobyl*. VAAP. First American edition published by Basic Books in 1991. ISBN 2-226-04031-5
 - [15] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, The Chernobyl Accident: Updating of INSAG-1, Safety Series No. 75-INSAG-7, IAEA, Vienna (1992).
 - [16] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Culture in Nuclear Installations: Guidance for Use in the Enhancement of Safety Culture, IAEA-TECDOC-1329, Vienna (2002).
 - [17] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Key Practical Issues in Strengthening Safety Culture, INSAG-15, IAEA, Vienna (2002).
 - [18] Skriver, J., A simple model of safety culture. In D. de Waard, K. A. Brookhuis & C. M. Weikert (Eds.), Human factors in design (pp. 51-59). Maastricht, NL: Shaker Publishing, (2004).
 - [19] Reason, J., Managing the risks of organizational accidents. Aldershot, UK: Ashgate, (1997).
 - [20] INTERNATIONAL ATOMIC ENERGY AGENCY, Developing Safety Culture in Nuclear Activities, Safety Reports Series No. 11, IAEA, Vienna (1998).
 - [21] INTERNATIONAL ATOMIC ENERGY AGENCY, Self-Assessment of Safety Culture in Nuclear Installations: Highlights and Good Practices, IAEA-TECDOC-1321, Vienna, (2002).
 - [22] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulatory Oversight of Safety Culture in Nuclear Installations, IAEA-TECDOC-1707, Vienna (2013).

5 Appendix: Case studies

Read the cases below and try to pinpoint possible conditions and latent failures that may have contributed to the accident. Discuss the safety culture of the organization and the role of the management.

5.1 Case 1: Piper Alpha Accident

Piper Alpha (Figure 5.1) was an oil and gas platform in the North Sea used to pump oil and gas, as well as to transport them to shore from other platforms located in the vicinity. It had two lines with two compressors for transportation purposes. The company policy was that no matter what, one compressor must be in operation as stopping transport would mean several days lost in re-starting it which in turn would be associated with large costs.



Figure 5.1: Piper Alpha oil and gas platform in the North Sea.

On one particular day, compressor A was in maintenance with the safety valve taken out and a blank plate installed in its place, which was the normal maintenance practice. The maintenance work was not completed during the normal shift and it was left to be completed by the next shift. There was, however, no verbal shift turnover and the next shift was not aware of the actual conditions in line A.

During the second shift, compressor B stopped and could not be restarted. The shift supervisor looked into the logbook and decided that it was safe to start compressor A. The practice at the platform was such that written information about the state of the equipment was stored locally, next to the equipment and not centrally in the logbook. This practice had the advantage that all information about the equipment was available locally, but had the huge disadvantage that the logbook did not contain the complete information on the status of the platform.

Once compressor A was restarted, the banking plate could not withstand the pressure which resulted in a large gas explosion. The fire quickly spread across the entire platform as the fire walls could not withstand the explosion. The reason for that was that the platform was originally designed only as an oil platform and that such an explosion was not considered to be a hazard. Once it became a gas platform as well this hazard had become real, but the original design of the firewalls was not re-examined.

The fire would eventually have burned itself out if it hadn't been fed new oil from two other platforms. Both platforms could see from a distance that Piper Alpha was in flames but the company procedure did not allow them to stop pumping oil as restart would take several days which would mean large costs.

Platform Piper Alfa eventually collapsed into the sea.

5.2 Case 2: Herald of Free Enterprise

The ferry Herald of Free Enterprise was docked at No. 12 berth in Zeebrugge harbour and was loading passengers and vehicles before making the crossing to Dover. The No 12 berth was not capable of loading both car decks (E and G) at the same time, having only a single ramp. Due to high water the ramp could not be elevated sufficiently to reach E deck. To achieve this it was necessary to trim the ship nose down and normal procedure was to start filling one of the trim tanks 2 hours before arrival.

At 18:05 on 6 March 1987 the Herald went astern from the berth, turned to starboard and proceeded to sea with both her inner and outer bow doors fully open. The assistant bosun, whose job it was to close the doors, was asleep in his cabin, having just been relieved from maintenance and cleaning duties. The bosun (his immediate superior) was the last man to leave G deck. He noticed that the bow doors were open, but did not close them since he did not see that as part of his duties.

The chief officer checked that there are no passengers on G deck and thought he saw the assistant bosun going to close the doors (the testimony is confused on this point). The chief officer responsible for ensuring door closure was also required (by company orders) to be on the bridge 15 minutes before sailing time.

Because of delays at Dover there was great pressure on crews to sail early. A memo from the operations manager said: "Put pressure on your first officer – if you don't think he's moving fast enough ... sailing late out of Zeebrugge isn't on. It's 15 minutes early for us".

Company standing orders (ambiguously worded) appear to call for

“negative reporting” only. If not told otherwise, the master should assume that all is well. The Chief Officer did not make a report, nor did the master ask him for one.

Despite repeated requests from the masters to the management, no bow door indicators were available on the bridge (it was not possible to see the bow doors from the bridge), and the master was unaware that he had sailed with the bow doors open. The estimated cost of indicators was £ 400 – 500.

On leaving harbour, the master increased speed. Water entered through the open bow doors and flooded into G deck. At around 18:27 Herald capsized to port.

5.3 Case 3: Space Shuttle Challenger



Figure 5.2: Space Shuttle Challenger during take-off.

In **1977** Thiokol engineers test firing the solid fuel rocket booster discover that casing joints expand instead of tightening (as designed). Thiokol tells NASA that this is “not desirable but acceptable”.

NASA plans two lightweight versions of the boosters in **1981** in order to increase payload. One of them is made of steel and the other of carbon filament. Hercules submits an improved design for the carbon filament version which includes a lip at the joint to prevent the O-ring from unseating (“a capture feature”). Thiokol continues to use unmodified joints.

In **November 1981** scorching was noticed on one of the six primary O-rings (the same one involved in the Challenger disaster). **December 1982** NASA upgrades the criticality rating on the joints to 1, meaning that the failure of this joint could cause loss of both crew and spacecraft.

In **April 1983** some NASA engineers seek to adapt the Hercules “capture feature” into the new thinner boosters. The proposal is shelved and the old joints continue to fly.

Just before the 10th shuttle launch in **February 1984** pressure air tests are carried out on the booster joints. On return an inch-long scorch is found on one of the primary O-rings. Despite the critical 1 rating, Marshall Space Centre reports that no remedial action is required. No connection is noticed between high-pressure testing and scorching.

In **April 1984**, on the 11th flight one of the O-rings is found to be breached altogether, but this was still regarded as acceptable. No connection was made between high-pressure air testing and scorching even though it was found on 10 of the previous 14 flights. In **January 1985** “blowbys” are found on four of the booster joints. The weather at launch was the coldest to date (51° F). No connection noted.

On the 17th shuttle mission the primary O-ring in the nozzle joint fails to seal and scorching is found all around the joint.

After another flight with three blowbys, the NASA booster project manager places a launch constraint on the entire shuttle system (**July 1985**), meaning that no launch can take place if there are any worries about a criticality 1-item. But waivers may be granted if it is thought that the problem will not occur in flight. Waivers are granted and since top NASA management were unaware of the constraint, the waivers are not queried.

In **July 1985** a Thiokol engineer writes a memo warning of catastrophe if a blowout should occur in a field joint.

In **August 1985** Marshall and Thiokol engineers meet to discuss blowbys. Senior NASA manager misses meeting. Subsequently 43 joint improvements are ordered.

Thiokol’s director of the solid rocket motor project urges “close out” on the O-ring problem (meaning it should be ignored) on the grounds that new designs were on the way and the difficulties were being worked on (**December 1985**). The solutions would, however, not be ready for some time.

On **January 23, 1986**, five days before launch, the entry “Problem is considered closed” is placed in a NASA document called the Marshall Problem Reports.

On the night before the launch it is thought probable that the temperature would fall into the twenties, some 15°F colder than the previous coldest launch (actual launch temperature was 36°F). At this point Thiokol's chief engineer at the Kennedy Space Centre (the "close out" man) experiences a change of heart and attempts to stop the launch.

On **January 28, 1986**, the Challenger shuttle is launched and explodes seconds after, killing all seven crew members. A blowout occurred on one of the primary booster O-rings.

The investigation after the event concluded that NASA's safety culture shifted into risk-taking, not suddenly and deliberately, but step by step over time. There was frequent use of the phrase "**acceptable risk**". Engineers that questioned the launch after an unusually cold night were asked to prove that it was unsafe.

17 years later.....



Figure 5.3: Accident of Space Shuttle Columbia.

.....in **2003 the Columbia Space Shuttle accident** occurred. 82 seconds after the launch, a large piece of insulating material from the external tank broke free and struck the shuttle's left wing, damaging the protective carbon heat shielding panels.

This damage allowed super-heated gases to enter the wing structure during re-entry into the atmosphere which proved to be fatal for the space shuttle's 7 crew members.

The problem of debris shedding from the external tank was well known. It had caused damage on every prior shuttle flight. The damage was usually, but not always, minor. Management gained confidence that it was **an acceptable risk**.

5.4 Case 4: Davis-Besse Reactor Pressure Vessel (RPV) Head deterioration

During an outage in 2002, inspection of the control rod drive mechanism (CRDM) revealed nozzle cracking on the head of the reactor pressure vessel. After the nozzle crack repair (welding), the nozzle was observed to tip sideways. After removing the deposited boric acid, a large cavity was observed (see the picture above) on the top of the reactor pressure vessel head.



Figure 5.4: Davis-Besse Reactor Pressure Vessel Head deterioration.

On ultrasonic testing the remaining thickness of the RPV head was found to measure 3/8 inch, which corresponds to the thickness of the stainless steel cladding. The stainless steel cladding was the only remaining boundary of the primary loop.

The corrosive effects of boric acid were first observed in 1987 at the Turkey Point and Salem nuclear power plants. In 1988 NRC issued a Generic Letter 88-05 addressing the corrosive effects of boric acid. At Davis-Besse itself these were observed from 1996 onwards.

The utility believed that corrosion was due to leakage through the CRDM flange and that elevated temperatures at that location would prevent corrosion.

For several years warning signs were ignored at Davis-Besse, including industry reports, coolant leakage, rust, boron on filters, and the amount of dry boric acid on the RPV head.

5.5 Case 5: Breached separation between fire compartments in a reactor building - Fire safety doors left open

This case has been selected to represent a common problem as observed in several nuclear power plants, in particular during outages. Fire safety doors are left open due to maintenance work and thus the fire safety separation principles are violated.

Read the case below and try to pinpoint possible conditions and latent failures that may have contributed to the accident. Discuss the safety culture of the organization and the role of the management.

On August 10th 2006 in cold shutdown conditions during the annual outage, the door between room no. 1.23 and 1.24 was detected to have been left open. The automatic door closing device was not working due to a technical failure. The fault was reported in the maintenance system. While waiting for the door to be repaired a sign was put up stating that the door must be closed after passage. After the sign had been posted by the door several people passed through it and despite the sign, the door was still left open by the people passing.

A member of the operational staff was assigned to guard the door until the automatic door closing device had been repaired. After the repair was completed the fire compartment separation was restored.

A number of persons passed through the door but did not obey to the sign stating that the door must be closed. The internal incident report stated that the causes of the incident were lack of knowledge of the rules that the door must be shut and the rules concerning fire safety regulations, and also due to lack of safety culture.

Fire safety zones and fire cells must be operational at all times in order to maintain the fire safety separation between different parts of the plant and to protect safety equipment. The fire safety separation is maintained through closed doors and sealed openings between rooms designed to be fire safety cells within the plant. When the separation is not maintained the defence in depth function is not in operation since a fire in one room could spread to other rooms.

The views expressed in this document do not necessarily reflect the views of the European Commission.