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TOPIC 1:

MANAGEMENT OF SAFETY AND SAFETY CULTURE

A Framework for the Organizational Assumptions Underlying Safety Culture

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Abstract. The safety culture of the nuclear organization can be addressed at the three levels of culture proposed by Edgar Schein. The industry literature provides a great deal of insight at the artefact and espoused value levels, although as yet it remains somewhat disorganized. There is, however, an overall lack of understanding of the assumption level of safety culture. This paper describes a possible framework for conceptualizing the assumption level, suggesting that safety culture is grounded in unconscious beliefs about the nature of the safety problem, its solution and how to organize to achieve the solution. Using this framework, the organization can begin to uncover the assumptions at play in its normal operation, decisions and events and, if necessary, engage in a process to shift them towards assumptions more supportive of a strong safety culture.

1. Introduction

The term Safety Culture was adopted by the IAEA in recognition of the fact that nuclear safety is heavily dependent on the actions and, therefore, the thoughts of people within the organization. The power of the concept lies in the notion of safety as cultural phenomenon: we know quite a lot about safety, we know quite a bit about culture, what happens when we combine the two?

Edgar Schein [1,2], one of the top thinkers on the subject, proposes three levels of organizational culture:

(a) artefacts: "visible organizational structures and processes...all the phenomena that one sees, hears and feels..."
(b) espoused values: "strategies, goals, philosophies..." - what the organization says about itself.
(c) underlying assumptions: "unconscious, taken-for-granted beliefs, perceptions, thoughts and feelings...the ultimate source of values and action."

Since the inception of the safety culture concept, the IAEA, WANO, INPO, numerous regulatory bodies, as well as nuclear organizations, have all worked to determine what it actually means both in theory and in practice. The result in 2002 is a large collection of valuable, but partially inconsistent and overlapping, insights. The safety culture literature has much to say about the artefacts, espoused values and underlying assumptions supportive of safety, but is often confusing for not making the distinction between them.

2. Artefacts: The Defences

The majority of the industry literature addresses the artefact level of safety culture. These are the things that we actually *do* to ensure safe operation, including, for example, up-to-date procedures, conservative decision-making, open communication, self-checking, clear lines of authority, assessment & improvement processes, etc. Generally speaking, these are the defences that exist to safeguard the nuclear hazard. As such, they are the ultimate focus of a strong safety culture.

Much is known about the defences needed to maintain nuclear safety. Given the disorganization of the industry literature, however, it is recommended that operating organizations construct a coherent model of what safety culture means to them at the artefact level, so that they can perform self-assessments and upgrade their understanding as they progress.

3. Espoused Values

Espoused values are what the organization says it wants to be and do, usually generated by management. They often take the form of slogans, posters and mission statements designed to promote certain types of behaviour, attitudes or expectations. They can assist change by becoming a memorable

prompt to thought or action. It is obvious, however, that espoused values are not always matched by action; what we say we want is not always the same as what we actually do. [1,2,3]

Industry insights often enter organizations as espoused values. In particular, the standards and criteria set out by agencies such as the IAEA (OSART Guidelines) and WANO (Performance Objectives and Criteria (PO&Cs)) are intended to hold the status of espoused values. Sometimes these are readily adopted and quickly become artefacts. On occasion, however, changes that would serve to enhance safety fail to become standard practice. The key to understanding an organization's pattern of artefacts, as well as the means to change them, lies one cultural level down with the underlying assumptions.

4. Underlying Assumptions

Assumptions, as discussed here, are largely unconscious beliefs that are only made visible by interpreting observable patterns of behaviour. Assumptions exist in an organization in order to simplify what is otherwise an enormously complex reality [4,5]. The assumption 'people are generally good', for instance, can help people interpret the motives of others, make judgments about who to trust and shape the disciplinary process. Underlying assumptions in the organization have a significant impact on artefacts [1,2] and, therefore, on safety.

In order to be successful an organization has to solve certain problems, a process that can be supported, enhanced, endangered or stymied by the underlying assumptions of the organizational culture. As such, an organization's underlying assumptions can be separated into three types:

(a) assumptions about the problem – what is it we are trying to achieve?
(b) assumptions about the solution
(c) assumptions about how to organize in order to achieve the solution

4.1. Assumptions about the Problem

When it comes to the nuclear power industry, the significant (although not the only) problem is obviously safe operation. Industry experience suggests that the best way of conceptualizing this problem is in terms of *vulnerability*: we are vulnerable to the (enormously) harmful potential of the nuclear reactor. The original IAEA document on the subject states that the purpose of safety culture is "to establish that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance." [6] This is the starting point.

4.2. Assumptions about the Solution

Faced with this vulnerability, the nuclear organization holds a number of assumptions about how to deal with it, how best to solve the problem. Industry experience also has much to say on this score. It is commonly accepted that the best, indeed the only way to reduce vulnerability, is through the principle of *defence in depth*. "To compensate for potential human and mechanical failures, a defence in depth concept is implemented, centered on several levels of protection, including successive barriers preventing the release of radioactive material to the environment." [7]

The safety culture of the nuclear organization should, therefore, hold the assumption that defence in depth is the only means to maintain safety. All defences can be separated into one of three types: plant, process or people. The nuclear organization holds assumptions about the importance and state of each of these types of defences. Generally speaking, the organization should assume that each type of defence is important to nuclear safety and not let assumptions about the efficacy of certain defences reduce the overall assumption of vulnerability. Assumptions that would be indicative of a strong safety culture are:

- PLANT: The plant is an effective safety barrier if it is in the design condition and design configuration
- PROCESS: Processes are effective if they are specified, understood and followed

- PEOPLE: People are effective if they are trained and qualified and if they get specific personal performance feedback in adopting human performance practices
- DEFENCE IN DEPTH: The types of safety barrier are mutually interdependent, and consequently they cannot be traded off against each other.

These assumptions can be looked for in the day-to-day functioning of the organization. For example operation with degraded equipment in the absence of compensatory measures indicates that decision makers are not holding to the safety culture assumption about the plant barrier.

4.3. Assumptions about How to Organize

Given the understanding of the problem and the solution, the organization holds a set of assumptions about how best to go about achieving the solution. In close accordance with Edgar Schein's work [1,2,3], we suggest that there are six types of assumptions shaping the nature of the organization:

(a) action – assumptions about the sorts of things we should be doing
(b) information – assumptions about the accepted basis for judgments
(c) motivation – assumptions about how people are motivated and how to change behavior
(d) hierarchy – assumptions about the application of power in the organization
(e) leadership – assumptions about the role of leaders
(f) time – assumptions about the relationship between past, present and future

When it comes to the assumptions about how to organize, there are no inherently 'good' or 'bad' assumptions; the question is whether they are supportive or unsupportive of the organization's purpose. In terms of the nuclear organization, this set of assumptions should be firmly grounded in the assumptions about vulnerability and defence in depth.

5. What Can Go Wrong?

There are essentially two potential problems with an organization's set of underlying assumptions: an invalid assumption (or more than one) or an imbalance in the relationship between assumptions. [1,2]

The most damaging type of invalid assumption occurs when the organization has a faulty conception of the problem and/or the solution. In the context of the nuclear organization this would include such assumptions as 'the reactor is inherently safe' or 'it is okay to compromise one line of defence as long as others are maintained'. If the organization begins with invalid assumptions about the nature of and the solution to the safety problem, achieving a strong safety culture becomes impossible.

The relationship between assumptions is problematic if one assumption has an undue influence on other assumptions. If, for example, the organization holds an overly powerful assumption that 'the leadership must not lose face' other assumptions will come to be defined in terms of it. Thus an assumption about information might become 'valid information is that which supports management's position', which would, in turn, compromise accurate assumptions about the state of the plant. These overly powerful assumptions are 'black-holes'.

It is important to note that a black-hole assumption is not necessarily an invalid one. It is vital, for instance, that the nuclear organization have an assumption about the importance of the physical state of the plant as a defence. A problem results, however, if this overwhelms and undermines assumptions about the importance of process and people as defences, such that all assumptions about action, time, motivation, etc. revolve around the plant.

6. Changing the Culture

It is people's actual behaviours and the plant conditions that create or prevent events. The first step towards improvement is, therefore, to assess which artefacts require change by comparing what actually happens (artefacts) against espoused values such as the WANO PO&Cs. If new procedures, etc. are capable of fixing safety problems within the existing culture then there is no need to alter the

organization's underlying assumptions [2,3]. However, if there are incorrect or misaligned assumptions at play then the organization must set about changing them.

Assumptions are social phenomena. They are passed from person to person and organizational generation to generation, and are significant precisely because they are held by almost everyone. If assumptions are damaging to the organization's purpose, it is the task of the leadership to shift them. [1,2] Leaders can only achieve this by becoming aware of the faults of their own assumptions and targeting a very specific area for change. They must then constantly and persistently model, explain and demand a new way of perceiving, thinking and acting.

As is evident in the discussion above, assumptions impact on each other and the relationships between them are often more significant than their actual content. Assumptions breed assumptions. If, for example, the leadership exhibits the assumption that 'up-to-date information about the state of the plant is vital', it is logical for people to infer that 'the plant is not inherently safe, rather it must be maintained in a safe state.' It is this process of 'assumption-hopping' that leaders must capitalize on when embarking on a process of culture change.

When entering into a process of culture change, leaders have a choice: they can either attempt to change the content of an invalid assumption or they can try to shift the relationship between assumptions. When it comes to black-hole assumptions, it may make more sense to build-up another complementary assumption, rather than attack the overly-powerful, but often valid assumption.

Some techniques for shifting assumptions include:

(a) creating a framework and a vocabulary for discussing the underlying assumptions, together with phrases that describe the targeted 'old' and 'new' assumptions
(b) developing a method to reveal the assumptions that were at play in certain events and decisions
(c) reviewing certain plans or actions before execution to look for embedded assumptions (both the old and the new set)
(d) developing communication skills to reveal assumptions through stories and in discussions with staff

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LNPS Safety Culture Enhancement during Operations Preparation

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Abstract: The safety culture enhancement programme during the LING AO nuclear power plant operation preparation is described in this paper.

1. Generals

1.1. Characteristics of operations preparation in nuclear power plant

Operations preparation in nuclear power plant includes preparation of organization, staff, technology, documentation and etc. At the same time, cooperation with project departments is required for commissioning and accepting systems and equipment. It has the following characteristics.

New staff: the development of civil nuclear industry in China is only of a short period and qualified personnel in the field of nuclear power is scarce. To set up the new organization for operations preparation, large number of new staff were recruited from schools, conventional power companies and other companies in the nuclear power industry and institutes.

New team: Due to the variety sources of operations preparation staff and short period of team organization, the concepts, knowledge structure and understanding of nuclear power among staff vary greatly. What's more, the operational organization of nuclear power plant differs with that of conventional power companies. For a new team, time is required to reach good understanding, cooperation and communication.

Heavy training tasks: With new staff, new team and new organization, staff require new skills and knowledge to complete new tasks jointly, and training is a very important method. What's more, training and promotion are needed to set up a culture commonly recognized by the team members.

Strict timing: the construction of a nuclear power plant is a huge project with large scope of investment and high investment risks. Thus, strict timing of project construction is emphasized. To guarantee on-schedule operation of the nuclear power plant, operations preparation must be scheduled to enable a timely or advanced take-over and every activity must match the progress of the project.

High risks: the construction site of nuclear power plant is complicated with cross-working and interfaces of all the activities including construction, installation, commissioning and take-over and there are many potential industrial safety risks on site. Operations preparation staff are working on site to be familiar with systems and equipment, prepare and validate operational procedures, participate commissioning and take-over equipment, systems and buildings, and be in charge of temporary operation and surveillance of system and equipment.

The risks and quality of these activities will have impact on the smooth progress of the project and take-over for operation.

1.2. Significance of safety culture promotion during operation preparation stage

From the above characteristics of operation preparation, it can be observed that it is significant to strongly promote safety culture development when the new team is set up at the beginning of operation preparation. Through the promotion of safety culture, the following advantages will be produced to operation preparation and future safe operation of the plant.

- Cultivate values and cultural concepts commonly abiding by and agreed upon by all the members;
- Form good work habits and the consciousness of "Safety First, Quality First" in the team at the beginning;
- On the basis of the commonly recognized culture, reinforce awareness to the importance of maintaining safe operation of the nuclear power plant, strengthen sense of crisis and improve the skills and knowledge of the staff;
- Lay a sound organizational, behavioral and mass foundation for the long-term stable and economic operation of the nuclear power plant.

1.3. Transfer of nuclear safety responsibility

Nuclear safety is unique to nuclear power plant. Its purpose is to set up and maintain effective in-depth defense to avoid the occurrence of event and to protect plant staff, the public and environment from the harm of radioactivity exposure.

Once the reactor is loaded, the operational unit of the nuclear power plant will undertake relevant nuclear safety responsibility in accordance with nuclear safety related national laws and regulations.

To guarantee the undertaking of nuclear safety responsibility, operational unit of the nuclear power plant must establish plant organization, mobilize qualified and suitable human resources and other resources, and set up rules and stipulations and work procedures governing various operational activities as per nuclear safety related national laws and regulations

To ensure the safety of first fuel core loading, LNPS has set up relevant fuel loading conditions check-list and guideline for their fulfillment.

In general, the safety management of nuclear power plant is a rather complicated systematic project, and the management concept itself involves "systematic safety" and the promotion of safety culture must be systematic which requires comprehensive planning, development and management. At the beginning of a new organization in the operations preparation stage, good and systematic management concepts and good work habits is set up. Good start means half way to the success. This will contribute greatly to the operational safety management during the lifetime of the nuclear power plant.

2. Organization and management of safety culture promotion

2.1. Organization of safety culture promotion

Leadership in the team plays a key role in the formation of a team culture and the activities of leaders are to be examples. The safety culture promotion organization shall be turned into a learning organization so as to drive the complete operations preparation organization to become active learning organization.

This promotion organization shall have project manager of the promotion group as the center and the promotion facilitator of every department as node so as to form a network structure. Thus, the promotion activities will not be broken by interfaces between different departments. The mutual development, impact and cooperation of this network structure can enable the operation preparation and safety culture promotion to be developed at the same time so as to realize the target of common values and cultures recognized by all the members of the power plant.

Leader in this organization functions as designer and coach. He is in charge of the organization and shall ensure new problems and issues understood during the process and clear up thoughts; define direction and target; keep learning and renovation spirits within the organization.

Every promotion facilitator is in charge of safety culture promotion of the department and, at the same time, is coordinator and liaison officer within the organization. Selection of the facilitator is very important in that he must have enough knowledge and experience in the area of safety, strong sense of responsibility, and be capable of promotion and active in learning.

2.2. Promotion management of safety culture

When the organization is set up, the following activity is the management of the promotion activity. It is appropriate to promote safety culture in the way of project management.

Firstly, investigation must be performed on the current status of safety culture within operations preparation organization to find out the weakness and potential problems within the organization, specify policy and strategy for safety culture promotion and define key points and target of promotion.

Secondly, stipulate implementation and checking schedule as per promotion projects defined. Every facilitator is in charge of promotion, implementation and follow-up of the schedule in the department.

Then, implementation of promotion strategy and schedule will be periodically assessed and reviewed to detect weakness; and at the same time, follow-up will be performed to the new issues and problems occurred during operations preparation activities, especially the problems, to update promotion schedule continuously so as to improve promotion by taking mistakes as chances of learning and lessons.

What's more, integrated consideration shall be given to safety culture promotion of contractors. Since all the contractors can contribute to the improvement of plant safety, they shall get involved in safety and quality related activities of the plant. Thus, a comprehensive

team will be formed so that responsibility of the plant to safety will not be diluted by the participation of contractors.

2. Promotion of Safety Culture

3.1. Safety culture promotion schedule during operations preparation period

3.1.1. Design of safety culture promotion schedule

The design of safety culture promotion schedule must be realistic: the operations preparation organization and status of staff and safety culture must be analyzed and realistic, effective and operable schedule shall be applied and promoted step by step. It is included the following contents in the LNPS safety culture promotion schedule:

(1) specify safety policy and safety culture expectation of the organization;
(2) investigate and assess the current safety culture status within the organization;
(3) define areas to be improved and strengthened;
(4) define contents and scope of safety culture promotion base on the above situation;
(5) set up safety culture promotion group and define facilitator of every department;
(6) define promotion schedule and assessment schedule;
(7) prepare for the next step of promotion as per assessment results.

The safety policy of LNPS is stipulated as per PDCA principle, which is:

- Plan: define safety commitments, standards, targets and purpose, division of responsibilities;
- Do: promotion of safety culture, process control requirements, risk prevention, normal and emergent operation control, STAR and transparency, PSA and etc. are included;
- Check: including internal and external assessment, audit and checks, self-assessment and problem management;
- Action: For all the deviations, root cause analysis and corrective actions must be performed, and external and internal experience feedback and follow-up and assessment of corrective actions shall also be carried out.

In our safety policy, it is stressed that:

- Nuclear safety is overriding and has the top priority;
- Strictly abide by relevant nuclear safety related national laws, regulations and criteria, and commitments to the country, the public and society. Strive to achieve good operation safety performance and ensure continuous improvement;
- Set up operation safety management system to improve the promotion of safety culture;
- Define clearly responsibilities from management level to working level;
- Ensure in-depth defense of risks, conservative decision-making and transparency for safety issues;
- Timely develop and apply PSA technology as technical support and safety decision;
- Implementation experience feedback system to set up learning organization and repetitive event prevention mechanism;
- Safety culture promotion and cultivation is the first step in management process and work process control;
- Stress the safety responsibility of every staff and that everyone is one safety barrier;
- Encourage every staff to become STAR: stop, think, act, review";

— Participation of all the staff to realize continuous improvement of safety performance.

3.1.2. Key points of safety culture promotion schedule of LNPS

Safety culture promotion schedule of LNPS includes two parts, which are organization management and individual behaviors, and their key points are as follows:

(1) organization management level

— define clearly responsibilities, tasks and requirements of every position of the plant;
— Stipulate transparent and clear safety policy which shall be understood and recognized by the staff and the public;
— Stipulate strict operational safety surveillance and evaluation policy of the plant and inform the staff the results of surveillance and assessment periodically;
— Emphasize attention to internal and external experience feedback, and implementation and effectiveness evaluation of corrective actions;
— Guarantee resources for safety management and safety culture construction;
— Set up and standardize various management means to carry out strict management on every type of operational activities, for example:
  - Stipulations of abiding by procedures;
  - Management patrol;
  - Staff qualification, performance evaluation, and periodic interview;
  - Performance indicators, management schedule follow-up and management and assessment.
— Accept actively and voluntarily the external and internal surveillance and audit , establish good relationship and interface with regulator and auditor;
— Create environment of self-assessment with transparent and open exchange and communication;
— Launch the Ergonomics study for exerting maximum performance of human and machine;
— Integration of constructions of safety culture and corporation culture.

(2) Human behavior:

The key to safety culture construction is the individual behavior and attitude in plant. Thus, the following areas is stressed:

— Firmly set up the idea of safety first and quality first;
— Cultivate good work style and habit;
  - Be serious (follow procedure without going through shortcut and never let go any doubts);
  - Keep learning with questioning attitude (continuous learning with questioning attitude);
  - Risk consciousness (safety consciousness, risk analysis and emergency handling);
  - Quality consciousness (do the thing correctly at the first time, and zero defect);
  - Insist on terminating habitual violation of rules for a long term.
— Cultivate professional morality
  - Sincere and devoting (to career of nuclear power);
  - Correct idea of life and values;

- Modest (respecting others, not self-satisfactory, and not complacent for the past achievement);
- Commitment for safety and sense of responsibility;
- Everyone is a safety barrier;

— Team spirit and individual development;
- Continuous improvement of professional knowledge and skills;
- Mutual trust, cooperation, support and development;
- Common targets and sense of values;
- Sense of team honor.

— Self-improvement and self-criticizing:
- Self-assessment (continuous looking for weakness of oneself);
- Criticize and self-criticize;
- Continuous improvement of team and individual;

— Sense of crisis:
- Discard without improvement;
- Be competitive for positions;
- Accurate knowledge of social environment.

3.1.3. Introduction of the schedule

To realize the key points of the above, the following implementing schedule has been stipulated to promote safety culture during operations preparation stage of LNPS:

(1) Implementing schedule on organization and management:

— Stipulating the Production Quality Organization Manual (PQOM) and organizing series training on quality culture and safety culture to all the staff (including series training on quality promotion such as "economic benefits of quality management and zero defect quality management", "introduction to PQOM", "introduction to quality assurance standards and regulations", "quality management inspection", "management self-assessment", "promotion of quality culture construction" and etc. and training on nuclear safety regulations and standards such as INSAG–3/INSAG–4 and etc.);
— Periodically organizing internal independent assessments on nuclear safety, inviting international peers for peer review and IAEA for Pre-OSART, and organizing periodic self-assessments as per the progress of operations preparation. All these activities help the operations preparation organization of LNPS to detect and eliminate timely potential deficiencies and weakness of the team;
— Responsibility of procedure modification and periodic review has been assigned to individuals;
— Increase the strength of safety culture promotion (such as publishing and issuance of Safety Culture Pamphlet) and training. As prerequisite of authorization, safety culture training and promotion must be updated in its content as per its international experiences;
— Set up and develop performance indicators system;
— The key point of experience feedback is on the detecting of root cause and implementation of corrective actions and its effectiveness assessment;
— RCA(root cause analysis) group is set up under plant operational experience feedback committee to be in charge of investigation of event and root cause analysis to avoid the phenomenon of being prejudiced during root cause analysis;

— Integration of safety culture promotion and team construction into the management plan of every department.

(2) Implementation schedule on individual behaviors

First step: define key elements of safety culture such as safety/quality consciousness, transparency, abiding by procedures and regulations, exchange, strict and serious, learning and questioning, professional morality, continuous self-improvement and etc.

Second step: prepare safety culture promotion and enhancement schedule;

Third step: learn from the lesson of the operation stopping of seven units of Canada Ontario Hydraulic Power Co., improve the safety culture training and integrate its content into individual training schedule;

Fourth step: after arrival of new staff, provide training on plant nuclear safety policy and requirements to cultivate good work style, habits, devoting to one's job and cultivating moral character;

Fifth step: integrate safety culture promotion and enhancement schedule with team construction, management plan, performance indicator to realize dynamic management;

Sixth step: assess and examine periodically to detect potential weakness and realize continuous improvement;

LNPS serves a project linking between the preceding Phase I and the following Phase III and is an honorable and difficult task. Thus, during the operation preparation stage, LNPS has always been adhering to the principles of "Safety First, Quality First" and "Staff Value" and enhancing and developing the safety culture so that the operations preparation can be implemented safety with high quality and efficiency as per schedule and the operation and takeover can be guaranteed. After multi-reactor management, LNPS, as Operations Department II, carries out the "Safety Culture Promotion Schedule" common to the five operations departments which enable the new team to be mature with faster steps. In the PRE-OSART organized by IAEA in August 2001, IAEA recommended the safety culture promotion schedule and measures as good practice to the international peers.

3.2. Function of safety culture elements analysis to promotion of safety culture

By means of detailed analysis of elements impacting safety culture, good and bad tokens of safety culture is detected, and trained to the staff so that employee especially new employee can be aware of individual behaviors and practices, values and professionalism that can help improve plant safety, work quality and economic benefit of the company. At the same time, these behaviors and practices may be standardized as common values and professionalism shared among the staff.

Since the very beginning of operations preparation, LNPS have compiled Safety Culture Pamphlet to include safety culture, safety knowledge, requirements of operational activities on staff behaviors, key elements of safety culture and etc.. This pamphlet is distributed to every staff and, especially when new staff is recruited, training will be organized timely to educate staff before work starts. Also, by means of teaching by personal example as well as

verbal instructions of the experienced staff, common values shared by the plant and concept of "Safety First, Quality First" is cultivated.

3. Self-assessment

Self-assessment is an important means in the "Feedback Circuit" to maintain and improve safety management capability. What's more, LNPS prepared Self-assessment Guideline base on international guidelines for the operational safety assessment (such as OSART, WANO Peer Review) so as to provide specific training to staff in charge of self-assessment to ensure that this tasks reaches acceptable criteria. Self-assessment is a process which not only enable the management to understand the effectiveness of every safety activity and weakness but also, more importantly, itself mobilizes the staff to contribute to the improvement of safety level, that is the chance of giving safety requirements is given to the staff. Practice proves that this is a very effective method.

During self-assessment, plant performance can also be compared with external and internal organizations with excellent performance so as to further stipulate staff to "Strive for Excellence" in work and insist on continuous improvement.

LNPS stipulates system and procedure for periodic self-assessment to detect problems in operations preparation, normal operation and management of plant and

To ensure integrity and effectiveness of operations preparation, timely and successfully putting into commercial operation and long term stable safety operation, the quality of operation preparation is guaranteed by means of the management tool of self-assessment which is applied to perform self-inspection and assessment to operations and preparation, and independent review and audit by internal quality assurance system. On the other hand, exchanges with international power plants are organized. Experts with rich nuclear power plant operational management experiences are invited to perform external independent assessments. By means of reviews by external peers, improvement suggestions are brought on the management and work of the power plant from different perspectives. Thus, international experiences are shared to avoid going into wrong ways and to improve the performance. During operations preparation, EDF, experts with rich nuclear power plant operational management experiences are invited to perform assessment and exchange and good results are achieved.

4. PRE-OSART Conclusion

To check the quality of operation preparation so as to ensure a long term safe operation after commercial operation, LNPS invited IAEA (International Atomic Energy Agency) to send a team perform the Pre-operational Safety Review (Pre-OSART) to the plant through Chinese government in August 2001.

IAEA performed Pre-OSART to LNPS in 9 areas of operations preparation including: a. Management, Organization and Administration; b. Training and Qualification; c. Operation; d. Maintenance; e. Technical Support; f. Radiation Protection; g. Chemistry; h. Emergency Planning and Preparedness; i. Safety Culture.

During the three-week period, experts from different countries performed detailed review to the above areas through site observations and discussions with relevant staff. In the final review report, LNPS is given impersonal evaluation, and 5 strengths are pointed out with

explicit indication of many items and processes of excellent quality, and 4 most important comments are given. For the weakness in operations preparation, the Pre-OSART team raised 44 comments in all including 33 Recommendations and 11 Suggestion. At the same time, experience of LNPS is given thorough recognition and 12 Good Practices of Ling Ao operations preparation is promoted to international peers, among which 2, Safety Culture Pamphlet and Self-assessment Guidance, are for the area of Safety Culture. This activity improves the confidence of LNPS in taking-over activities and safe operation, points out the direction of future improvement and lay a solid foundation for future long term safe operation of the plant.

The MTO Concept and Organisational Learning at Forsmark NPP, Sweden

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Abstract. The term "MTO" (Man-Technology-Organisation) has been widely used by Swedish utilities and regulators to describe knowledge and analytical techniques that focus on human and organisational factors and their relationship with nuclear safety. MTO was introduced in Sweden after the TMI accident as a concept similar to the "Human Factors" (HF) concept developed in the USA. It was the intent that the explicit mention of the three interrelated elements in the concept – Man, Technology and Organisation – would stimulate a comprehensive "system view" on nuclear safety. This view should go beyond a strict technological perspective to recognise and highlight human and organisational factors as important moderators of risk. In retrospect, the MTO concept has been successful in stimulating a socio-technological view of nuclear safety in Sweden – a general trend supported by international developments. A further step along this path has been taken with the LearnSafe project.

1. THE MTO CONCEPT

1.1. Introduction

The MTO concept can be looked upon as three domains: as methods, as a specialist domain, and as an over all system thinking that includes organisational learning. By providing examples and experience from the Forsmark nuclear power plant (NPP), we will illustrate how these different perspectives have been applied and what has been achieved over the years. The description of the MTO concept is a shortened version of a paper presented at the ENS Top Operation Meeting in Berlin 1999 [1]. The future development of organisational learning is illustrated by the description of the EU-project LearnSafe [2].

1.2. Domains of the MTO concept

MTO is associated with at least three different (but related) domains:

(a) MTO as a set of *analytical techniques.*
In this domain the MTO concept focuses on the methods that analyses the relationships between humans, their activities and the organisational and technological context in which these activities take place.

(b) MTO as a *human factors specialist domain.*
In this domain the MTO concept is foremost perceived as a *specialist domain,* supported by know-ledge in human factors, psychology and other human related sciences.

(c) MTO as a *metaphor* for *system thinking* about safety.
In this perspective is the MTO concept viewed neither as a set of specialist domains, nor as a set of specific methods, but rather as a general attempt to develop a safety culture thinking that focuses on the entire socio-technical system (including technology, human factors and organisational issues).

The difference between the three domains may be difficult to grasp at first. MTO methods do, after all, require a system perspective if they are to be applied successfully. Experience supports the conclusion that misunderstanding and neglect of the necessary system perspective are not that uncommon when HF or other MTO methods are applied. A result of this may be neglect of the organisational context in which MTO methods are used. Another result can be that MTO issues are dealt with too much in isolation.

1.3. Management Support

Management attention, understanding and commitment are key issues. Without this commitment and support, the MTO concept would still have been viewed as nothing more than a set of methods or as "those specialists who know something about humans".

The introduction of the MTO concept had already from the beginning in 1988 a strong support from the senior management at the Forsmark NPP. The strong support explains the positive attitude to the concept, especially in the operating departments. People who have experienced different cultures and who have worked in different parts of the organisation are the ones who most readily understand the MTO concept in a broader sense. However it is undeniable that personality factors also have a role to play – some people seem to have an aptitude for understanding and accepting a "system perspective" and are therefore attracted by the MTO concept.

Despite this, some people still have a limited perception of MTO. To change their perception from a focus on individual techniques to a broader view is far from easy as it relates to the way the nuclear industry is traditionally organised. The introduction of the "safety culture" concept has made it easier to support a system-oriented MTO approach. Pressure from the regulators to focus on MTO issues has also promoted the development of the concept. Although regulatory pressure may help to develop MTO, there is also a risk that the utilities will simply comply with regulators' views without gaining a real insight into what MTO represents in a deeper and broader sense.

Financial pressure, a deregulated market, competition and other external factors may also represent threats to the time needed for co-operation and the discussions needed for a system perspective to emerge. On the other hand, these changes may also lead to the need for more cost-effective strategies in which a system perspective and effective co-operation are necessary in order to save money and to avoid mistakes. The LearnSafe project aims to find those strategies.

MTO methods should not be introduced without account being taken of the context in which they are to be used. A root-cause analysis methodology, for example, is of no use if it is not supported by the necessary organisational arrangements.

It is important that people constantly feel involved in the work. Human factors people must be used more as *facilitators* than "doers" in this process. Line organisation staff can carry out many of the MTO-related tasks. External support is necessary in this process, but people must feel that they "own" the methods.

2. METHODS AND TOOLS USED AT THE FORSMARK NPP

Analytical methods using human factors specialists have been developed to support:
- Root-cause[1] analysis.
- Analysis methods used in the retrofit design process.
- Organisational assessment analysis methods.

2.1. Root-cause analysis

Root-cause analysis was introduced at the Forsmark NPP and other Swedish NPP:s in the mid-eighties, and is now well established. The technique most often used has its origin in the HPES method [3] developed by INPO in the USA.
To qualify as a root-cause method, the method must clearly identify the very basic causes of an event. Earlier versions of the MTO analysis method allowed the analyst to stop too early in the analytical process and to concentrate only on direct causes. The reasons for this could be the unease that the analyst may feel when the root cause of an event is found to lie with the management. Another reason for not following the chain of events and causes to the root could be the abstract nature of cultural and organisational issues. The methods are in themselves also partly responsible for failures to find basic root causes. The HPES methodology, and similar methods involve nothing that really forces the analytical process to include higher management levels – much is up to the judgement of the person performing the analysis.

To facilitate the root-cause analysis the method used at Forsmark has the following features:

- The manual used to support the process has a simple "accident cause" model that describes the differences between direct causes and root causes. In the cause-event diagram, a "line" is used in order to separate direct and root causes. In the space above the line are causes relating to safety management, organisational culture, internal control systems etc. shown, below the line are more direct causes shown.
- There is a distinction between "barrier functions" and "supportive functions". Barrier functions are defined as those activities or processes that are designed to *capture* a deviation or fault, while supportive functions are things that are implemented to *support activities so that errors do not occur in the first place.*
- A third change has been to look at the ASSET [4] methodology, developed by IAEA, in order to support the analysis with questions such as *"Why was the event not prevented?"* This and similar questions have been valuable in supporting a more in-depth analytical strategy.

If event analysis is to be successful, it is important to support a collective awareness that a system perspective on safety is necessary in order to understand the underlying MTO-related causes of an event. Such a perspective emerges partly from co-operation between specific competence's found in the organisation. While it is possible to develop a system perspective through theoretical training and education, it is hands-on analytical activity that transforms such theoretical knowledge into real insights. Event analysis provides a very good benchmark for checking theory against observations and is therefore an important tool in the process of learning to think in a system-oriented way.

[1] The term root cause is used to describe basic causes supposed to be under control of the own organisation.

2.2. MTO Methods used in the retrofit design process

Another set of MTO methods and tools is used in the design process for control-room retrofits and modernization's. The application of these methods and the use of the analysis tools aim to enhance the control room's usefulness, ergonomics and working environment. The application of the MTO concept is highly relevant in this work, both as a specialist domain and – perhaps to a greater extent – as a general system perspective.

There is sometimes a tendency to overly separate ergonomic issues from the broader context. One of the lessons learned is that the organisation of retrofit projects, such as the modernisation of control rooms, is highly dependent on the establishment, organisation and utilisation of different competence's, such as operator experience, instructor competence, HF competence, IT competence etc. In order facilitate the integration of all these specialist domains and applying a system-oriented approach has a new method been developed. This method is called MANFRED and has been developed to support the process for modifications affecting the control room and other parts of the plant, which have an HMI (Human-Machine Interface). The MANFRED process is integrated into the overall change management process.

2.3. Organisational assessment

Methods and tools based on the MTO concept are also used to carry out organisational assessments, for example as part of periodical safety reviews. An example of the application of such methods and tools is the organisational assessments performed as part of the mandatory periodic (repeated every 10 year) safety review, PSR (ASAR). Another example is the structured assessments made before organizational changes are performed.

3. METHODS FOR PROMOTING MTO AWARENESS

Nuclear safety needs competence from many areas in order to create useful strategies and risk estimates.

A strategy to support system thinking and organisational learning is needed. Setting up seminars, creating MTO groups, supporting human factor methods, integrating the MTO concept with quality concepts etc. and, most important, letting people with different and varied competence's be part of this work will all facilitate learning. The organisation should develop an "open mind" with respect to how different competence's can be used in the analysis of risk. Such initiatives might include experiencing feedback and exchanging experiences with other nuclear utilities as well as co-operating with universities, consultant organisations and other sectors.

3.1. The LearnSafe project

LearnSafe is a EU-project financed by the European Union and a group of European utilities and organisations, including WANO. The project has 14 partners representing five countries, it is co-ordinated by VTT Automation in Finland.

The main objective of the LearnSafe project is to create methods and tools for supporting processes of *organisational learning* at NPP:s. Organisational learning has become increasingly important for the nuclear industry in its adaptation to changes in the political and economic environment, changing regulatory requirements, a changing work force, changing technology, and the changing organisation of NPPs and power utilities. The danger during a

rapid process of change is that minor problems may trigger a chain of events leading to actual degrading of safety and/or diminishing political and public trust in the safety standards of the particular NPP, utility or corporation.

The focus of the project is senior managers at NPPs and power utilities who are responsible for strategic planning and resource allocation. This focus was selected with the understanding that their decisions, approaches and attitudes have an important influence both on the safety and the economy of the NPPs. The LearnSafe project will develop methods and tools, which can be used in the management of change, and in ensuring an efficient organisational learning. Project results will include recommendations and inventories of good practices.

The project is set up in two major phases, which cover both theoretical considerations and empirical investigations. The first phase places an emphasis on management of change and the second on components of organisational learning. Both phases start with the creation of data collection instruments to be used in the empirical part of the work. The second include the development of methods and tools, which can be applied by the NPPs themselves in creating efficient processes of organisational learning.

One important feature of the project is a continuous interaction between the researchers and managers at the NPPs in addressing issues connected to organisation and management, which are important for safety and efficiency. Preliminary results of the project will be presented and discussed in small workshops during the project, to ensure that relevant problems are addressed and solved in a practical way.

Five milestones are identified. The first milestone is the selection of a research model including a framework of concepts and phenomena to be considered in the project. Tools for describing organisations and data collection instruments for the first empirical phase are also a part of the first milestone. The second milestone marks the completion of the first major theoretical and empirical phase of the project. The third milestone and the mid-project evaluation is based on the finalised analysis of NPP approaches to change and the data collection methods and tools to be used in the second phase of the project. A mid-project seminar for a larger audience for presenting preliminary project results is also planned. The fourth milestone marks the completion of the first major theoretical and empirical phase of the project. The fifth milestone is connected to the completion of the project. A final seminar will be used to collect comments to a draft final report. It is the intention to place the completed final report in the public domain after due review by project partners.

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Safety Culture at Mochovce NPP

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Abstract. This article presents the approach of Mochovce NPP to the Safety culture. It presents activities, which have been taken by Mochovce NPP up to date in the area of Safety culture enhancement with the aim of getting the term into the subconscious of each employee, and thus minimising the human factor impact on occurrence of operational events in all safety areas. The article furthermore presents the most essential information on how the elements characterising a continuous progress in reaching the planned Safety culture goals of the company management have been implemented at Mochovce NPP, as well as the management's efforts to get among the best nuclear power plant operators in this area and to be an example for the others.

1. Introduction

The management of Mochovce NPP is aware of the Safety culture importance in ensuring a safe, reliable, economic, and environment-friendly operation of their nuclear facilities, and therefore the issues of Safety culture enhancement were dealt with intensively at the organisation and a number of measures and activities have been adopted to enhance the Safety culture level. The basic documents that the management based their Safety culture strategies on were the Agency's documents INSAG-3 "Basic safety goals and principles", and INSAG-4 "Safety culture". The management's crucial involvement in implementing the safety measures that enhanced Mochovce NPP units safety to a level acceptable in the countries of Western NPP operators has been done in the spirit of the principles set out in the above documents. The management has in parallel dealt with the Safety culture approach of individuals so as to meet the basic definition of the Safety culture saying that "Safety culture is that assembly of characteristics and attitudes in organisations and individuals which establishes that as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance". Steps, which fulfilled the idea of the definition, were the following.

2. Safety culture history at Mochovce NPP

In the view of Safety culture principles implementation at Mochovce NPP, the history can be split in two periods: the first one since the issuance of the INSAG-1 document (in 1986) till 1995, and the second one from 1995 to 1999.

In the first period the plant personnel was informed about the basic Safety culture documents (INSAG-1, INSAG-3, and INSAG-4) as a part of the education process, while the top stress was put on the terms such as human factor and Safety culture, which can't be separated from one another, and are mutually conditioned. The main goal of the education process was to explain to the staff what is the role of an individual in his/her attitude to the Safety culture within the three attributes: critical approach, exact and prudent approach, and communication.

The beginning of the second historical period in the view of the Safety culture approach dates back to 1995, when the Mochovce NPP's management declared the "Safety strategy", which in the subsequent period became the priority goal at everyday work of the management as well as executive personnel.

Prior to the issuance of the "Safety strategy" broad discussions with the power plant personnel were held, and main tasks and topics were defined, which should have been fulfilled in the coming period linked to the successful commissioning of the first two Mochovce NPP units. At the time a series of articles appeared in the plant monthly newspaper "Mochovce" describing approaches and opinions on the strategy prepared. The plant management on 20 December 1995 declared the „Safety strategy" and the document was issued in Slovak and English and was distributed to each plant staff member annexed to the plant director's New Year Letter (January 1996).

The "Safety strategy" was a lived document used for work for the next 4 years. The document issuance was followed by activities related to informing the public, representatives of state administration organisations in the regions around the NPP. Linked to the "Safety strategy" the plant director's order "Fulfilment of the Safety strategy goals" was issued defining 93 tasks, which were time-limited till the successful commissioning of Mochovce NPP unit 2. The tasks of the Order had been fulfilled and the plant director's order was cancelled in January 2000.

Other activities aimed at Safety culture level enhancement in the period included the following:

- Establishment of the Nuclear Safety Committee of Mochovce NPP (October 1997)
- Start of issuing the half-monthly newspaper "ATOM plus" (January 1998) as a tool to improve internal communication and informing the plant staff
- Establishment of a group in charge of documentation preparation for the NPP licensing (January 1998)
- Issuance of the plant director's order "Safety culture" and establishment of the "Group for the Safety culture assessment" (January 1999), appointment of which has started the new strategy and new approach to the Safety culture at Mochovce NPP.

3. Current status of safety culture at Mochovce NPP

By the establishment of the "Safety culture self-assessment group" at Mochovce NPP, the management decided to implement management tools in the Safety culture area, which had been recently recommended in IAEA-published documents, i.e. Safety Reports Series No. 11 – Safety Culture Development in Nuclear Activities (published in 1998), and INSAG-13 – Management of Operational Safety in Nuclear Power Plants (issued in 1999).

The group consisted of 9 members who were representatives of Mochovce NPP divisions and representatives of crucial Mochovce NPP safety departments. Each member of the group was familiar with Safety culture principles, promoted the principles and thus helped to bring the organisation culture to the light. Activities of the group were governed by the "Statute" and to fulfil particular tasks the group suggested "Safety culture Action plans", which – after being approved by the organisation management – became tools of the Safety culture control. The Safety culture Action plans since the group establishment were the following:

Safety culture action plan for 1999

1. To issue the rule PR/0001 - Safety culture
2. To perform Safety culture initial status analysis at Mochovce NPP
3. To organise a seminar on the "Approach to Safety culture Management" through Electricité de France
4. To organise a seminar on Safety culture through IAEA and NRA SR

5. To issue booklets about Safety culture for the operation and maintenance personnel
6. To include the issue of Safety culture in training programmes of operation and maintenance personnel
7. To issue declarations of Mochovce NPP management on physical and power commissioning of the unit 2 and outage of the unit 1 in the plant half-monthly "ATOM plus"
8. To perform the Safety culture self-assessment at single divisions of Mochovce NPP

Safety culture action plan for 2000

1. To inform Mochovce NPP employees regularly on Safety culture issues by means of notice boards
2. To provide a field in the operation and maintenance areas for a Safety culture visual agitation
3. To organise a seminar on Safety culture in co-operation with IAEA
4. To organise a seminar on the Safety culture self-assessment in co-operation with IAEA
5. To organise a meeting with a western NPP operator with the topic of Safety culture
6. To include regularly the Safety culture topics into personnel training programmes
7. To define methods and criteria of Safety culture self-assessment at all Mochovce NPP divisions
8. To accomplish the self-assessment of Safety culture at all Mochovce NPP divisions.
9. To improve Safety Culture areas, which based on the Safety culture input analysis at particular divisions of Mochovce NPP were evaluated as unfavourable and weak
10. To issue regularly articles on positive and negative attitudes and approaches of Mochovce NPP personnel to Safety culture in the half-monthly "ATOM plus".

Safety culture action plan for 2001

1. To evaluate Safety culture Indicators of 2000 in compliance with the document PR/8400 - Rules of Safety culture self–assessment
2. To organise a motivation training course „Safety culture self-assessment" for heads of departments and foremen, focused on clarification of the contents and importance of Safety culture, as well as practical application of the Rule PR/8400
3. To prepare a questionnaire for repeating survey of Safety culture level at Mochovce NPP and to prepare a conduct of the survey for year of 2002
4. To provide suggestions for works during a general overhaul at Safety culture notice boards.

Safety culture action plan for 2002

1. To evaluate Safety culture Indicators of 2001 in compliance with the Rule PR/8400
2. To organise a motivation training course „Safety culture self-assessment" for the control room personnel
3. To conduct a repeated survey of Safety culture level at Mochovce NPP
4. To issue a booklet about Mochovce NPP unit 2 outage
5. To issue a new "Safety strategy of Mochovce NPP"

Practical experience proved that the Safety culture Action Plans became tools that helped increase the Safety culture level at Mochovce NPP. As a part of Safety culture Action plan

task fulfilment, we would like to mention five most important ones, which crucially defined further drift and further measures to enhance Safety culture.

4. Survey of safety culture initial level

Identification of the Safety culture initial level at a company, particularly its weaknesses is a very important task and therefore this task was included in the Safety culture Action plan for 1999. A questionnaire recommended by IAEA, which had been previously used at operating nuclear power plants all over the world, was used as a tool for the conduct of the survey. The survey included 1821 employees of Mochovce NPP and results in 11 Safety culture areas - based on 1417 returned questionnaires - were comparable with a company having the Safety culture at the world-class level, as shown at the Figure 1 below. When comparing the results of Mochovce NPP in the three major Safety culture elements, which include safety climate, safety management, and safety behaviour with Savanah River, U.S., that used the same questionnaire for the survey, the results are obvious from the Figure 2. The questionnaire-type survey will be repeated in August 2002 by the same tools as in 1999. At the time of conference in Brazil the results will be known and trends in the single areas will be compared to the ones of 1999.

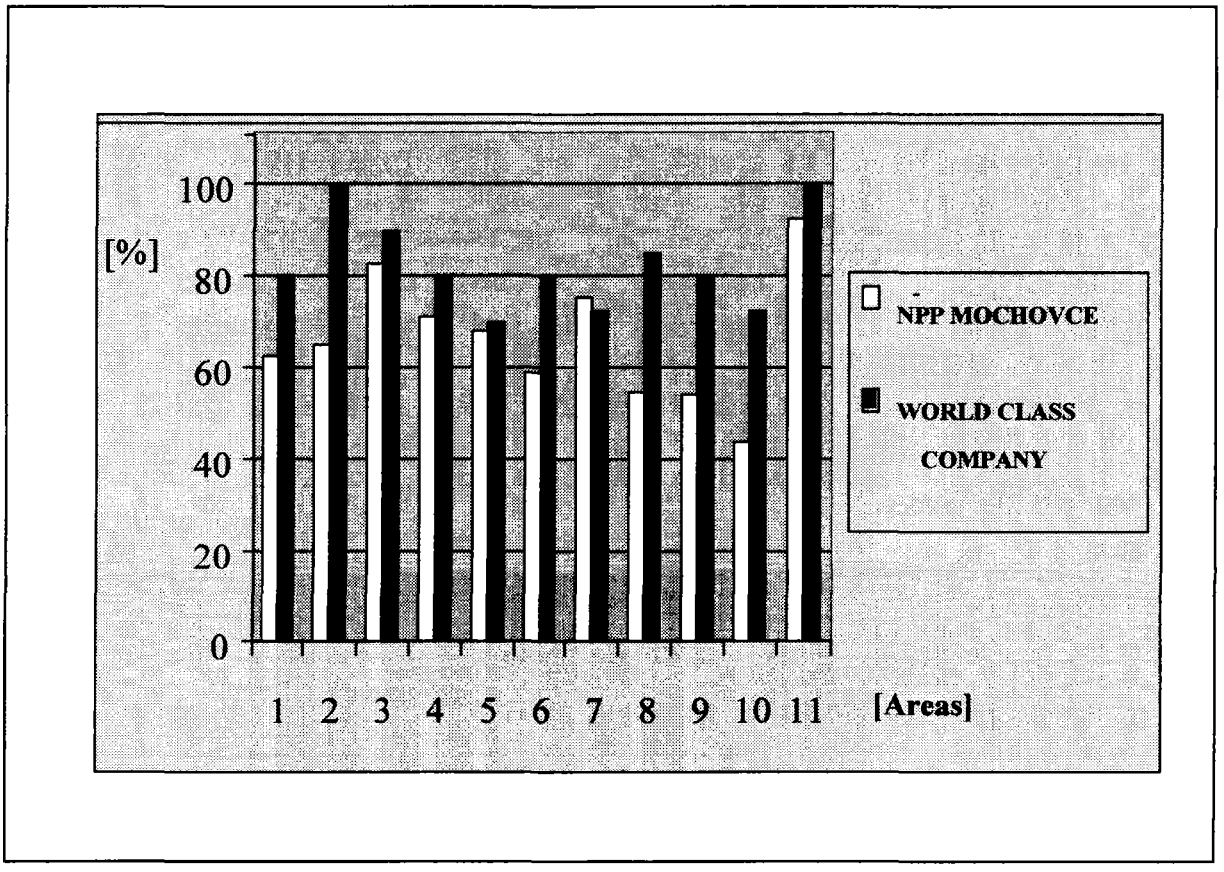

FIG. 1: Comparison of Safety culture profile in single areas between Mochovce NPP and Safety culture world-class company.

Safety culture assessment areas (acc. to Fig. 1)

1. Visible leadership and commitment of top management
2. Safety role of line management
3. Safety importance for strategic matters
4. Supportive organisational culture
5. Involvement of all employees
6. Organisational learning
7. Measurement of safety performance
8. Mutual trust and confidence between the management and execution staff
9. Openness in communication
10. Absence of safety versus production conflict
11. Demonstration of care about employees

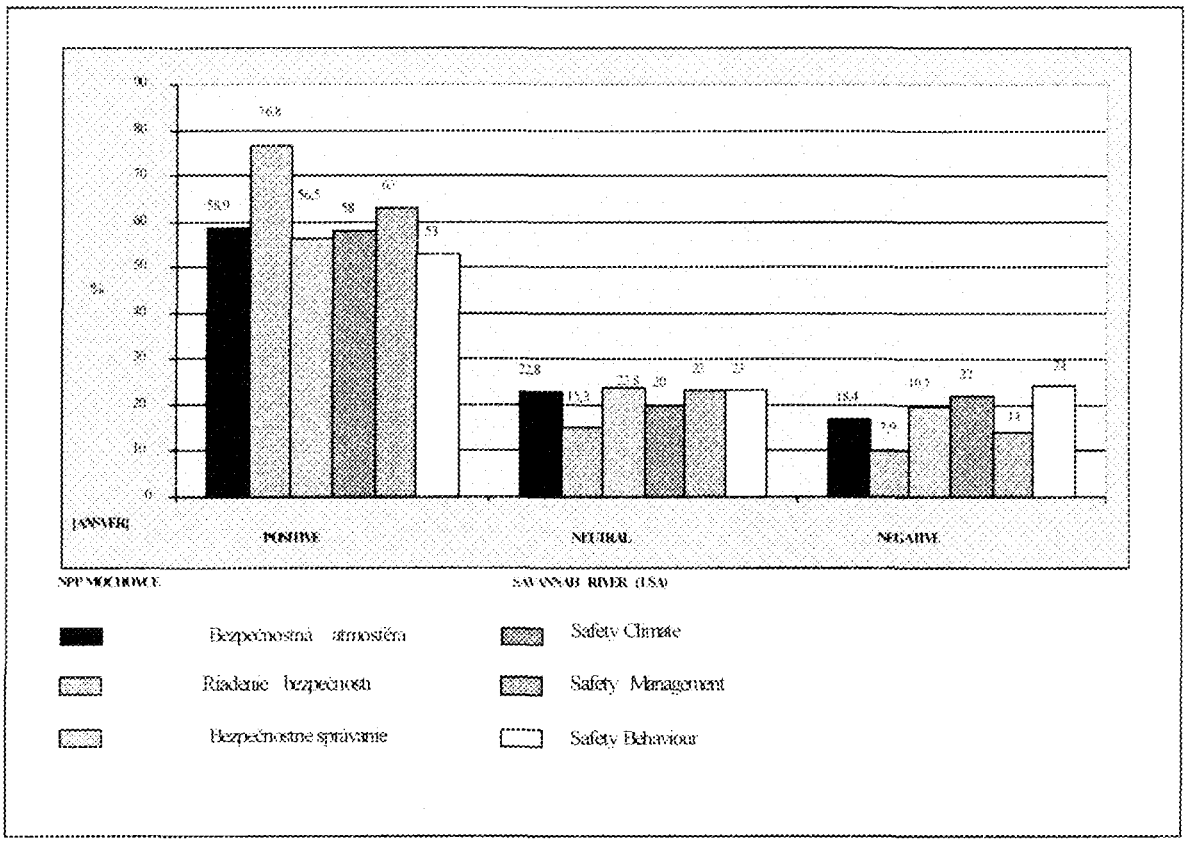

FIG. 2: Comparison of major Safety culture elements at Mochovce and Savanah River NPPs.

5. Safety culture seminar in co-operation with IAEA

The IAEA based in Vienna, as a part of services for member countries, offers organisation of seminars with the topic of Safety culture and Safety culture self-assessment. Mochovce NPP management used the opportunity to organise such a seminar in 2000, and the task was also included in the Safety culture Action plan for 2000. At this seminar, which was held in March 2000, IAEA representatives and their foreign lecturers presented trends in the Safety culture area in the world. The event proved a correct drift of the Mochovce NPP Safety culture strategy and in parallel indicated which areas and how could be improved. Based on the seminar conclusions Mochovce NPP management decided that the process of Safety culture enhancement should include new tools to be prepared by the extended "Group for Safety culture self-assessment", which had been complemented by new key functions and positions at the power plant.

6. Defining methods and criteria for safety culture self-assessment

The third task presented as a part of the Safety culture Action plan task fulfilment assessment, was the task from the Safety culture Action plan of 2000 "Defining methods and criteria for Safety culture self-assessment at Mochovce NPP divisions". Based on the seminar organised with the IAEA it was decided that it was necessary to use more tools for Safety culture level identification. The Safety culture self-assessment group decided that the tools should include a system of Safety culture Indicators, which should measurable, achievable, inspiring towards a positive change, and particularly comparable in time within the following 11 areas:

- highlighting safety
- definition of responsibility
- selection of managers
- relations between plant management and regulators
- review of safety performance criteria
- training
- local practices
- NPP supervision by the management
- work load
- attitudes of managers
- attitudes of individuals.

The group established a system of indicators and questions to assess Safety culture in a relatively short time. Suitability of the system was reviewed by a zero assessment done in 2000 based on 1999 data.

The group suggested a regulatory document "Safety Culture self-assessment" issued as the director's order, and determined a tool for the work with the indicators and questions, which was issued as the Rule "Rules for Safety culture self-assessment" (PR/8400). The rule clearly shows results of the group's work that included identification of:

- guarantors of single indicators
- which department the indicators are related to
- which indicators and questions particular department heads shall deal with
- how shall department heads assess the indicators in their departments

- a manner of filing and accepting suggestions for improvement in areas developing adversely.

7. Safety culture self-assessment system application process

Teamwork results were necessary to be applied in practice. Plant management decided it is necessary for all employees to provide training activities and proper enlightenment for broad Safety culture self-assessment system application. A new task "Performance of motivational course of Safety culture self-assessment for Heads of departments and Foremen" focused on knowledge of Safety culture content and relevance and on practical use of Safety culture rule was included to 2001 Safety culture Action plan. Moreover, information on new approach to Safety culture and its self-assessment was provided by way of notice boards with Safety culture theme, articles published in "ATOM plus" fortnightly and lot of information of this kind can plant employees reach on plant web site called "Safety culture" within Mochovce NPP computer network.

First Safety culture Indicators evaluation was performed in February 2001 and its results were published in "2001 Mochovce NPP Nuclear and Operational Safety Status Report". The reached results from individual Safety culture Indicators evaluation became the basic data for making comparison in following years.

The next Safety culture Indicator evaluation was performed in February 2002, its results were compared with results from 2001 as well as development trends in individual evaluated areas were indicated. Since proper attention to indicator evaluation and data collection and recording was devoted in 2002 than last year the Plant management, after discussion on "2002 Mochovce NPP Nuclear and Operational Safety Status Report", proposed to carry out revision of Rule PR/8400. The Plant management made decision to leave out indicators without any information capability and to add them with new ones suggested by Mochovce NPP employees after their motivational training course completion organised in 2001. It was clear to us from the beginning that appropriate indicators choice process is a current issue and it will take certain time to choose the most advantageous. However providing this process is deliberate it is a sign of good approach to Safety culture and its continuous improving.

Informing the contractor personnel about the existence of Safety culture Indicators as a part of pre-outage training can also be considered an important part of the system application. Many Safety culture Indicators have been focused on the assessment of unit outage preparation and implementation, which in the view of safety can also be affected by involved contractor's staff.

8. Conclusion

Bringing new Safety culture elements into life and continuous improvement of results in the Safety culture self-assessment area has become the prime goal of Mochovce NPP management that is every year rooted in the main tasks and goals of the company. The effort of each senior staff member is to apply the Safety culture elements in the work process and to familiarise his/her junior staff about the topics and activities performed at Mochovce NPP in this area. The Safety culture term has become a part of education activities at all power plant divisions and the issue of Safety culture has been also included into a periodical staff training organised by Training centre of VÚJE Trnava, which— after a 7-year break—had re-started at Mochovce NPP in 2001.

Good approach to Safety culture at Mochovce NPP was awarded by the IAEA, which invite Mochovce NPP representatives to all activities organised since 1999 in the Safety culture area with the aim of promoting the good Slovak approach in the Safety culture area. In June 2001, Mochovce NPP representatives have been invited by IAEA to participate in creation of the document "Safety culture" – Training guide.

This approach towards Safety culture at Mochovce NPP should ensure that the Safety culture term will become a commonplace for each power plant staff member, and that keeping and applying of Safety culture will support the culture of our company.

Steps taken at Mochovce NPP in the field of Safety culture have ranked us among companies, which—in the view of IAEA assessment—shift from the Safety culture level 2, when a "Safe performance starts to be the company's goal" to the level 3 (top level), when the principle "Safety can always be improved" is applied.

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Assessing progress in the development of safety culture

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Abstract. This paper is focussed on the organizational culture and learning processes required for the implementation of all aspects of safety culture. There is no prescriptive formula for improving safety culture. However, some common characteristics and practices are emerging that can be adopted by organizations in order to make progress. The paper refers to some approaches that have been successful in a number of countries. The experience of the international nuclear industry in the development and improvement of safety culture could be extended and found useful in other nuclear activities, irrespective of scale. The examples given of specific practice cover a wide range of activities including analysis of events, the regulatory approach on safety culture, employee participation and safety performance measures. Many of these practices may be relevant to smaller organizations and could contribute to improving safety culture, whatever the size of the organization. The most effective approach is to pursue a range of practices that can be mutually supportive in the development of a progressive safety culture, supported by professional standards, organizational and management commitment. Some guidance is also given on the assessment of safety culture and on the detection of a weakening safety culture. Few suggestions for accelerating the safety culture development and improvement process are also provided.

1. Introduction

Since 1990, in Romania, the Cernavoda NPP Project status had been reviewed and important decisions were taken for further project developments. Meanwhile the conflict of interest represented by the positions of the Regulatory Body and Utility in the same organization was solved and the new organizations were set-up separately for both main actors of nuclear sectors. The Nuclear Safety Authority named the National Commission for Nuclear Activities Control (CNCAN) and the Nuclear Energy Group, today so called "NUCLEARELECTRICA" (SNN), started to play their important role as the independent organizations which are in charge to promote safety culture principle and practices in the Romanian nuclear sector. The Romanian economy environment characterized by the transition process from the centralized economy to the market oriented one imposed specific approaches both for CNCAN and for SNN in order to fulfil their duties and responsibilities defined by the legislation and regulations.

The concept of safety culture was introduced by the International Nuclear Safety Advisory Group (INSAG) in the Summary Report of the Post-Accident Meeting on the Chernobyl Accident in 1986. The concept was further expended in the 1988 INSAG-3 Report, Basic Safety Principles for Nuclear Power Plants, and again in 1991 in the INSAG-4 Report, Safety Culture. Recognizing the increasing role that safety culture is expected to play in nuclear

installations world wide, the Convention on Nuclear Safety states the Contracting Parties desired "to promote an effective nuclear safety culture".

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

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

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

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

No composite measures of safety culture exist. The multifaceted nature of safety culture makes it unlikely that such a measure could ever be found.

Cultural changes are usually slow and often imperceptible. History demonstrated that cultural changes could be discerned over finite periods of time. The same should be true with safety culture.

This document is intended to offer practical advice to assist in the development, improvement and evaluation of a progressive safety culture.

The approach to developing a safety culture has much in common with the approach to developing an effective organization. The process can be assisted by a learning process within an organization.

2. The safety culture progress assessment

We have to abandon the search for a single composite measure and concentrate on *identifying the range of indicators that reflect the individual sub-components of culture.* The basic range would comprise measures and the measurement methods are presented in Table I.

TABLE I. BASIC RANGES AND MEASUREMENT METHODS

Basic range	Measurements methods
ɔservable behaviour	• Third party audit • Observation • Shadowing
ɪnscious attitudes	• Employee surveys • Interviews • Focus groups
ɪconscious attitudes (perceptions and beliefs)	• Psychometric instruments • Gap analysis

2.1. Behavioural measures

This is the easiest cultural component because the change is observable. The observation may be for general activities or of a specific individual or group. It must be conducted carefully to minimize any influence on the behaviour. Otherwise the conclusions may be erroneous.

The use of a person familiar to those observed should minimize any influence but runs the risk of a biased view. Conversely, using a third party unfamiliar to those observed could ensure an unbiased viewpoint but increases the likelihood that the behaviour observed may not be typical.

The best solution for an in-depth behavioural evaluation may require the use of a trained and skilled third party. Changes in behaviour will only be revealed by a serious observations and evaluations over a period of time. The results of these observations will reveal a trend, which can be used as a basis for measuring behavioural change.

2.2. Attitudinal measures

Employee attitude surveys are the most common method for obtaining information at this cultural level. This survey can be done by a person skilled in attitude measurement. Analysis and interpretation of the results require equally high skills.

Before conducting any large-scale employee survey it is worthwhile carrying out a small-scale trial to test the usefulness of the survey. The trial may include interviewing small groups of employees to test the practical implementation of the survey. The results of an employee survey can provide useful information that allows management to target areas for more effective safety improvement actions.

The survey questions can explore not only the personal attitude of the individuals, but also his or her perceptions on the attitude of their supervisor, other line managers and their peers.

Repeated use of the same attitude surveys over time and the same population can provide useful information about trends in attitude.

The results of an attitude survey can be compared with the results of behavioural observation to identify correlation.

2.3. Perceptions or belief measures

It is very difficult to measure change in perception or belief, particularly since many of them may be at the subconscious level. An indication that a subconscious belief may be having an important influence is the presence of a significant inconsistency between observable behaviour and conscious attitude (or between words and acts).

To measure beliefs requires psychometric techniques of an advanced nature and the interpretation of results can be difficult. Normally, behavioural observation and attitudinal surveys should provide ample information for major cultural changes.

3. Specific organizational indicators of a progressive safety culture

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

Some organizational indicators of progressive safety culture are:

a) Widespread employee commitment to good safety performance, including visible leadership by top management;
b) Good safety performance, considered to be a goal in itself that is important to the organization, and not merely intended to comply with regulatory requirements;
c) Investigations of the fundamental causes of events or near misses to learn lessons rather than to allocate blame;
d) Effective communication of safety information including safety performance trends;
e) No blame attached to employees who voluntarily report mistakes;
f) Commitment to continues evaluation and improvement of safety performance;
g) Coordinated and regular audit programme;
h) Managerial awareness of safety culture issues;
i) Employee involvement in safety improvement activities;
j) Primarily organizational goals include safety and are not focussed on cost or financial targets only;
k) Adequate allocation of financial and other resources to support safety;
l) Positive efforts made to learn from safety performance of external organization;
m) Safety performance measures include measurement of the effectiveness of activities on processes that affect safety, and not just measurement of the results of this activities or processes.

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

4. Detection of incipient weakness in safety culture - symptoms of a weakened safety culture

There is often a delay between the development of weakness and an event involving significant safety consequences. Alertness to the early warning signs allows remedial actions to be taken in sufficient time to avoid adverse safety consequences.

4.1. Organizational issues

4.1.1. Pressure from external environment

- Increasing economic and market pressures to reduce cost base through downsizing the workforce;
- Major political and social changes;
- Significant corporate change processes not well managed;

These changes create uncertainty in organizations that inevitably affect personal behaviour and attitude.

4.1.2. Inadequate resolution of problems

- Repeated crisis;
- Significant accumulation of corrective actions;
- Lack of effective managerial prioritization of remedial actions;
- Failure to address the root cause of the problems.

The constant barrage of problems may provoke a sense of hopelessness in employees who perceive that their individual efforts are ineffective.

The frustration of management in this situation may appear as an increased tendency to blame those individuals who seem to be the source of their problems.

4.1.3. Organization insularity

- Managers come to believe that their safety performance is satisfactory and therefore became complacent.
- Managers have no bench marks or learning opportunities;
- Lack of interaction with other plants, lack of interchanges of information and poor collective problem solving.

4.1.4. Openness

- Lack of open and honest communication between representatives of an organization and regulator;
- Restrictions of the organization to participate and contribute to international exchanges and initiatives.

Difficulty in obtaining information may be a sign that there is a weakness in the safety culture.

4.2. Employee issues

4.2.1. Excessive hours of work

- Tiredness and stress of employees
- Excessive and sustained overtime
- Continued reuse of staff on call-outs or replacement work

Fatigue is a significant factor in the degradation of the personal performance and would indicate that resource levels and planning of work require investigation.

4.2.2. Number of persons not completing adequate training

- Inadequate attention paid to the quality and applicability of training programs;
- Continuous monitoring of the attendance and performance of staff at training sessions;
- Regular checks of the status of training hours and the result of training.

This information, when correlated with the results of occurrence analysis, particularly if groups or departments are highlighted, can provide supporting evidence that further investigation and targeted corrective action are needed in the training area.

4.2.3. Failure to use suitably qualified and experienced persons

- Identification of the principal duties and responsibilities of the job holder;
- Definition of the attributes required for the task to be performed;
- Preparation of a profile outlining the characteristics required of the incumbent in order to carry out effectively the duties.

Good safety culture would not only have all the basic systems in place, but would seek to use incident feedback, amongst other things, to identify any personnel deficiencies, and incorporate any such identified features into their selection and recruitment procedures for future application, as appropriate.

4.2.4. Understanding of job descriptions

- Job descriptions have not been properly prepared;
- Individuals have not been properly briefed on their employer's expectations;
- The licensee should produce the necessary safety components of the relevant job description;

It is necessary an evidence that there is a one-to-one correspondence between the job holders' understanding of their job responsibilities.

4.2.5. Employment of contractors

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

— Control and directions of contractors employees can fall short of that expected from permanent plant employees;
— The effect of employment of contractors on regular employees who may feel threatened, insecure or resentful, all of which may adversely affect their safety performance.

4.3. Technology issues: plant conditions

Plant conditions provide a useful and valuable insight into the general health of an organization's safety culture.

— Poor housekeeping standards;
— Lack of attention to alarms;
— Not repair of malfunctioning equipment;
— Overdue maintenance work;
— Poor information recording and archiving system;

These deficiencies are prevalent when there is inadequate managerial and supervisory attention to safety matters and reflect the absence of an effective self-assessment and self-inspection regime.

5. Revitalizing a weakened safety culture

a) Early detection of problems will lead to early diagnosis and the application of effective remedial measures;

b) Senior management must be seen to be committed to stabilizing the situation by demonstrating leadership and taking responsibility for the problems;

c) It is essential to regain effective control of the safety mission and implement effective remedial action when faced with a weakening safety culture;

d) Making inroads into outstanding corrective actions can lead to early feeling of success and resumption of control;

e) Management have to emphasize that safety takes priority over production objectives;

f) Introducing a safety performance measurement systems based on the indicators of a progressive safety culture can help refocus an organization's safety efforts in the right direction.

6. Nuclear Safety Authority Objectives

The main objectives for the Nuclear Safety Authority (CNCAN) specific actions were to have in place an appropriate regulatory process designed to maintain regulatory surveillance on Cernavoda 1 NPP project implementation related activities, as follows:

a) Compliance with legislation and regulations requirements;
b) Unit 1 project completion as per the best international recognized methodologies and practices;
c) Acceptance criteria fulfillment during all commissioning process;

d) Safety goals achievement;
e) Turnover process of responsibilities from AECL-ANSALDO Consortium (AAC) to the Romanian Utility (now "Nuclearelectrica" SA);
f) Romanian staff training process;
g) Adherence to the safety culture related aspects.

The relevant regulatory actions, which define the CNCAN policies and practices adopted in the areas of safety management and safety culture regulatory surveillance related activities have focussed on the practices adopted to harmonize the Romanian regulatory prescriptive approach with the Canadian non-prescriptive approach in the Cernavoda 1 NPP project.

The management of the interfaces relations between Regulatory Body and Utility, the complexity of the relations developed within project imposed a specific regulatory strategy strongly focussed on the implementation of the safety culture at the all Romanian relevant players.

The key elements of the CNCAN policy to maintain an adequate regulatory mechanism to survey the level of safety culture implementation are as follows:

a) To set up from the beginning very clear interfaces between all licensing process players and to agree an appropriate level I and level II commissioning and licensing schedules, including the local contractors participation;
b) Periodically high level regulatory/utility managers meetings to discuss achievements in the utility commitments to excellent performance in all activities important for the safety of nuclear plants;
c) Monthly licensing meetings to review that the nuclear plant safety has the utmost priority, overriding if necessary the demands of production or project schedules;
d) Regulatory self-assessment on its commitment status to implement legislation and to act to promote plant safety and the protection of individuals and the public, and to protect the environment.
e) Periodically high level regulatory/supporting organizations/contractors managers meetings to discuss their primary responsibility for quality of the product, whether this is a design or a manufactured component, installed equipment, a safety report or software development, or any other output important to safety;
f) Systematic regulatory audits on various process aspects important to assess the achievements within nuclear safety area and safety culture level implementation;
g) To use extensively the IAEA support to review on independent basis the implementation status of various recommendations and suggestions considered for both utility and regulator;
h) To promote and to contribute to the international exchange of safety related information.
i) The promote an management style to ensure that common concern for safety leads to relations between CNCAN and SNN that are open and co-operative and yet have the formality and separateness appropriate for bodies with recognisably different accountabilities.
j) To solve controversial topics in an open approach adopted to setting safety objectives.
k) To ensure that regulatory requirements are clear but not so prescriptive as to set undue constraints.

l) To have periodically meetings with those organizations who regulate economic aspects of nuclear power to discuss their decisions based on purely economic factors, which could be prejudicial to reactor safety, if any.

7. Overall assessment of safety culture

The information accumulated from the behavioural observation and attitudinal or belief surveys can give a valuable indication of whether safety culture is developing successfully.

The information can also be used to confirm the effectiveness of specific management in relation to safety. This is in addition to the more tangible evidence of a maturing safety culture, namely sustained improved safety performance.

Sustained improved safety culture can be achieved with appropriate training and development of existing resources.

7.1. General evaluation model

The screening matrix presented below illustrates a general model that provides a framework for a high level screening evaluation of safety culture. The model identifies factors that can significantly influence safety culture. The potential benefit of the model is that it prompts consideration of the various influences on safety culture and can highlight areas that warrant more detailed consideration.

Although the model is primarily qualitative, it can serve as a basis for a simple screening matrix that provides a quantitative dimension.

The matrix can be used to evaluate generally the synergistic influence of the various factors that could affect the successful development of safety culture in an organization.

TABLE II. RATING OF FACTORS WITH A POTENTIALLY HIGH LEVEL IMPACT ON SAFETY CULTURE

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

TABLE II RATING OF FACTORS WITH A POTENTIALLY HIGH LEVEL IMPACT ON SAFETY CULTURE (CONTINUED)

Technology characteristics	Positive	• Mature technology • Safety features incorporated in design • Limited modification required • Good ergonomics • Fault tolerant
	Negative	• Immature technology • Obsolete technology • Poor design from safety perspective • Significant on-going modification • Poor ergonomics • Not fault tolerant • Significant consequences if fault occurs
National culture	Positive	• Ethos of personal responsibility • Not status conscious • Questioning attitude
	Negative	• Hierarchical orientation • Unquestioning attitude • Overly sensitive to criticism
Social and political environment	Positive	• Stable • Adequate funding • Mature institutions • Cohesive society • Respect for law
	Negative	• Volatile • Immature constitutions • Fragmented society • Recent experience of major change • Severe governmental budget restraints

7.2. Scoring criteria

TABLE III. SCORE AND CRITERIA DESCRIPTION

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

7.3. Screening matrix

TABLE IV. SCREENING MATRIX (SAMPLE FOR A HYPOTHETICAL NPP)

Influencing factor	***Weight***	Rating	Score
Business environment	X 2	5 (sample)	10 (sample)
Regulatory environment	X 2	3 (sample)	6 (sample)
Organizational environment	X 3	3 (sample)	9 (sample)
Organizational history	X 1	3 (sample)	3 (sample)
Worker characteristics	X 3	3 (sample)	9 (sample)
Technology characteristics	X 2	5 (sample)	10 (sample)
National culture	X 2	3 (sample)	6 (sample)
Social and political environment	X 1	3 (sample)	3 (sample)
Total score			56 (sample)

7.4. Evaluation

TABLE V. EVALUATION RESULTS

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

8. Conclusions

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

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

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

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

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TOPIC 2:

THE ROLE OF THE REGULATOR

Canadian Regulatory Perspective on Organization and Management Assessments

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Abstract. The Canadian nuclear industry is undergoing change in response to a variety of internal and external pressures on licensee organizations. Operational experience also indicates that management and human performance aspects are among the leading causes of unplanned events at licensed facilities. These observations have raised the CNSC's awareness of the importance of organization and management processes and human performance to the safety performance of a facility. The CNSC is utilizing quality management and organizational assessment approaches to address this issue. The Organization and Management Review Method has been developed to carry out organizational evaluations. The method has been applied to a number of nuclear facilities in Canada. Results have provided a more complete profile of the organizations and have thereby contributed to the oversight monitoring of licensees. Some of the data are being meta-analyzed to determine what influence culture has on the other organizational dimensions and whether there are performance indicators that can predict future safety performance. We hope that a clear profile of a "good performer" will allow us to compare and rate facilities against a series of benchmarks or standards yet to be developed. Some of the challenges that the CNSC faces with respect to the implementation of the O&M Method are being addressed. All of the information relevant to safety performance should be taken into account when giving recommendations pertaining to licensing decisions.

1. Introduction

In recent years a number of pressures have come to bear on Canadian nuclear facilities. These pressures include the need to improve operational performance, the privatization of nuclear power plant operating organizations, deregulation of the electricity market, organization downsizing and outsourcing of selected support functions such as engineering and safety analysis services. In addition, operational experience has indicated that management and human performance aspects are among the leading causes of unplanned events at licensed facilities. These have raised the CNSC's awareness of the importance of organization and management, and human performance to the safety performance of a facility.

The CNSC is utilizing two approaches to respond to these challenges in the organization and management area. The first is quality management (QM), traditionally referred to as quality assurance. This approach focuses on establishing the adequacy of implementing formal management processes such as design, engineering change control, operating experience review and corrective action. Quality management audits demonstrate that a management structure and managed processes, which meet specified standards, are in place. For many years quality management was implemented at Canadian nuclear facilities on a voluntary basis. The new Nuclear Safety and Control Act and Regulations, and the introduction of QM requirements in facility licence conditions, have made mandatory the implementation of quality management programs at nuclear facilities. This is resulting in organization and management improvement as management and structured processes, which meet defined standards, are being put into place and implemented.

The quality management audit approach, however, is not well suited to assess organizational culture and the behavioural aspects associated with activities such as communication, organizational learning and the coordination of work. To assess those behavioural aspects, the CNSC has, since the late 1990's, developed and implemented the Organization and Management Review Method (O&M Method), which was based on the preliminary work conducted in the US and Sweden (Haber and Barriere, 1998). It provides the user with the tools, both qualitative and quantitative, for measuring those organizational factors, including safety culture, that influence safety performance. Based on our experience to date, we believe that the O&M Method complements the quality management approach and gives the CNSC an improved understanding of the safety performance of a licensee's organization and management processes. A review of the literature that examines the importance of organizational factors and their relationship to safety culture follows.

Sorenson (2002) provides a survey of the state of the art in the study of safety culture and its link to safety performance. In his review of the empirical evidence, he notes that much work has been done to validate the notion that safety culture and other organizational factors have a strong relationship to the safety of operations. Although there has only been little direct research on the organizational factors that comprise a "good" safety culture, much literature is available that makes the indirect assumption that plants with low accident rates have a relatively good safety culture (Lee, 1998). In its extensive study of the predictors of safety performance, the Advisory Committee for the Safety of Nuclear Installations (ACSNI, 1993) has shown that the regulator's behaviour will affect the culture of the licensees, and that the most effective safety cultures will develop in less prescriptive regulatory structures. The study goes on to indicate that, along with the external impact of the regulator on the organization, the key predictive indicators of safety performance are effective communication, good organizational learning, and an organizational focus on safety.

Haber and Shurberg (2002) have shown that safety culture is a construct that can be measured. They suggest that the O&M Method can tell us about the organization's performance and will discriminate between high and low performers. High performers will demonstrate such behaviours as constructive values, a drive to perfection, a questioning attitude, effective communication, as well as a strong emphasis on safety. These behaviours are consistent with those described by ACSNI (1993).

2. Organization and Management Review Method

The O&M Method starts with a conceptual model of the organization (Haber and Barriere, 1998). The model, known as the Canadian Adaptive Machine Model, or CAMM, was developed to assist the CNSC in examining the various functional groupings or components of the organization and the ways in which information flows. The model was adapted to the Canadian nuclear industry to illustrate a typical facility that could adapt itself or reconfigure itself to off-normal situations when necessary. A nuclear organization can be configured into five components that include the Strategic Apex (to set the corporate vision, goals and policies), a Middle Line (to oversee activities related to operations, maintenance and service), a Technostructure (to standardize work processes, outputs and the skills of the operating professionals), an Operating Core (to accomplish the work of the organization) and Support Staff (to facilitate work and minimize any disruptions to the flow of work). Once the model was described, statements about the roles, responsibilities and interactions of the various components were generated, along with their coordinating mechanisms. From those statements, nineteen observable behaviours, that we refer to as dimensions, were identified that could be measured within the organization.

3. Application of the Method

Five types of data collection tools are used to measure the dimensions. First, a functional analysis of the organization's documentation such as its organization charts, procedures (especially those related to safety), and results from recent performance assessments is carried out. Based on this analysis the evaluation team chooses a subset of the dimensions to examine. Structured interviews, behavioural anchored rating scales (BARS), work observations (using Behavioural Checklists) and a paper-and-pencil survey (an Organization Culture Survey, including safety scales) are then used at site to assess each of the identified organizational dimensions. Depending on the size of the facility and the extent of the data collection, the evaluation can take from 10 days to 2 weeks. The corporate units that have a direct working relationship with the facility are also included in the evaluation. The method has been applied to all nuclear power plants in Canada, as well as other types of facilities, such as a mine/mill facility, a conversion facility, a research reactor and a particle accelerator. A total of 9 facilities have been evaluated to date.

4. Results

The results of the O&M Method have been used by CNSC staff to obtain a more complete profile of organizations and have thereby contributed to the oversight monitoring of licensees. More specifically, results have pointed out those organizational factors and management principles and processes that are working well, and those requiring improvement. They have also verified findings from previous audits and inspections, and have provided information to assist CNSC staff in identifying areas for more focused follow-up examinations utilizing audits or inspections.

The reaction of the licensees to the method varies from those that embrace it whole-heartedly to those that remain unconvinced of its merit. Many licensees see the value of the evaluations in confirming organizational weaknesses. On the basis of the results, some licensees have developed facility improvement plans, incorporating the findings from multiple performance assessments, including the O&M evaluation. Some licensees have also expressed concern with the intrusiveness of the evaluation team on-site because of the labour-intensive nature of the data collection activities.

At present, some of the data from all of the evaluations are being meta-analyzed to determine what influence culture has on the other organizational dimensions and whether there are performance indicators that can predict future safety performance. This research is preliminary and no clear conclusion can be drawn at this time.

5. Regulatory Challenges

There are a number of challenges that the CNSC faces with respect to the implementation and reliance on the O&M Method as a regulatory inspection tool. Although the method is generally recognized by CNSC staff as providing additional information about the effectiveness of the organizational factors, management principles and processes of the facility, its role in the CNSC compliance program has yet to be established. Areas requiring attention include: the lack of criteria which define when organizational behaviours are acceptable; the use of results to monitor improvement in the facility; and the enforcement of corrective actions.

In addition, the role that the O&M Method may play in the regulatory oversight of the changes facing the Canadian nuclear industry is currently under consideration. Examples of regulatory challenges that have emerged in this area include: the adequacy of a change management process to confirm that a licensee can justify and rationalize proposed changes within the organization (with no negative impact on safety); the industry's increasing use of contractors, raising issues such as contractor training, work protection and worksite supervision; the aging of plants and the problems associated with maintaining or replacing components while complying with regulatory requirements; and the costs and difficulties that the industry faces to maintain and attract a skilled workforce while ensuring that safety is not compromised.

A number of activities are under consideration to address those challenges. Workshops and information sessions have been initiated to better assist regulatory staff in tracking licensee improvements. The production of a regulatory document which touches on those organizational areas not currently addressed in other regulatory documents or requirements may be developed. In order to do that, first the criteria for good performance must be established before it can be determined whether all organizational factors should be included. The ACSNI has suggested that the best safety standards "can arguably only be achieved by a program which has a scope well beyond the traditional patterns of safety management functions" (1993, pg. 37). Thus, it is incumbent on the regulator to ensure that any regulatory documents encompass the scope and breadth of those issues that are intrinsic to safety but may not be evident. The CNSC will endeavour to meet that challenge.

Sorenson (2002) points out that it is important to identify performance indicators that capture the attributes of safety culture and its relationship to safety and operations, and safety regulation. It is therefore our longer term goal to develop performance indicators which can be used to flag potential problems in the licensee's organization and that will help us to predict when safety in a nuclear facility is likely to decline.

6. Future

One way that we are trying to advance the practical aspects of the O&M Method is to suggest a complementary way of integrating O&M evaluations with QM audits to embrace their similarities. Although, in some respects, some of the methods used in both approaches are not compatible with each other in terms of their data collection techniques, results from each method show both confirmatory findings and the unique information that each method contributes to build an organizational profile of the licensee's facility. QM audit information, although most effective for ensuring compliance, can provide information useful in O&M evaluations, and vice versa. From the research presently being conducted on the data, it is hoped that what will emerge will be a clear profile of a "good performer" which will allow the CNSC to compare and rate performers against a series of benchmarks or standards yet to be developed. That step will help licensing staff to better monitor those areas of their licensee facilities where improvements are needed in terms of organizational effectiveness.

7. Conclusion

Organizational change can occur over a long period of time and through informal processes, as well as through planned and managed change initiatives. It is therefore important that the regulator keep a close watch on organizational factors as part of the normal regulatory oversight activities. In today's economy with unstable markets and de-regulation of the electricity industry, it is more important than ever that a regulator make informed decisions

that benefit the health, environment and safety of the public. This is the modern regulatory environment in which the regulator needs to be mindful of the challenges that the nuclear industry faces. The most comprehensive information about licensee performance is the key to making well-informed regulatory decisions. That means that all of the information relevant to the organizational factors, management principles and processes that relate to safety performance, whether it comes from specialized audits, inspections or evaluations, should be taken into account when making licensing decisions.

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National Program for the Fostering and Development of Safety Culture in the nuclear activities in Cuba.

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Abstract. Since its appearance, as a result of the investigations of the accident in the Chernobyl Nuclear Power Plant, the term Safety Culture has been considered a key element to achieve a high level of safety in the nuclear installations, becoming a basic safety principle, internationally. The Cuban regulatory authority understood from very early the importance of the promotion and development of attitudes and characteristics in the organizations and personnel involved in the nuclear sector, reflecting a high Safety Culture, in order to propitiate a higher involvement of all employees in safety, contributing this way to the prevention of accidents in the nuclear facilities. Although the Cuban Nuclear Program was significantly reduced in the 90's, the regulatory authority has continued working in this direction and assimilated all the international experience for its application in its strategies for the development of a Safety Culture in the nuclear activities in the country. The present work summarizes the Cuban experience in the establishment of a National Program for the fostering and development of a Safety Culture.

1. Introduction

The appearance in 1987 of the term Safety Culture after the investigation of the causes of the accident in the Chernobyl Nuclear Power Plant (NPP) meant an important recognition of the influences of the human and organizational factors on safety of the nuclear installations. Numerous studies and investigations have been carried out to achieve a clear understanding of this concept and to develop methods that allow evaluating the level of Safety Culture. In Cuba, the regulatory authority understood from very early the importance of this concept. At the beginnings of the 90's it started the dissemination and promotion of Safety Culture by means of several studies and investigations to obtain a preliminary diagnosis on the actual situation in regard to Safety Culture. The aim of these first steps was to elaborate a strategy to develop the attitudes and characteristics in organizations and individuals which would reflect a high Safety Culture. Although the Cuban Nuclear Program was drastically reduced in the 90's, fundamentally in the nuclear power area, the regulatory authority continued working to promote and to develop the Safety Culture in the rest of nuclear activities, basically the preservation of the Juragua NPP structures, buildings and equipment and in the practices involving the use of sources of radiation in sectors like medicine, industry, research and education. The validity of this strategy has been corroborated in several of the papers and documents presented in international events or by the International Nuclear Safety Advisory Group (INSAG) of the International Atomic Energy Agency (IAEA) [1, 2, 3] in which have been recognized that the root cause of most of the problems and shortcomings that have occurred in the industrial and medical practices using sources of radiation has been, in fact, an inadequate Safety Culture. Therefore one of the main strategies for the control of the radiological risks and the management of safety in these practices is the development of a strong Safety Culture.

The Cuban regulatory authority has established a National Program for the fostering and development of Safety Culture in the nuclear activities that constitutes the basis for the whole regulatory strategy in this field.

2. National survey on safety culture

During the years 1990 trough 1994 the Cuban regulatory authority focused its efforts in the study of the IAEA documents and other reports and publications on Safety Culture in the nuclear sector and other non-nuclear industries with high technological risk. For this purpose a Human Factors Group (HFG) at the regulatory authority was created. As a result of this first stage a First National Survey on Safety Culture was carried out in 1995 [4], focusing the attention mainly toward those aspects that affect the creation of a national climate for the development of the Safety Culture.

An important part of this survey was oriented to obtain a diagnosis about the utilities understanding the Safety Culture issues and also to know their appreciation of the regulatory performance. This allowed to identify areas that required improvement from the point of view of Safety Culture. The survey was based on several IAEA documents [5,6]. The poll comprised a total of 32 questions on the following topics:

(a) Regulatory safety objectives and regulatory authority role
(b) Responsibility for Safety of the organizations involved in the Nuclear Program
(c) Regulatory Requirements: Clear statement, understanding and acceptance. Feedback and review systems for comments
(d) Communication and interaction between the utilities and the regulatory authority
(e) Presence and interference of the regulatory authority in the utilities
(f) Safety information dissemination
(g) Professional recognition to the regulatory personnel and to the regulatory activities

The poll was taken from all provinces of the country, from different kind of practices and from several types of organizations, with the aim at achieving the broadest range in the results of the survey. Of those interviewed, 36% were managers and 64% workers [4].

As a result of the analysis of this survey 10 general recommendations from the Safety Culture point of view were given for the Regulatory Directives for enhancing the styles and work methods of the organization and its staff. Amongst the immediate actions taken were the statement of the Regulatory Safety Policy, the implementation of a new regulatory practice practical through the Annual Regulatory Conference and the reformulation of the National Program for Safety Culture of the whole nuclear sector.

3. National program for the fostering and development of safety culture in the nuclear activities in Cuba.

Based on the experience gained from the first national survey on Safety Culture, the actions undertaken, the study of similar experiences in other industrial sectors with high technological risks and, the knowledge acquired during IAEA Regional Workshop on Safety Culture for Non-Power installation, held in Santiago de Chile last December, the HFG reviewed and re-elaborate the National Program for Safety Culture.

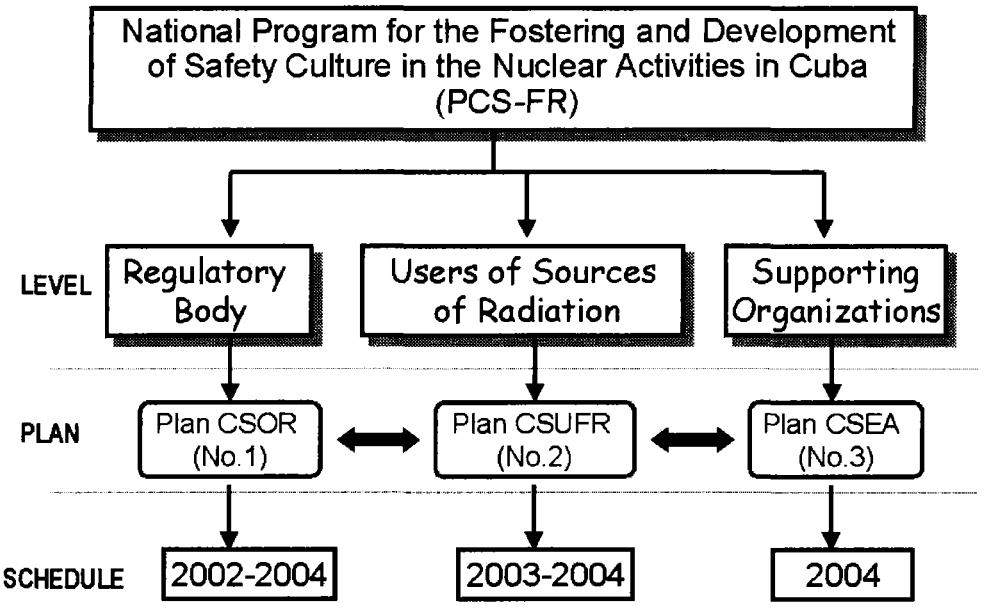

FIG. 1. Simplified scheme of the National Program for the Fostering and Development of the Safety Culture in the nuclear activities in Cuba.

This program is structured in three main stages to consider the three types of organizations that are involved in the nuclear sector: regulatory, users of radioactive sources and supporting organizations. Since each type of organization has its specific functions and features with regard to safety, the aspects to consider during the assessment of their respective Safety Culture level are different. For this reason a specific plan to assess the Safety Culture level for each kind of organization was elaborated. Each one of these plans has a close relationship to each other and they are executed in semi-parallel form, to be able to obtain a general diagnosis of the Safety Culture in the nuclear sector and an Integrated Action Plan. In Fig. 1 appears a simplified scheme of the National Program, where the levels or organization types to be evaluated, the codes of the respective plans and the schedule dates are indicated.

The Board of Directors of the regulatory authority approved the new formulation of the National Program in January of the 2002. At present the Plan No. 1 is being carried out, focused on the development of Safety Culture in the regulatory activity. This plan integrates the results of the previous studies and actions taken together with the new activities of assessment, action implementation, follow up and independent review. In Fig. 2 appears a graphically represented Plan No. 1 that at present is in its second stage. The Plan No. 2 is being currently organized to be initiated in 2003.

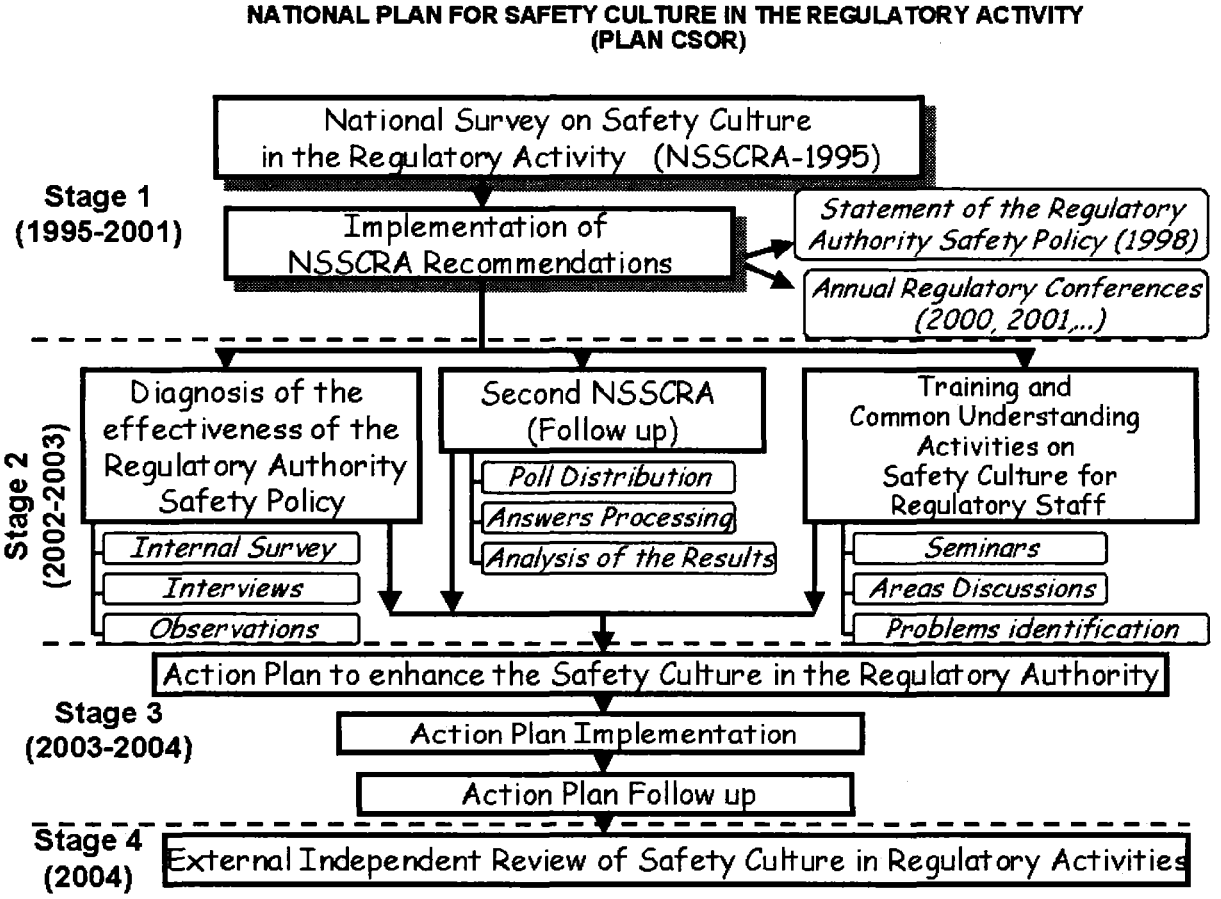

FIG. 2. Graphic representation of the Plan No. 1 for the Development of the Safety Culture in the Regulatory Activity. (Plan CSOR).

4. Conclusions

For fostering and developing a Safety Culture it is important to define national strategies that allow carry out the diagnosis of the existing situation considering the particularities of each country and their organizations. This contributes significantly in the identification of the Safety Culture issues that require improvements and in establishment of an effective Action Plan to obtain the expected results in as short term as possible. With this purpose, the Cuban regulatory authority has been working, to create a national climate where a strong Safety Culture prevails in the performance of the organizations and individuals involved in the nuclear sector.

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Management of safety and safety culture in regulatory work – the case of decommissioning of a Swedish plant

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Abstract. The case of early closure of one of the units at a plant is one example of a situation where the regulator has to reflect on and choose its role in order to prevent an impairment of the safety culture at the plant. The strategy chosen by the Swedish Nuclear Power Inspectorate is presented and some conclusions are drawn.

1. The legal basis of regulation

Swedish legislation requires that those who have permits to carry out nuclear activities also have the full and sole responsibility for taking all necessary actions to achieve safety. This includes organizational as well as technical measures. As a consequence the regulatory supervision must cover both types of measures. In 1998 SKI issued general safety regulations [1]. They have a strong focus on the quality of key processes for safety for example the processes for investigating and learning from incidents, for ensuring competence of staff and contractors, for ensuring appropriate working conditions, for managing organizational changes and plant modifications, and for conducting safety reviews. SKI evaluates the design and implementation of the processes in process-oriented inspections and in reviews of the self-assessments by the licensee in accordance with the supervision strategy of the Inspectorate.

The general safety regulations do not have specific requirements on safety culture. Safety culture is mentioned with reference to INSAG 10 [2] as a necessary condition for achieving an effective defence in depth. It is required to make recurring analyses and assessments and to develop a safety programme containing measures, technical as well as organizational, to improve safety. The safety programme shall be reviewed annually. Analyses and self-assessments of safety culture and measures to improve safety culture are expected to be part of a licensee safety programme. The role of the SKI is to evaluate the licensee programme and assessments. We have not yet systematically evaluated the safety culture self-assessment and development initiatives of the licensees. Safety culture issues are however addressed indirectly as part of "the way supervision is done at SKI" and directly in preventive and reactive ways. In the following an example is presented of a situation where we analysed potential threats to safety and safety culture and developed a suitable regulatory strategy.

2. The case of early termination of production at one plant

In the late 1990's SKI was faced with regulating the decommissioning of a plant for the first time, when the Swedish government decided to shut down Unit 1 of the Barsebäck nuclear power plant. In the spring of 1997, the Swedish Parliament adopted a bill on a new energy proposal. The proposal included the closure of one of the two units of Barsebäck in 1998 and the closure of the other one in July 2001. It was a political decision and it dragged on for a lengthy period of time. During the decision-making period SKI established requirements for Barsebäck to meet prior to shutdown. SKI required that the plant provide special safety

reports on decommissioning focusing on first, the operation of both units until closure of Unit 1 and second, the operation of Unit 2 when Unit 1 was closed.

In addition, SKI identified areas that might be affected by decommissioning and called out these areas for special attention. They included:

- The organizational consequences of the shutdown
- The staff competence and motivation
- The plant safety culture
- The safe operation of the site
- The maintenance of the site
- The safeguards and physical protection of the site
- The strategies to be used for decommissioning

With regard to these areas of special attention, SKI required that the plant provide monthly reports on changing and emerging issues as well as self-assessments of the areas to be addressed in the special safety reports.

The key safety culture and organizational issues that were identified as emerging during decommissioning were:

A) Obtaining and retaining staff competence during decommissioning
B) Sustaining organizational memory
C) Identifying key organizational functions and management skills that are critical during the transition from operations to decommissioning
D) Sustaining organizational viability and accountability for decommissioning
E) Sustaining motivation and trust in management
F) Overseeing contractor work
G) Decommissioning a multi-unit site when one unit continues to operate
H) Delaying dismantling of decommissioned nuclear power plants
I) Establishing organizational processes and control systems to identify and address emerging as well as known safety issues
J) Determining and communicating the level of risk during decommissioning.

3. Response of Barsebäck and SKI to key safety issues prior to and during initial stages of decommissioning

A brief summary is presented below of the activities taken by SKI and Barsebäck with regard to several of these safety issues. A more extensive review is presented by Durbin et al [3].

Obtaining and retaining staff competence

Barsebäck provided a five-year guarantee of employment for all staff in order to prevent that key staff would leave while their skills were still needed for the safe operation and, then, decommissioning of the plant. In addition, Barsebäck made an initial review of competence needed now and in the future and availability of staff for the first phase of decommissioning. SKI requires a monthly report from Barsebäck evaluating the current status of staff

competence and SKI and Barsebäck discuss staff competence at monthly meetings. In addition, SKI conducts inspections of the system that Barsebäck uses to assure staff competence.

Sustaining organizational memory

Barsebäck addressed two primary sources of information on organizational memory, documentation and staff knowledge. Barsebäck conducted a quality audit and assessed the status of documentation to assure adequate written organizational memory. A program was also implemented to obtain information from staff leaving the plant. SKI reviews these assessments and this program.

Assuring adequate organizational structure for decommissioning

Barsebäck analysed alternative ways of organizing the work for energy production in one unit and decommissioning of the other and produced a plan for a new organization. The transition to the new organizational system was made in May 2000. SKI reviews and provides feedback on all proposed organizational changes that may impact safety. For example, SKI required that Barsebäck develop a procedure for managing organizational change and required an analysis of control room staffing.

sustaining organizational viability and accountability

When plants decommission there is a risk that the organization will lose staff and/or resources to the point that it is no longer able to conduct necessary work and maintain safety. In addition, since the plant is no longer producing power, it may be difficult to assure that there is an adequate organizational presence to maintain accountability for safety and financial costs. There were discussions between the Swedish government and owners of Barsebäck about a transfer of the license to another organization. There also were discussions about mergers among power plant owners. SKI:s role in this process is to review proposed changes and to advise the Swedish government on potential safety concerns.

Sustaining motivation and trust in management

The strategy of the plant was to continuously keep the staff informed and ensure their participation in the discussions of the future. This together with the five-year employment guarantee was essential in sustaining motivation and trust in management. In order to track any changes in safety culture and motivation Barsebäck conducted regular surveys. In addition, Barsebäck requested that WANO (World Association Nuclear Organizations) conduct a peer review and provide recommendations for improvements. SKI reviews the monthly reports regarding these efforts and plans, and discusses the issues that have emerged at monthly meetings as well as covering this area as part of its regular inspections. Incidents are analysed and trended by the plant in search for possible indications of impacts. SKI inspects the process for analysing and learning from events following through on how the licensee has assured that measures are implemented.

Overseeing contractor work

This has not been a significant issue at Barsebäck so far because there has not yet been a significant change in the use of contractors. SKI continues to monitor plans for future reliance

on contractors and adequate contractor oversight as well as plans for enhancing the in-house competence.

Decommissioning at multi-unit sites

SKI made a safety decision for all sites that dismantlement activity is not allowed until all units at a site are closed. Barsebäck has done a number of analyses with regard to this safety issue that has been evaluated by SKI. Barsebäck analysed the use of unit 1 as a backup for unit 2. Barsebäck also identified the need for workers to give the same level of attention to the closed unit as to the operating unit. In order to assure that shift staff members were motivated and to improve integration of the work at the closed and operating unit, Barsebäck has integrated staffing of units 1 and 2. In this system the shift crew covers both units (1 operator per shift is assigned to unit 1 and operators rotate this assignment) and maintenance, quality assurance, and other service departments cover the needs of both units. SKI is monitoring the effectiveness of this strategy.

4. Conclusions

Melber and Durbin [4] have discussed different regulatory strategies, their differences, strengths and weaknesses. In the example provided SKI worked with a combination of what they define as a self-assessment strategy and a process-based or system-based strategy. The main strengths of the self-assessment strategy as discussed by Melber and Durbin were observed, and also some of its weaknesses. One of the strengths is a clear responsibility for safety on the licensee fostering plant initiatives in preventing and solving problems. The licencee took many good initiatives such as "the future factory", and training of managers in handling crisis etc and several were successfully implemented. Some of the potential disadvantages of the strategy were also observed. Melber and Durbin point out that there might be a delay before the regulator recognizes specific problems in the plants due to an inadequate self-assessment process of the licensee. Such delays were sometimes experienced and brought to the licensee senior management to make sure that management understood that a reorientation was needed in order to solve the problems identified.

Systematically gathering information from the experiences of others by research, visits and seminars proved to be extremely helpful in responding effectively to the needs for regulation of a new phase of nuclear power plant activity.

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Safety Culture in Mexico

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Abstract. In this paper, there are describe the activities already accomplished and the activities planned to be executed by the licensee and the regulator with the aim to develop, maintain and strength Safety Culture in all the Laguna Verde Nuclear Power Plant activities.

1. Legal framework

The legal requirements related with safety in nuclear installations are:

- The Regulatory Law of the Constitutional Article 27 on Nuclear Matters ("the Nuclear Law") decrees that in every activity accomplished by nuclear installation owner, always shall be given to safety (nuclear, radiological and physical protection) the first place in priority. There is not a specific requirement concerning safety culture, but it is required to count with procedures, qualified personnel, training and responsibility for all the tasks to realize.
- Mexico is a Contracting Party of the IAEA Convention on Nuclear Safety, this obligation was ratified on July 26th, 1996.
- On the Laguna Verde Nuclear Power Plant Units 1 and 2 Operations Licenses, emitted on December 8th, 1999, were established as the Requirement No. 19 to maintain the licenses force that: "The LVNPP shall encourage the Safety Culture elements, making a special emphasis in the conservative decision-making and the strict follow-up of the procedures, which would be reflected in a substantive improvement of every safety indicator, as they are defined in the international field.

2. Development. licensee activities

In 1996, there were developed the first activities in the compile and analysis of the information related with the Safety Culture concepts, as well as the formalities to obtain the IAEA technical assistance. Later on, there were developed several diffusion activities of the Safety Culture concepts.

As a result of these activities and of the IAEA technical assistance, on November 1996 it was developed the "Continuous Improvement Integral Program", which contained the Safety Culture Strengthening Plan.

It is considered that this preliminary stage of the Safety Culture implementation ends with the OSART mission visit, on February 1997, in which the Safety Culture Strengthening Plan was presented, and do not seemed to be appropriate since it contained in first priority productivity objectives rather than the safety ones. They emitted an Observation with the aim that the Management stress on safety as its maximum priority.

The Safety Culture Strengthening Subcommittee was integrated, which performed an applicability study of the INSAG-3, INSAG-4 and the ASCOT Guidelines, and executed a self-assessment based on INSAG-4. As a result, there were obtained the improvement actions for the weak areas detected, and finally, it was executed an identification process of the specific Safety Culture characteristics for LVNPP.

On March, 1997, it was established the **Safety Policy**, as follows: ***"The LVNPP Management declares that safety (Nuclear, Radiological, Physical Protection and Industrial) has the highest priority to fulfil its mission to produce safe, confident and profitable kw-h, with a deep respect to the environment".***

It was promoted the Safety Culture Strengthening Plan, with the aim of foster the working groups, the communications and the self-assessment as indispensable tools to maintain and continually improve the safety levels and the operations quality. The Total Quality Management Committee, marking the beginning of the massive diffusion and promotion of the Safety Culture concepts, for all the personnel in the Organization, approved this Plan on August 11th, 1998. The strategic statements in which the Plan is based on the following declarations: the **Vision**: ***"To be recognized as one of the best Plants in its type in the world, by its safety, environmental, technical and economical optimal results, supported in the constant training and its personnel positive attitude, compromised to make a leader enterprise of excellence"***; and the **Mission**: ***"To generate electricity in a safe, confident and competitive manner, promoting the development and comfort of the human resources, with a deep respect to the environment".***

The activities performed until the end of 1998 were principally focused to the supervisor personnel (medium and high level managers) with the purpose that through their attitudes, decisions and operative methods, would be showed to all the personnel of the LVNPP which is the real priority that is assigned to every safety related affair.

With the purpose of maintaining a chronological reference in the advance of the activities of Strengthening, it is consider convenient to establish the visit of an IAEA expert, on May 12th to 16th, 1998, as the point which marks the end of the initial stage of Strengthening and the beginning of a second stage in which the pending activities would continue and should be given a more firm and decided for the diffusion and training in all the levels of the Organization of the Safety Culture concepts.

In this second stage, on August 17th to 21st, 1998, it was received the follow-up visit of the OSART mission, which expressed its satisfaction due to the big effort performed in solving their recommendation and their convincement that with the participation of all the personnel the Safety Culture Strengthening Plan would be enriched.

During 1998 and 1999, the Safety Culture diffusion and training continued in all the levels of the Organization and during the fourth quarter of 1999 it was performed the analysis of the results of an inquiry developed to feedback the Safety Culture Strengthening Plan with the opinions of all the personnel.

Since the Safety Culture Workshop performed on November, 2000, in which the IAEA experts granted the basic concepts of the self-assessment methodology, the LVNPP Manager decided to conform a professional team of several areas to be trained in the self-assessment methodology implementation.

IAEA experts, trained the members of the Assessment Team on March, 2001, to leader the self-assessment process.

Later on, the Assessment Team met weekly during the period April – September 2001, to develop the activities related with the self-assessment process, which first step was the execution of a Safety Culture concerns interviews for Managers.

It was designed and applied an interview format, which was conformed by several questions related with Safety Culture characteristics previously defined as specific for LVNPP, with the IAEA experts help.

The interviews were performed on May and June and as a result, it was obtained a qualitative measure of the main problems that the personnel perceived regarding Safety Culture. As a result of the interviews it was developed a questionnaire based on the same Safety Culture characteristics. This questionnaire was tested with a small group of employees of several

areas of the Organization to validate and improve it. Mainly, it was looking for well-formulated and understandable questions for the personnel majority.
The resultant questionnaire included a first section to compile general data, like the personnel seniority / experience, age, sex, education, etc.
The 80 questions of the questionnaire were grouped in the 22 characteristics selected in accordance with the aspects of interest for the LVNPP.
The questionnaire was applied in all the areas; all the permanent, temporary, incidental and contracting personnel were invited to participate. The application period was August 6th – 17th, 2001. The total number of validated questionnaires was 1142, which represented a participation of around the 45% of the population.
In this process of self-assessment in all the areas resulted in a big interest for knowing the more urgent areas of opportunity, and the initiatives to be taken to improve them.
The characteristics that obtained the lowest evaluations were: Visible leadership (66.11%); Collaboration and Team Working (65.72%); and, Responsibility for the Performance and Rewards (65.71%). (See Ref. 1)
The characteristics that obtained the highest evaluations were: Fulfilment with Regulations and Procedures (83.64%); High Priority to Safety (82.99%); and, Relationship with the regulatory body and other external groups (81.74%). (See Ref. 1)

3. Activities plan. licensee

On May 2002, the IAEA experts will perform a validation process of the methodology of self-assessment developed by CFE, and CFE will inform CNSNS about the results.
Once the IAEA has validated the self-assessment, the Action Plan formulated for the solution of the improvement areas and, in general, for the 22 characteristics evaluated, will increase and make notice in the leadership of the managers and the team working in all the hierarchy levels of the Organization.
With the purpose of verifying the effectiveness of the resultant Action Plan, it will be applied a second questionnaire 12 months after the implementation of the improvement measures.

4. Development. regulatory body activities

In 1999, the CNSNS included as a requirement, into the conditions to maintain the force of the LVNPP Units 1 and 2 Operations Licenses, in which is established that CFE shall reinforce the Safety Culture elements. The fixed term for this requirement is to realize a program of continuous follow-up with an assessment every 12 months, beginning on February 2000.
On March 22nd, 2001, the CNSNS developed a follow-up to the CFE activities performed to comply with the Operations License conditions. The CFE made a presentation giving a description of all their activities concerning Safety Culture and establishing the Mission, Vision, Values, the Redefinition of Strategies, Improvement Actions and its results. It was shown the document "Safety Culture Policy Declaration". There were given details of their 4 goals: (1) Seminaries and Workshops, Diffusion; (2) Safety Culture Characteristics Revision and Analysis; (3) Self-assessment Process; and, (4) Strengthening Actions Implementation. Finally, there were shown graphs of the results of an inquiry related with how the personnel have observed changes due to safety culture improvement. (See Ref. 2)
On April 18th, 2002, CNSNS performed a second follow-up of the activities that CFE has developed to strength the Safety Culture elements. Again, the CFE made a presentation of their activities and hand over the safety culture executive report "Self-Assessment Process – 2001". As a result of the presentation and the report, CNSNS observed that the 3 first Goals mentioned above are already met. CFE is waiting for the visit of the IAEA experts to make

the validation of the self-assessment process, since after the process has been validated, CFE will proceed to the execution of the 4th Goal, this means, the Strengthening Actions Implementation. (See Ref. 3)

5. Activities plan. regulatory body

CNSNS is also waiting for the results of the validation of the self-assessment process and the establishment of the improvement actions plan to make a detailed follow-up of every improvement action definition and implementation. In addition to the follow-up, CNSNS will evaluate, and depending on the case, will approve or rectify each one of the improvement actions.
By the other hand, CNSNS is preparing a program of activities with the aim to develop an independent evaluation process. CNSNS will perform inquiries and apply questionnaires to a sample of the LVNPP personnel to verify their safety culture current state and make a comparison with the results obtained by the licensee in its safety culture self-assessment process. Besides, CNSNS will conclude which is the licensee safety culture level.
In this point, we can mention that CNSNS performs semi-annually an Evaluation of the Effectiveness and Implementation of the Inspections Program, in which, based on the inspections results (i.e. findings, observations and recommendations) are concluded some licensee strengths and weaknesses, which could be an extra tool to determine the licensee safety culture current level.

6. Conclusions

It has been taken 6 years of work to reach the point in which we actually are, the advance has been very slow in the process of LVNPP Safety Culture developing and implementation, but basically this has been happen because of 2 motives: (1) the lack of resources (economical and human); and, (2) the organizational changes that has been taken in LVNPP. In general, this kind of problems causes a break in the continuity of every established plan or program.
The aim of CNSNS of making a follow-up of the LVNPP activities is to promote an effective advance and avoid another break in the continuity. In the other hand, CNSNS is beginning a verification process to validate the results obtained by the licensee.

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Safety culture as a matter of regulatory control and regulatory effectiveness

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Abstract. More than 15 years have passed since the term "safety culture" was introduced by the International Nuclear Safety Advisory Group (INSAG), and although the concept now is widely accepted, practical applications and characteristics have been disseminated mainly for nuclear power plant operating organizations. There is still a lack of international guidance on the use of safety culture as a regulatory matter and on the application of the concept within regulatory organizations. This work explores the meaning of safety culture in two different fields: as an element of safety management systems it shall be a matter of regulatory control; as a complementary tool for quality management it should be used to enhance regulatory effectiveness. Brazilian recent experience on regulating nuclear power reactors provide some examples on how the concept of safety culture may influence regulatory strategies and regulatory management.

1. Introduction

The concept of safety culture is stated in INSAG-4 [1] as "safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance".

The Safety Fundamentals publication, The Safety of Nuclear Installations [2], does not mention the expression safety culture at all. However, within its section 4, Management of Safety, related aspects are addressed as, for instance, the need to recognize the safety significance of each organizational activity. Principle (4), of reference [2], requires that "organizations engaged in activities important to safety shall establish policies that give safety matters the highest priority, and shall ensure that these policies are implemented within managerial structure having clear divisions of responsibility and clear lines of communication."

As regulators have considerable discretionary authority in matters of nuclear safety, this Principle (4) should have influence on regulatory organizations, as well. According to INSAG-4 [1], in all types of activities, for organizations and for individuals at all levels, attention to safety involves the following elements: (1) individual awareness; (2) knowledge and competence; (3) commitment; (4) motivation; (5) supervision; (6) responsibility. These so called universal features of safety culture should imply on requirements at policy level and requirements on managers and on the response of individuals.

In spite of that, the IAEA Safety Requirements on Legal and Governmental Infrastructure [3] does not make use of the expression safety culture, although its scope covers regulatory body organization and activities. With respect to regulatory management system, it states only that "the regulatory body shall establish and implement appropriate arrangements for a systematic approach to quality management which should extend throughout the range of responsibilities and functions undertaken".

Regulatory management systems have recently been the subject of a peer discussions among senior regulators, promoted by IAEA, which produced a technical report [4] containing a valuable set of good management practices on the subject.

Consistently with such practices, the top management of the Brazilian regulatory body issued, in 1996, its safety and quality policy statements. Later, a project co-ordination team was appointed to control the development and implementation of a quality management system within the Brazilian regulatory authority. This work presents some practical experience on the matter of safety culture and lessons learned during preliminary steps taken in this project, particularly when trying to apply available concepts to regulatory management and regulatory strategies.

2. Applying the concept for regulatory bodies

If the universal features of safety culture are easily recognizable as also applicable to regulatory organizations, some specific features of regulatory activity are not explicitly addressed in many IAEA documents dealing with safety culture. They were mostly developed for, and applicable to operating organizations. Nevertheless, they usually claim the applicability for any organization with some responsibility on safety. The authors experience showed the need to adapt some concepts to specific features derived from the regulatory mission.

The report INSAG-13, Management of Operational Safety in Nuclear Power Plants [5], has the purpose to build upon the ideas outlined in INSAG-4 and to develop a set of universal features for an effective safety management system, which is considered to be an integral part of the organization's quality management system. As safety is primarily the responsibility of the plant operating organization, to discharge its responsibility, the operating organization needs to establish an effective safety management system which, by definition, "comprises those arrangements made by the organization for the management of safety in order to promote a strong safety culture and achieve good safety performance". Therefore, the concept of safety management system does not apply to regulatory body itself. Nevertheless, as a tool to enhance safety performance of nuclear installations, safety culture should be object of systematic regulatory actions.

According to INSAG-10, Defence in Depth in Nuclear Safety [6], "safety culture is broadly relevant to all areas related to defence in depth and is particularly important for operational safety. One of the most important lessons learned from severe accidents is that there is a need to encourage a questioning and learning attitude to protection and safety and to discourage complacency." As an element of the defence in depth system, safety culture should also be a matter of regulatory control.

While the operators should declare, in their policy statements, a commitment to excellence in all activities important to safety, making it clear that safety has the highest priority, for regulators such an equivalent statement should declare a commitment to implement legislation and act to promote plant safety and protection of individuals and environment. As safety is the only aim of regulatory mission, instead of highest priority, the policy statement should address the commitment to apply the limited resources where the benefit to safety would be the greatest.

The Safety Report Nº 11, Developing Safety Culture in Nuclear Activities [7], recognizes that the approach to develop a safety culture has much in common with the approach to

developing an effective organization and that, in promoting an improved safety culture, an appropriate balance of behavioural sciences and quality management systems approach should be pursued. As a subset of the wider organizational culture, safety culture inside regulatory body can play an important role for regulatory effectiveness.

3. Regulatory control over safety culture

As discussed above, as an element of the defence in depth system and of the safety management system, safety culture within operating organizations shall be a matter of regulatory control. INSAG-13 [5] identifies two complementary aspects of the relationship of the regulator with the operator's safety management system which contribute to its effectiveness, by ensuring that there are critical self-assessment and corrective actions (described as self-regulation) and by avoiding to act in a manner that diminishes the responsibility for safety of the regulated organization.

The Safety Requirements, Safety of Nuclear Power Plants: Operation [8], does include, as general requirements for operating organizations, some "shall statements" with respect to safety culture, although it does not include neither the concept of safety management system nor the safety culture as regulatory matter.

The Brazilian nuclear standard, Safety in the Operation of Nuclear Power Plants [9], was issued in 1996 based on the previous IAEA standard for operation, Code on the Safety of Nuclear Power Plants [10], and it has just one broad "shall statement" addressing safety culture.

The Safety Report Nº 11 [7] recognizes considerable international diversity in the regulatory approach to safety with regard to where emphasis should be placed, particularly when dealing with the regulation of human and organizational factors. Three types of regulatory strategies are discussed, named compliance based, performance based and process based approaches. The report states the advantage of process based regulation for the areas of organization and safety culture because the assessments focusing on the logic of key organizational processes, and the care in implementing and self-assessing these processes, allow a degree of flexibility, avoiding to transfer to the regulatory body undue responsibilities over plant safety.

A solely performance based approach characterizes a "corrective regulatory control", based on indicators of safety performance. In nuclear safety matters, preventive actions should prevail over corrective ones. For the compliance based approach, a regular inspection programme covering all areas of operational safety characterizes a "preventive regulatory control". However, to increase regulatory efficiency, a "predictive regulatory control" should complementarily be followed, monitoring processes of the safety management system, focusing on trends of key process variables.

In 1997, Brazilian regulatory practices over nuclear power plant safety have experimentally introduced a formal strategy which included explicit consideration of safety culture within the operating organization. A methodology to determine the safety significance of a violation or a deficiency introduced the so called "Nuclear Safety Significance Scale" [11]. As a tool for the regulatory enforcement, the scale provides a classification of the issue into 3 possible levels of severity:

- **Level 3 or Impeditive**, which corresponds to unacceptable risk or unreviewed safety problem;

- **Level 2 or Conditional**, which corresponds to temporarily acceptable limitations;
- **Level 1 or Potential**, which corresponds to a systematic failure or deficiency in safety culture.

Additionally, when the deficiency has no safety consequences and can be considered as an isolated failure, the issued is classified as **Deviation**, corresponding to a **Below Scale** of Severity.

By definition, the existence of a single deficiency of severity level 3 is enough to impose a restriction to plant power operation mode. If a nominal weight of 1000 is associated to this single deficiency, it is possible to investigate how many deficiencies of different levels of severity will correspond to the same level of unacceptable risk. Assuming weight 100 for severity level 2, weight 10 for severity level 1, and weight 1 for below scale deviations related to safety, a Total of Demerits is defined as the weighted sum of all deficiencies and is used as a performance indicator for the safety management system. As one example of "predictive regulatory control", monitoring time trends of the Total of Demerits, the regulatory strategy is focused on the ability of the safety management system to prevent or correct deficiencies during operation.

4. Enhancing regulatory effectiveness

According to the Safety Report Nº 11 [7], within an organization, safety culture is a subset of the wider organizational culture. Many practices which are used internationally to improve organizational effectiveness aim to promote the unity of purposes among the employees, motivating them to achieve organizational goals. The concepts of Mission, Vision, Goals and Values are often used to achieve these desired requirements.

To implement the safety and quality policies inside the Brazilian nuclear regulatory body, a project was launched for the development of a quality management system applicable to the main regulatory functions: rulemaking, licensing and control, review and assessment, inspection and enforcement. Soon it was recognized the importance of considering the cultural aspects inside regulatory organization. Different from operating organizations, a failure in human behaviour of a regulatory staff can not directly challenge the safety of nuclear installations. A consistent regulatory strategy, however, may have a stronger influence over plant safety performance.

If an adequate set of shared values can promote attitudes and behaviours of the individuals towards organizational goals, a selected set of regulatory principles will define the consistency of regulatory strategies. Focusing the resources on the mission, both initiatives will contribute to enhance regulatory effectiveness.

Initiatives derived from the adoption of the Nuclear Safety Significance Scale, to categorize deficiencies associated with the operational safety of nuclear power plants, and so prioritizing regulatory inspection efforts or escalating enforcement actions over plant operators, are consistent with the application of the concept of safety culture to regulatory bodies, warranting attention to issues proportionally to their safety significance.

5. Final remarks

As an element of defence in depth system and as a tool for the effectiveness of safety management systems, more than a regulatory concern, safety culture shall be matter of

regulatory control. Because safety culture involves human behaviour and organizational factors, special care should be taken when developing related regulatory strategies, to avoid being excessively prescriptive or unduly transferring responsibilities over safety management to the regulatory body.

Inside regulatory organizations, in the framework of a quality management system, the adoption of values and principles consistent with a strong safety culture will promote the fulfilment of the regulatory mission.

There is still room for international guidance on subjects related to safety culture within regulatory bodies and their relation with regulatory strategies and regulatory effectiveness.

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TOPIC 3:

ASSESSMENT OF THE MANAGEMENT OF SAFETY AND SAFETY CULTURE

Safety culture in a Belgian Nuclear Research Centre from a social science point of view

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Abstract. This paper is the result of a reflection within the framework of a Ph.D. research at SCK•CEN (Belgian Nuclear Research Centre) in collaboration with the University of Liège. The starting point of the work was the "safety culture" model presented in the IAEA report 75-INSAG-4. This model is applied to the working organization of the SCK•CEN, also considering the safety culture as an open concept given its multidimensionality. The methodology is based on three methods: observations, focus groups and interviews. The fieldwork was limited to two main installations : a research reactor, and a dismantling site. The preliminary findings are based on the data resulting from 4 Focus Groups. The most prominent components of a safety culture and the multiplicity of safety cultures in a large organization such as SCK•CEN will be discussed.

1. Introduction

Some years ago, the board of directors of the SCK•CEN decided to launch a research program on the theme "Science and Society" in collaboration with universities. In this human sciences program SCK•CEN offers opportunities to social scientists to work on a Ph.D., in fields such as sociology, law and philosophy [1].

To trace the evolution of our reasoning it is needed to consider the IAEA report 75-INSAG-4 which presents a "theoretical model" of safety culture [2]. Since this publication the term "safety culture" became rapidly famous [3]. The difficulty of this notion relates to its complexity of dimensions and to its broadly defined characteristics, which allow multiple representations of the safety culture [4]. Our ambition is to combine the contribution of the 75-INSAG-4 report with this complexity of dimensions. Our objectives are firstly to confront the model defined by the Group with the working organization of the SCK•CEN, secondly to consider new components of the safety culture and finally to understand how the organization can enhance or spoil the safety culture. This paper presents our investigation field and the scope of this paper, our approach and method. To conclude, some results will be presented concerning the components of the safety culture and the unity of the safety culture.

2. Fieldwork

The fieldwork is limited to two installations in SCK•CEN: the BR2 MTR and the BR3 PWR. The BR2 is a research reactor, which is used to realize different experiments to test the reliability of materials. The BR2 is in use since 1963. The BR2 is also well known in Europe for producing radioisotopes [5]. The BR2 employs 80 workers for shift teams, maintenance, and nuclear experimentation. The BR3 is a small nuclear power plant started in 1962 and definitely shut down in June 1987 [6]. The European Union selected the BR3 in 1989 as a pilot-decommissioning project. The project gives a unique opportunity to demonstrate that direct dismantling is safe and cost effective. The BR3 employs 50 people divided into two main departments: decommissioning and dismantling. The target population also included the safety advisors.

3. Approach and Objectives of the research

The International Nuclear Safety Advisory Group (INSAG) defined the term safety culture as "that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear safety issues receive the attention warranted by their significance". The framework refers to related attitudes as the questioning attitude, the prudent and rigorous approach and the communication at the individual level and it refers to a set of characteristics such as safety committees, safety rules, reward and sanction at the organizational level. But no mention is made of informal elements that can reinforce or spoil the components of safety culture. Therefore one of the objectives is to make concrete the components of safety culture, by discussing these components with our target population. The following step is to open up the notion of safety culture by considering our target population as the holders of particular experiences, allowing them to present new components of the safety culture. Finally the last step consists in, , in understanding how the working organization can enhance or weaken the safety culture, based on experiences of our target population

Our approach draws its inspiration from theories of social construction of risks, which defined risks as the product of social interactions [7]. According our point of view safety culture is also a social construct, which emerges from the working organization, and not an organizational variable as specified in "In Search of excellence" [8]. Rochlin recently suggested this approach [9]. Therefore our method aims first to collect representations and perceptions related to safety and to the elements which contribute to safety or not. Then we wish to go deeper into these representations in order to understand their construction process applying the bases of the comprehensive approach [10].

4. Methodology

Observations of the workforce

These observations also gave us the possibility to observe interactions between the workers and the middle management. They were designed to have a first experience of their work given it was our first enquiry in a nuclear research reactor and to have the opportunity to talk informally. The observations were also planned to feed further "official discussions" with practical examples and to facilitate them.

The Focus Group

This technique was used with several groups: 3 groups with the shift teams and 1 group with the nuclear maintenance of the BR2, 1 with the workforce of the BR3, 2 groups with the middle management of the BR2 and the BR3, 1 with the safety advisors. Each discussion was planned over two hours. The Focus Group technique is a collective interview conducted by an animator. This technique derives from the social psychology based on the group dynamic and whose data result from the group interaction [11]. We applied a sociological analysis based on the "Cut and Paste" technique.

Interviews

The interviews, with the safety advisors, were needed in order to go deeper into their representations, which was particularly difficult during the Focus Group given the bilingual discussion.

5. Preliminary Findings

The preliminary findings are based on the data resulting from the Focus Group with the shift teams of the BR2 and the workforce of the BR3. These data allow us to answer several questions. First we want to focus the attention on the representations of our target population. Their representations related to safety are generally complex, defining safety as something, which is overall and pervasive. The difficulty to catch precise information with such a fuzzy concept gave strong importance to the role of the animator of the focus groups, particularly for constantly interrogating constantly the answers [12]. The framework of safety culture designed by the INSAG presents three important elements (questioning attitude, prudent approach and communication) at the individual level. Our results confirm these elements but they are expressed throughout a collective working inside the teams which can lead to either collective work rules or to practical knowledge often defining as "savoir-faire" in French sociological literature. According to these preliminary results, we identify three new components of safety culture: the collective work rules, the "savoir-faire" and the personality. The collective work rules can have a direct or indirect impact on safety. In the sociological literature we can link them to the work of Jean-Daniel Reynaud [13]. The second component relates to the savoir-faire, which is well developed by D. Cru and C. Déjours [14] concerning the building sector. Finally, the personality: The participants have always conditioned their answers according the personal characteristics. This particularity means for example that no collective work rule is absolute, for each work situation workers take into account the nature of people for the execution of their tasks. We think this third element has to be mentioned even if actually we cannot explore it into greater depth.

As an illustration, we present some results for the two installations in greater detail. During our observations with the shift teams we noted some practices, which seem to be obvious for workers. For example, workers put on a ventilated suit and gloves before going down the reactor's pool in order to lock the channel of the reactor. They also use scotch at the level of the wrist. They explain that it is a question of "individual safety" in order to avoid to be in contact with the contaminated water. For example also, when they lock the channel the last attention is given to a "click" which guarantees the lock. These practices can serve different objectives such as protection at the level of the individual, the execution of the work, the team management, and the physical resources management. According to us they are a component of the safety culture because they directly or indirectly relate to safety and depending on the case they relate to different dimensions of safety: individual safety, collective safety and technical safety. Throughout the data analysis resulting from the workforce at BR3, we discovered a set of rules which lead their work: "know your job", "consult the most experienced before executing the job", the right to retreat, the right to intervene with the colleagues.

To conclude, we wish to stress the classical question concerning the unity of the safety culture within an organization. Comparing results originating from the two installations, we can argue that more than one safety culture exists at SCK•CEN. The different safety cultures regroup identical components but the distinction between the cultures results on one hand from the complex articulation between the components themselves and on the other hand from the interaction between these components and others factors such as the organizational context or the history of the installation and so on. This point emphasizes the need for research and knowledge about safety culture in order to exchange experiences and to appreciate "the specific level of safety culture" within a team.

6. Conclusions

Although a complex and broad concept, the safety culture is very real for workers of the BR2 and the BR3 at SCK•CEN. Throughout their experience, it appears that safety culture become manifest in realization of the work. The working team leads to the adoption of ways to execute the work, defined as the "savoir-faire" and to adoption of collective work rules in order to regulate the work. According to our cultural approach, we consider that these two new elements are new components of the safety culture because they serve directly or indirectly the safety and this, at different levels: individual safety, collective safety, and technical safety. Even if the two installations present some identical components, we argue that more than one safety culture exists at SCK•CEN because the articulation between them and the articulation between the components of safety culture and others factors as the installation's history, the relations between the staff and the management, and so on, can conduct to different representations and as a consequence to different safety cultures. We benefit also from this paper to argue it is difficult to determine what can be the deciding factor which influences the safety culture, only a global and integrated view can map the reality of the safety culture.

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A Total Safety Management Model

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Abstract. In nuclear organizations, quality and safety are inextricably linked. Therefore, the search for excellence means reaching excellence in nuclear safety. The International Atomic Energy Agency, IAEA, developed, after the Chernobyl accident, the organizational approach for improving nuclear safety based on the safety culture, which requires a framework necessary to provide modifications in personnel attitudes and behaviors in situations related to safety. This work presents a Total Safety Management Model, based on the Model of Excellence of the Brazilian Quality Award and on the safety culture approach, which represents an alternative to this framework. The Model is currently under validation at the Nuclear Engineering Institute, in Rio de Janeiro, Brazil, and the results of its initial safety culture self assessment are also presented and discussed.

1. Introduction

Deep analyses of industrial accidents with severe consequences have demonstrated that safe and reliable operation of industrial processes based on complex and risky technology, such as nuclear, depend not only on the technical issues, but on issues related to human and organizational factors as well. Therefore, new methodologies for reliability and safety improvement started to be developed, giving rise to the development of human factors approach, and more recently, organizational approaches have been proposed and utilized. After the Chernobyl nuclear accident, in 1986, IAEA [1] started the development of the safety culture organizational approach aiming at improving nuclear safety. This approach requires the implementation of a management change program in the organization in order to improve the organizational factors related to safety.

Many scientists have commented on the crucial importance of the organizational culture when implementing management change programs. According to Schein [2], organizational culture components must be organized in three levels: underlying assumptions, shared values, and artefacts, and that cultural changes are consolidated when the level of underlying assumptions are affected. A research performed by Hofstede [3] has demonstrated that, on the organizational level, cultural differences reside more on the daily management practices than on the organizational values, and consequently that the shared perceptions of the routine practices may be considered as the center of the organizational culture, meaning that its underlying assumptions can be modified by the implementation of new management practices within the organization. According to Schein [2], when the members of the organization get a shared perception of the good results achieved by the new practices introduced, a process of cognitive transformation starts, modifying the cultural underlying assumptions. Therefore, a deep inter-relationship between the organizational culture and the daily practices occurs permanently and simultaneously, in a complex fashion. This means that a successful cultural change program requires the implementation of a management process in the organization so that these inter-relationships can be properly treated. Fig. 1 presents an adaptation of the complex causative bi-directional inter-relationship model proposed by Souza-Poza [4],

considering reasonable to assume safety culture as the major importance subset of the organizational culture due to the determinant importance of safety to the nuclear field.

This work introduces an integrated organizational management model named 'Total Safety Management Model', TSM, composed by an organizational management process based on the Model of Excellence of the Brazilian Quality Award [5], that integrates the safety culture approach (assessment and enhancement of organizational factors related to safety) as one of its management practices. The Model constitutes a complex adaptive system that adapts continuously, providing the possibility for improving the safety culture and facilitating an effective implementation of the management process, thus assuring a certain level of "governability" to the system.

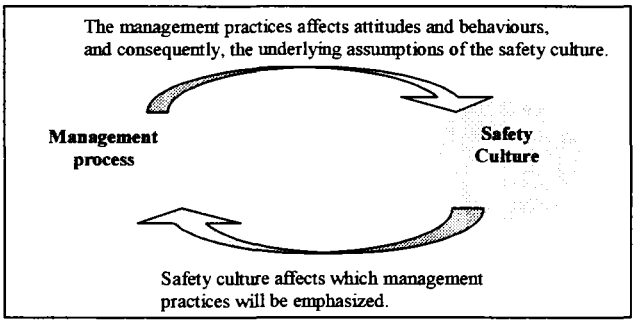

FIG. 1. Causative bi-directional inter-relationships between the management process and the safety culture, modified from [4].

2. Development of the Total Safety Management Model

2.1. The Model of Excellence of the Brazilian Quality Award

The Model of Excellence of the Brazilian Quality Award, BQA, was established in 1991 based on the Malcolm Baldridge American Quality Award, with the objective to identify 'world class' organizations. It comprises a sociotechnical, holistic and non-prescriptive model, designed to assess the level of excellence achieved by the organizations, through a set of requirements established to each of its seven criteria of excellence: Leadership; Strategies and Plans; Clients and Society; Information and Knowledge; Personnel; Processes and Results. The level of attendance by the organization to these requirements, as a function of the management practices and their corresponding results, reflects the level of excellence achieved. This model fosters a culture of excellence within the organization and considers that its evolution towards excellence is a function of its continuous learning processes, as well as of the management process assessment, performed by external experts, that identifies strengths and weaknesses which turn into a management improvement action plan.

2.2. The Total Safety Management Model

The 'TSM' model constitutes a complex adaptive system, where the management process is embedded in the safety culture, and the following actions cycle, partially represented in Fig. 2, is performed:

1: The influence of the safety culture over the management process is evaluated by the safety culture practice, which assesses the organizational factors related to safety and identifies those

that must be improved. Since the Model of Excellence of the Brazilian Quality Award provides a holistic management approach to the organization, it is possible to correlate these organizational factors to the seven criteria of excellence of the management process, as presented in Table I for the organizational factors assessed by IEN, in its first safety culture assessment. Therefore, this enables that new practices be implemented within the scope of the requirements of these criteria, aiming at improving those organizational factors identified as critical.

2: The new systematic practices implemented within the management process, through the corresponding criteria of excellence, and theirs consequent results, are supposed to affect persons attitudes and behaviors and, therefore modifying the associated safety culture underlying assumptions.

3: The Performance Measurement System of the organization (item 2.3 of the BQA model), developed using the balanced scorecard technique [6], specifies 'safety' as one of the output perspectives, whose results are controlled by performance indicators such as safety culture mean global index, nuclear/radiological accident rates, among others. The performance of all safety indicators is evaluated by the Critical Analysis Practice (item 1.3 of the BQA model), which identifies corrective actions where needed, and provides a learning means to improve the management practices of each criteria toward excellence.

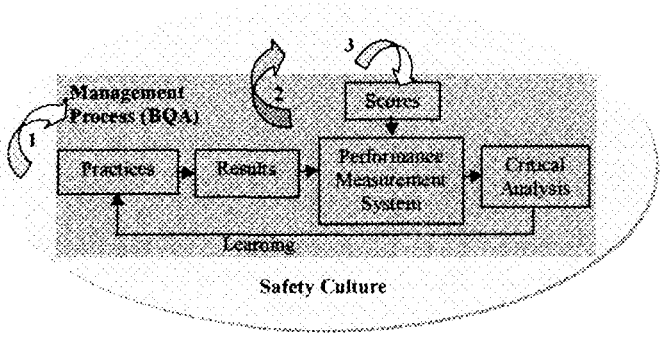

FIG. 2. Simplified schematic of the safety culture practice, as part of the TSM Model.

In order to monitor the system's evolution, the 'TSM' model assesses the level of excellence achieved by the organization, using the methodology of the Brazilian Quality Award Model of Excellence. During each actions' cycle a simultaneous and continuos adaptation happens to the system, meaning that the safety culture underlying assumptions are modified and the effective implementation of the management process is facilitated. The degree of adaptation achieved by the system is mainly a function of the initial conditions prevailing within the organization and on the effectiveness of the practical implementation process.

As a complex adaptive system, the 'TSM' model suggests that a 'facilitated change' type of intervention be used, based on the emergence and self-organizing properties, instead of the frequently used 'planned change' type, which is framed under the mechanical paradigm that 'sees' the organization as a controllable machine and "whose results have little lasting radical effects" [7].

TABLE I. CORRELATION BETWEEN THE SAFETY CULTURE ORGANIZATIONAL FACTORS ASSESSED BY IEN AND THE CRITERIA OF EXCELLENCE OF THE BRAZILIAN QUALITY AWARD MODEL OF EXCELLENCE.

Organizational Factor Assessed	Criteria of Excellence
F1. High-level management commitment to safety / F2. Evident leadership / F3. High priority to safety / F4. Systematic approach to safety / F6. Lack of conflicts between production and safety / F9. Management of changes / F10. Quality of documents and procedures / F19. Error treatment at work / F20. Management of conflicts / F21. Organizational evolution through learning.	1 LEADERSHIP
F5. Importance of safety on the organization's strategic plan / F6. Lack of conflicts between production and safety / F7. Relationship with licensing and regulatory body / F8. Proactive and long-term perspective / F12. Qualified and well dimensioned personnel / F13. Well defined tasks and responsibilities / F17. Adequate resources allocation / F21. Organizational evolution through learning.	2 STRATEGIES AND PLANS
F3. High priority to safety / F7. Relationship with licensing and regulatory body / F11.Compliance with regulations and procedures / F21. Organizational evolution through learning.	3 CLIENTS AND SOCIETY
F7. Relationship with licensing and regulatory body / F14. Transparency and communication / F21. Organizational evolution through learning.	4 INFORMATION AND KNOWLEDGE
F6. Lack of conflicts between production and safety / F9. Management of changes / F12. Qualified and well dimensioned personnel / F13. Well defined tasks and responsibilities / F14. Transparency and communication / F15. Motivation and satisfaction at work / F16. Good working conditions related to execution time, workload and stress / F18. Collaboration and teamwork / F20. Management of conflicts / F21. Organizational evolution through learning / F22. Commitment to performance and rewards.	5 PERSONNEL
F4. Systematic approach to safety / F10. Quality of documents and procedures / F11. Compliance with regulations and procedures / F17. Adequate resources allocation / F19. Error treatment at work / F21. Organizational evolution through learning.	6 PROCESSES

3. Validation of the Total Safety Management Model at IEN

The Nuclear Engineering Institute, IEN, is a research and technological development unit of the Brazilian Nuclear Energy Commission, CNEN, where a nuclear research reactor and a cyclotron type accelerator are operated, industrial radioactive waste is stored, radiopharmaceuticals are produced, among others activities. In 1999, IEN started an organizational change program in search of excellence based on the 'TSM' model. In 2001 IEN performed its initial safety culture self-assessment based on IAEA approach and on the same 22 organizational factors used by Eletronuclear [8]. 73% of IEN's task force participated in this assessment, whose general results, presented in Fig. 3 and 4, indicate that IEN's safety culture mean global indexes were classified as REGULAR [50, 65%), 4

organizational factors were classified as unsatisfactory (<50%), 12 as regular, and 6 as satisfactory [65, 75%), demonstrating the existence of critical factors that must be improved.

The 'TSM' model introduced in this work has not completed a full cycle of application at IEN yet. The results obtained at IEN's initial safety culture self-assessment demonstrate that the influence of the safety culture is mainly concerned to the criteria 1, Leadership and 2, Strategies and Plans, of the BQA model. To complete a full cycle of application, an adaptation plan is under development, which is composed by the design and implementation of new management practices related to these criteria of excellence, which are supposed to improve the corresponding organizational factors identified as critical and, therefore affect the safety culture underlying assumptions. After implementation, considering the cycle time, safety culture will be assessed again, and the results may demonstrate that the 'TSM' model constitutes an effective alternative to the necessary integrated framework for safety culture strengthening programs in nuclear organizations as well as in any other industrial segment.

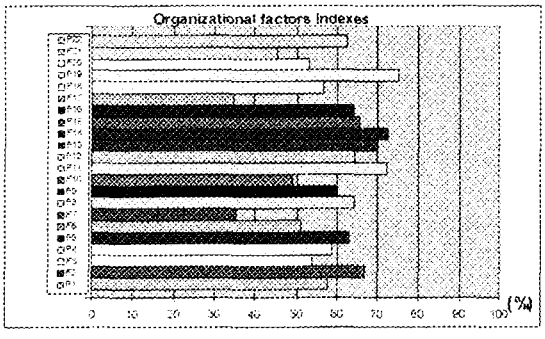

FIG. 3. Mean indexes of the 22 organizational factors assessed

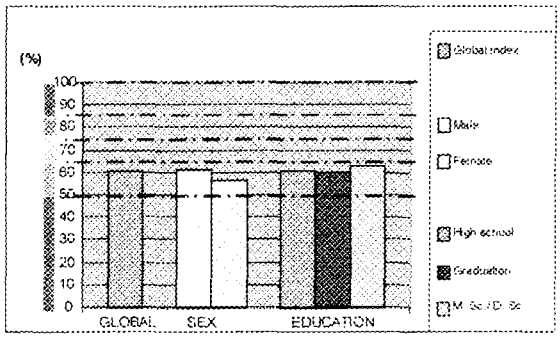

FIG. 4. IEN's safety culture mean global indexes

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Analysis of Safety Culture Components based on Site Interviews

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Abstract. Safety culture of an organization is influenced by many factors such as employee's moral, safety policy of top management and questioning attitude among site staff. First this paper analyzes key factors of safety culture on the basis of site interviews. Then the paper presents a safety culture composite model and its applicability in various contexts.

1. Introduction

A healthy safety culture plays a crucial role in safety assurance of nuclear facilities. On the contrary, decline of safety culture increases the possibility of errors and accidents. The reasons for shifts in safety culture (from healthy to unhealthy situation or vice versa) can be determined by analyzing several typical cases of the sites and their context.

2. Essential factors extracted from the group interviews with site employees

The Nuclear Safety Commission (NSC) of Japan has had group interviews with employees of nuclear facility sites all over the country since July 2001. The interviews were carried out directly by the chairperson of the NSC and a few of Commissioners, who have visited ten nuclear sites and exchanged views on safety culture with section chiefs by April in 2002. In this section we present an overview of good practices and problems gathered in the group interviews and classify factors that compose safety culture.

2.1. Good practices enhancing a safety culture

We would point to some of good practices, listed as follows, for a healthy safety culture in the nuclear facilities where the group interviews on sites were held.

1) Boosting motivation and morale of individuals
   - Set out basic rules for actions, mottos and illustrated posters on a section-by section basis (e.g. Establishing 7 basic rules at workplace)
   - Let younger staff have the time to sit in Zen meditation (in a cross-legged position) to cultivate their moral senses
   - Put up a board with the names and photographs of each day's workers, near the entrance of the workplace for increasing their sense of responsibility
   - Build an organizational climate to actively investigate problems (e.g. Daily group discussion, rotational talking)

2) Learning a lesson from past mistakes, being able to be informed each other
   - Investigate causes of the errors thoroughly not to repeat the same ones
   - Make a database of small troubles in which site workers voice their concern for the possibility of the troubles leading to accidents (called "Hiyari-Hat" experience in Japan)
   - Learn lessons from troubles in other facilities and industries

3) More effective learning and training, with frank communication

- Trainees make their manual by themselves to prevent taking the existing manual on trust and understand multifacetedly what is described in it
- Share small trouble experiences (near-miss incidents) through regular report meeting
- Simulate accident situations (case studies or virtual simulators)
- Risk predictive activities by small groups (e.g. Investigation of causes of disaster examples)

4) Realizing open communication inside and outside the site
   - Opinion box to seek employees' views and proposals, which gives employees much opportunity to speak out freely and get a feedback from views of the workplace
   - Cultivate a questioning attitude (Organizational climate of recommending subordinates to propose or question to their bosses)
   - Executive director's regular visit to the sites
   - Take members in subcontracting companies into the party to issue house journals, have a campaign of exchanging greetings among workers cheerfully and host social gathering meetings
   - President's visit to contractors and lecture on the safety there
   - Local meetings with local for younger staff to explain their own daily behaviors to local people (Thereby younger staff can know general society)
   - Actively Open a facility to local people

2.2. Important problems in safety culture

We will list some of important problems with which nuclear facilities are confronted, as follows.

1) Problems in relation to changing circumstances around the nuclear industry
   - Decline in motivation of younger employees under the adverse wind against the nuclear industry
   - Change of business environment (Future concern about safety-economics trade-off)
   - Weakened morale due to unreasonable regulation

2) Problems in relation to awareness of employees
   - Unique attitude of younger employees that they manage their work well but don't consider it carefully
   - Lack of customary report, communication and consultation
   - Difficulty of changing an inclination to hide their own mistakes
   - Expanded and complicated manuals because of reflection of many lessons from past experiences
   - Lowered adaptation to rare events through employees' excessive dependence on manuals (merits and demerits of manuals)

3) Problems in relation to difficulty in taking over experiences and skills
   - Difficulty in developing human resources and organizational culture because of regional characteristics and multicultural background
   - Difficulty in handing lessons from the past accidents on to the younger people who don't have their experience nor knowledge
   - Difficulty in handing the hard experiences in the early days of nuclear power development on to the next generation

4) Problems in relation to difficulty of communication inside and outside sites

- Organizational climate of Inhibiting subordinates from making suggestion to their bosses
- Difficulty in establishing an organizational identity due to collection of various contractors
- Difficulty in coping with frequently changing contractors

2.3. Key factors of safety culture based on site interviews

The result of group interviews on 10 nuclear sites, as we showed above, has identified several items of concern and interest common to the sites, based on classification by good practices and problems. We can summarize those items related with safety culture as the following keywords. ***Motivation, Morale, Communication, Experience and Learning, Adverse Wind against Nuclear Industry, Risk Awareness, Top Manager's Attitude***

Especially "Communication skipping hierarchy" must be noted as the most effective one for a healthy safety culture. Such communication of knowledge and will on safety has psychological influence, that is different from that of commands by bosses. It produces a pleasant atmosphere for a safety culture all over among the persons communicating directly.

3. How to think the components of a safety culture model?

Survey of existing safety culture assessment methods and safety culture management tools shows that three factors are common to the components of safety culture [1][2]. These factors can be summarized as follows:

(a) Individual's safety consciousness and behavior.
(b) Organizational features of site (e.g. Rank relationship and communication).
(c) Awareness of working environment.

These are the internal factors of safety culture of an organization (components of safety culture in a narrow sense). On the other hand, there exist some external factors that can affect safety culture. The external factors, including "local community", "mass-media", "public sentiment", "industry" and "regulators", and "market force (deregulation, price competition" have not been discussed so much in the concept of safety culture. We suggest here that they must be included in the safety culture in a broad sense, for the sake of development of effective management plan.

The factors that influence situations of safety culture are described in Fig. 1. The inner area of the broken line shows the inside of certain (facility) site. Safety culture of an inner organization is categorized into three elements: individuals, group/organization, and working environment. Each of these safety culture elements also contains component factors[2]. The external factors of Fig.1 can influence some or all the components of internal factors in accordance with various situations.

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[1] The element of individuals contains two factors, "motivation" and "morale/ethics". The element of group/organization contains "communication" and "management", and the element of working environment contains "man-machine interface" and "risk perception". As three factors are strongly connected with one another, there exist some factors that belong to two or three elements. The overlap area of the elements of individuals and group/organization contains "leadership". The overlap of the elements of group/organization and working environment area contains "learning/training", and the overlap of the elements of working environment and individuals contains "experience/expertise".

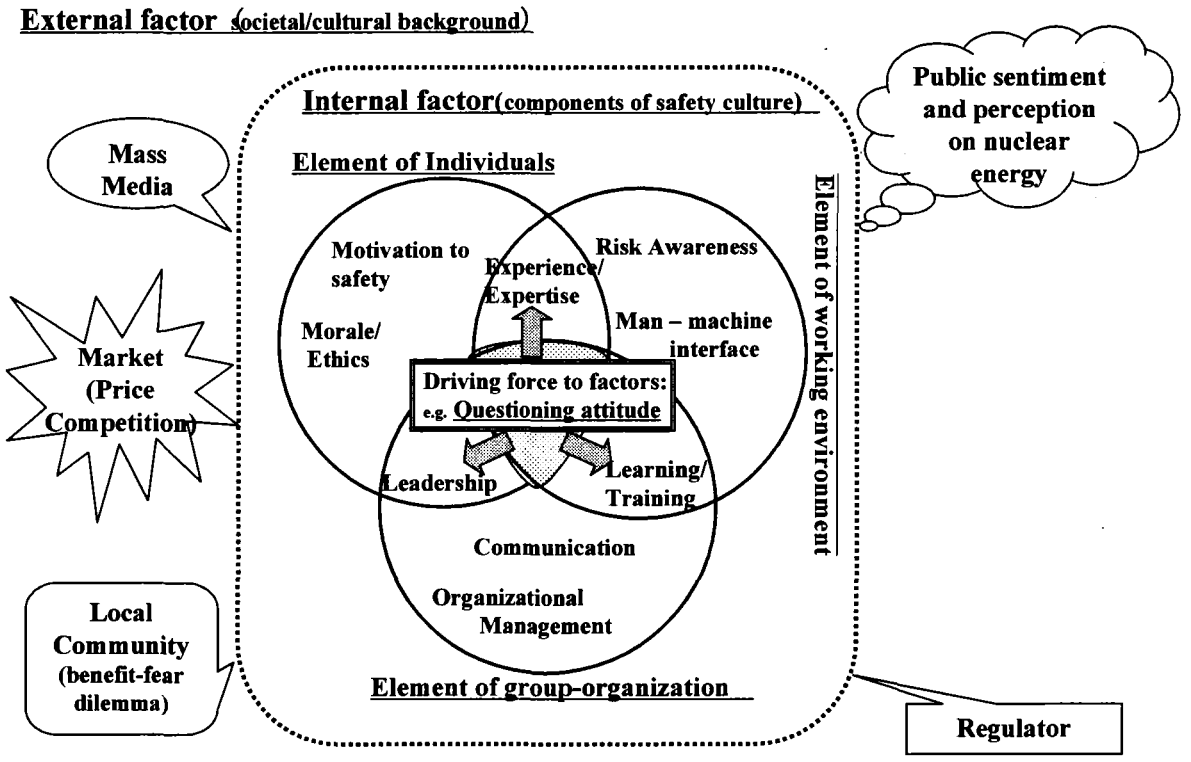

FIG.1. Safety culture composite image model.

For the purpose of improving safety culture, each factor must be activated by driving forces. The result of our interviews and conceptual surveys suggest that one of the most effective driving forces to activate all the component factors is "questioning attitude". In other words, the situation of questioning attitude among site staff can be regarded as a dominant indicator of safety culture management.

4. Conclusions: next step to manage safety culture model

The image model that we showed in Fig.1 is highly abstracted from actual facts in site. When the image model is applied to safety culture management in nuclear facilities, it must be interpreted in the context of each site. So it is important for us to observe how the model is interpreted and applied in the context of sites. Field research with the methodology of anthropology and sociology are practical in assessing and modifying the applicability of a safety culture component model.

The safety culture model like Fig.1 tends to be considered as static one. On the contrary, safety culture will not remain in regular conditions, but always move from one situation to another. So the model must be thought as a dynamic concept. To understand the dynamism of safety culture, especially the dynamism of an organization and its driving forces, learning from case studies is the most effective method.

Our next step is to conduct case studies on the important accidents that occurred in nuclear, railway, food processing, and other fields on the basis of safety culture composite model. Especially we will analyze how the cultural factors affected on recent accidents and how they depended upon inner or outer organizational contexts.

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The safety performance management system: *A tool for diagnosis, intervention, and measurement*

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Abstract. Many organizations depend on human performance to avoid incidents involving significant adverse consequences. Such organizations are typically termed high reliability organizations (HROs). While heavy emphasis has been placed on designing system hardware and software to intercept and mitigate events that could cause adverse consequences, dealing with the design of the human component has proven to be more complicated. Examination of various safety-related incidents makes it clear that human performance, and in particular organizational processes, plays a dominant role. The human errors are of various origins and are typically part of larger organizational processes that encourage unsafe acts that ultimately produce system failures. It is generally postulated that without an effective organizational safety culture, a safe working environment is impossible. While many different perspectives exist from which safety issues might be addressed, a method that allows the quantitative measurement of organizational processes deemed to impact overall safety performance is considered useful to understand the potential for future inadequate safety performance. This paper describes the Safety Performance Management System, a method useful for diagnosis, subsequent intervention and follow-on measurement. Implications for use of this method are presented and the concluding discussion includes insights regarding the general application of the method to improved facility safety performance.

1. Introduction

Many organizations depend on effective human performance to avoid incidents involving significant adverse consequences. Heavy emphasis has been placed on designing system hardware and software to intercept and mitigate events that could cause adverse consequences. However, it is clear from an examination of various safety-related incidents that human performance, and in particular organizational processes, has played a dominant role in the root cause of such events. The significant industrial catastrophes of modern times (e.g., Chernobyl, Bhopal) have led to greater attention being placed on some components of human performance. Yet, safety statistics continue to attribute at least 50 percent [1], and as high as 90 percent [2] of the causes of many accidents to human error. The human errors are of various origins and are generally part of larger organizational processes that encourage unsafe acts that ultimately produce system failures.

It is generally agreed that without an effective organizational safety culture, a safe working environment is impossible. The organizational culture consists of the context within which behaviors occur and more specifically the expectations and values that are perceived to be reinforced by the organization. While many different perspectives exist from which safety issues might be addressed, a method that allows an objective and quantitative measurement of organizational processes deemed to impact overall safety performance is considered to be a useful tool in the assessment of safety culture and the potential for future inadequate safety performance.

2. Identification and assessment of organizational processes

The organizational processes which impact overall safety performance have been identified and a method for their assessment developed. The effectiveness of this method has been demonstrated in numerous different organizations representing industries as diverse as nuclear power, research, mining, health care, and chemical reprocessing. Seventeen organizational dimensions are postulated to impact safety performance. These dimensions, and their definitions, have been reviewed in detail elsewhere [4]. Data collection tools have also been developed to assess and evaluate these dimensions within an industrial setting. The five data collection tools developed to assess the seventeen dimensions have also been reviewed in detail elsewhere [5]. The tools include: Functional Analysis, Structured Interview Protocols, Behavioral Anchored Rating Scales (BARS), Behavioral Checklists, and Organizational and Safety Culture Survey Instrument.

Multiple tools are used to assess each of the identified seventeen dimensions. Convergent data from the multiple tools is of particular interest. The tools allow for collection of both quantitative and qualitative data, which can be used to provide supporting evidence for the results obtained regarding the dimensions of interest.

3. High reliability organizations

A set of literature exists that defines one type of organization as a "high reliability organization" (HRO) [6]. HROs are defined as organizations which (1) must maintain high levels of operational and/or safety reliability in order to be allowed to continue operations, (2) cannot easily tradeoff between capacity and safety because of the consequence of error, (3) are not allowed the benefit of learning through trial and error due to the cost of error, (4) must be able to manage normal operations while maintaining flexibility to cope with unanticipated events, and (5) are judged to fail if high levels of performance are not continually maintained [7].

The issue becomes determining how an organization achieves the status of an HRO. Some common characteristics of successful HROs [8] include:

- Employees buy into the big picture through consistent communication and teamwork to arrive at a common path forward;
- Being 'learning organizations' by aggressively seeking to know what they don't know; and
- Measurement is used to manage so that reward and incentive systems are designed to recognize the costs of failure as well as the benefits of reliability.

Further amplification of each of these attributes and their proposed relationships to the dimensions identified earlier is provided in Fig. 1.

4. Safety performance management system

The Safety Performance Management System (SPMS) has been developed to assist in the assessment of organizational performance in relationship to the attributes identified as important for achieving the status of HRO and the dimensions related to the identified attributes. The SPMS is graphically displayed in Fig. 2.

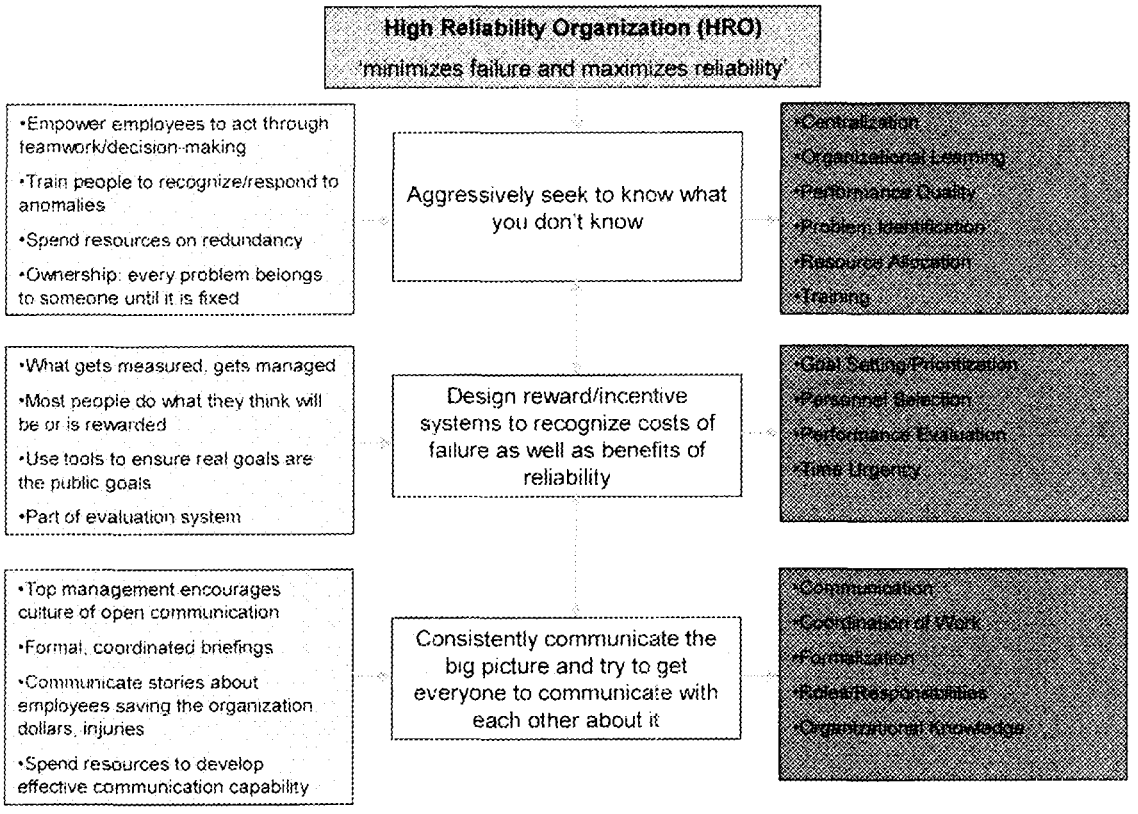

FIG. 1. HRO characteristics and relationship to organizational dimensions.

FIG. 2. Safety performance management system.

SPMS is a dynamic and iterative model especially useful in organizations that engage in complex operations that impact employee and public health and safety (e.g. HROs). The model allows for:

- The diagnosis of management and organizational strengths and weaknesses,
- The development of intervention strategies to address the areas identified for improvement, and
- The measurement of performance to ensure the effectiveness of programs for enhanced safety.

Using the set of 17 organizational dimensions identified and the five tools for measurement, the ability of an organization to perform the behaviors important to achieving the status of an HRO can be assessed. Outcomes of such an assessment include:

- Overall organizational profile with respect to the behaviors important to safety,
- Identified differences within organizational groups,
- Highlighted strengths and areas for improvement,
- Prioritized and integrated recommendations to enhance safety performance in a cost-effective manner, and
- Comparisons to other organizations on which similar data has been collected.

Once the organization is well understood with respect to safety performance, targeted solutions for organizational improvement can be developed. Intervention strategies might include:

- Human performance skills training, in topics such as communications, leadership, management and supervisory skills, and safety culture.
- Programmatic initiatives to enhance organizational infrastructure.
- Streamlining existing organizational processes.

Finally, the SPMS model ensures that once targeted solutions have been implemented that the desired effect is being achieved. The measurement phase of the model includes a process for the collection and incorporation of feedback related to intervention strategies. Such a process is essential to ensure continual organizational safety performance improvement. The SPMS measurment phase includes:

- Use of interviews, focus groups, and employee surveys to measure the effectiveness of the balance between efficiency and safety.
- The development of measures to allow continued monitoring and self-assessment in key areas.
- Development and maintenance of a database for trending and tracking performance measures related to safety.

Data collected during the measurement phase of the SPMS model is evaluated to determine if the organization is where it wants to be, is going where it wants to go, and what needs to be done to get where it wants to go. This evaluation provides the critical link from measurement back to diagnosis.

5. Implications

The implications of this work are broad based and particularly critical in the identification of those organizations which are performing in a manner more or less indicative of a high reliability organization. Organizational safety culture is an assessable construct and the Safety Performance Management System is an effective method for diagnosis, intervention, and measurement of those attributes important to sustaining a safety culture. By systematically measuring safety culture, organizations can identify areas for improvement or continued maintenance.

Data from such assessments can be used to improve overall safety performance by implementing highly cost-effective and focused intervention strategies. By identifying the specific variables or organizational areas in which improvement is most needed, such focused and cost-effective strategies can be developed to ensure that the focus of the entire organization is on the development and maintenance of a safety culture that will support achievement of a high reliability organizational focus.

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Practical applications of safety culture concepts in human performance advances on russia nuclear industry

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Abstract. Sometimes, many from negative external factors can be compensated by human psychological readiness of worker. However there would be main worse to come: some cases of personnel activity and organisational factors, some person's peculiarities (attitudes, responsibility, etc.) add considerable number of the events at NPPs. A lot of aspects of Human Factor Reliability are united in Safety Culture concept. This paper presents some results of our recently research in that area.

In "proactive approach": Unique methods for measuring maturity and satisfaction of personnel motivation: comparative analysis of the labour and safety culture motivation from attitude; organization of the socio-psychological climate and safety attitude examining monitoring at all of Russia's NPPs; working-out recommendations for managers on improving human performance are presented. Besides, ergonomical research concerning work conditions at the NPP is displayed.

In "reactive approach": Analysis of the incorrect activity cases, which led to the breaches of work of the Russian NPPs, is shown. The special method to work-up is used. It was issue, that events caused by a human error, depends not only on the worker's professional competence, but on the attitude and motivation, some professionally important psychological and psycho-physiological quality data, the functional state, the group's socio-psychological climate, etc.

The researches of the human factor reliability in Russia have been carried out for more than 20 years. ORC "Prognoz" accomplishes methodological co-ordination of sociology-psychological work of the nuclear safety services and other services of NPPs and organizations, which are in charge of improving personnel safety situation, consulting and rendering psycho-pedagogical services. ORC "Prognoz" keeps central data base for the industry, which holds more than 10.000 psychological and psycho-physiological tests-data of the personnel in Russia's Minatom companies.

The experience of normal work and an event cases on Nuclear Power Plants (NPPs) shows that the human factor provides both reliability and failure cases. It is difficult to overestimate the role of human factor. Our approach in definition of the human factor role consists of recognition and measurement as possible more complete list of the factors, which influence on mistakes and (or) work successful of the NPP-personnel. We was convince, hat safety culture is really the main condition of normal work.

The enhancement in Nuclear power industry includes an optimisation of organizational structures and development of personnel safety attitudes (INSAG–3, INSAG–4, INSAG– 12, etc) as global problems. Organizational factors can be root causes of human errors, they need to be identified, assessed and improved. Now twelve organizational factors are identified as an important for access in determining organizational safety performance, "organizational safety"[1].

The system of maintenance of the personnel reliable work is reflected in the legal documentation creating the rules of works and legal space for realization of the personnel activity in objects, using atomic energy, at a faultless level. Reliability of the human factor depends on many parameters, external and internal, psychological.

The reliability researches of the human factor in Russia have been carried out for more than 20 years. The researches have shown that there are a lot of external factors, which influence on performance and activity of the man, but which can be compensated by influence of human psychological readiness of worker.

The decrease of psychological readiness becomes obvious in a situation of wrong action and incident at station. The psychological situation of events caused by a human error depends on:

(a) The professional competence;
(b) The professional motivation;
(c) The some professionally important psychological and psycho-physiological qualities of a person, including mentality, attention and memory data,;
(d) The functional state of human in the work time. This parameter is most vulnerable to influences of external environment. The latent mood or weariness influences on the accuracy of hands movement, on correctness of the decision acceptance.

The analysis of wrong actions of the personnel has the purpose to raise reliability of work, with the help of mistakes correction, improvement of rules and methods of work.

Following logic of influence to the man behavior from external organizational factors in Russia as well as over all countries - IAEA members, the work in two directions is carried out [1]:

(a) Prevention of infringements and preventive maintenance of failures;
(b) Analysis of the direct and root reasons of infringements in work of plants.

In Russia the careful activities of a legislative and organizational character are carried out. So, The Law on Use of atomic energy was accepted, some decisions of the Russian government were accepted, including strengthening of a request on professional training and health in admission of staff to work.. The requests to the personnel selection organization are changed. As to the second problem of safety culture - to form the staff "safety attitudes ", such problem is concerned with psychological area and decided due to a context of the world and national culture. Both problems of the safety culture - perfection of organizational structures and formation of the personnel attitude to priorities of safety - are interconnected and decided only simultaneously. The appropriate methodical maintenance is developed for deriving an objective picture about outcomes of such correlation.

Investigation of motivation to the safe work of employees at nuclear power objects included studying motivational sphere of IPPE's scientific and submarine reactors' operational staff on the Russian Federation Navy Fleet.

The example of examining safety motivation is presented in Fig.1, where **U** stands for utilitarian motivation, **P** – for prestige motivation, **T** – for achievement motivation, **C** – for cognitive motivation and **I** – for avoidance motives.

Comparative analysis data on the motivation sphere of specialists at different plants of the nuclear industry gives evidence that NPP workers are characterized by the most mature motivation sphere.

In this rating they are followed by the research workers of PPEI and the Navy officers. And the last in the list are the students as the future employees of nuclear industry, although they have rather mature utilitarian motivation (**U**).

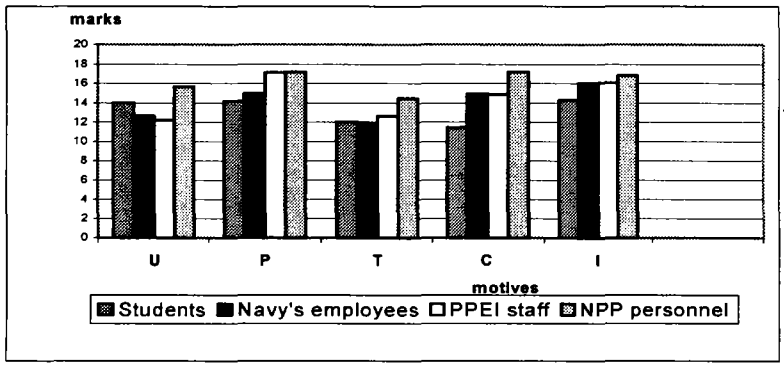


FIG.1 Motivation sphere of the specialists at different nuclear power installations concerning safety.

In Russia the method of reasons of the staff incorrect actions in failures of the NPP operation analysis is rare for the global experience [2, 3]. Not only operational and technical characteristics of incorrect actions are studied, but also psychological root reasons, which induced the person to take this actions. The application purpose of this method is to study factors reducing and raising professional reliability of the worker, synthesis of optimising measures of staff activity.

There is a specialized service on problems of HF reliability, which represents a system of Psycho-physiological Maintenance Laboratories (PML), at the enterprises of Russia's Atomic Energy Ministry on many objects of power energy usage. This system realizes:

(a) Psycho-physiological inspection and monitoring in the medical selection system (according to desire of supporting and monitoring of Russia Health Services),
(b) psychological support and rehabilitation of staff,
(c) ergonomical examination of jobs and technological processes, monitoring of social and psychological climate and settlement of conflicts,
(d) participation in the work of commissions on investigation of the direct and root reasons of failures and malfunctions in work of the enterprises,
(e) management of data bank with results of the psychological service work.

PML are successfully working functioning almost on every Russian NPP. The purpose of creation of a service on NPP, and now at the remaining enterprises of Russia Ministry for

Atomic Energy - extension of professional longevity of staff and increase of the human factor reliability of industry.

The scientific - methodical management of a psychological service, including PLM, is carried out by Obninsk Research Center "Prognoz" (ORC "Prognoz"). The personnel of ORC "Prognoz" consists of PHD specialists in psychology, biology, medicine, sociology, pedagogy (teaching) and etc. The ORC "Prognoz" implements scientific research and services under the contracts with different organizations.

Activity of the ORC "Prognoz":

(a) Legal and methodical co-ordination of the laboratories of psycho-physiological maintenance (LPM);
(b) Methodological co-ordination of work of the nuclear security services, labor protection service and other services of the NPPs and organizations, which are in charge of the improvement of the situation with personnel safety;
(c) Socio-psychological maintenance of the activities of the personnel department; Sociological analysis of the NPP personnel problems, analysis of the work motivation, organization of the monitoring examining socio-psychological climate on the NPPs, creation of the prognosis concerning social tense on the NPPs and working-out recommendations for managers to adjust conflicts;
(d) Working-out the problem of reliability of personnel working on NPP;
(e) Ergonomical research concerning work conditions on the NPP;
(f) Consulting and rendering psycho-pedagogical services;
(g) Central data base for the industry, which holds more than 10.000 psychological and psycho-physiological tests of the personnel of companies of Minatom of Russia;
(h) Central data base of the industry of the incorrect activity of the personnel (including psychological and psychophisiological, ergonomical, socio-psychological, economical and socio-political factors), which led to the breaches in the work of the NPP and affected the professional reliability of the personnel;
(i) Conception of psychological service in the industry of nuclear power.

Unique methods: measuring the maturity and satisfaction of work motivation of the personnel, motivation of the improvement of safety culture on the NPPs ; analysis of the causes of incorrect activity, which led to the breaches of the work of the NPP; number of diagnostics psychological methodics and criterions, which help to estimate the psychological reliability of the management of NPPs.

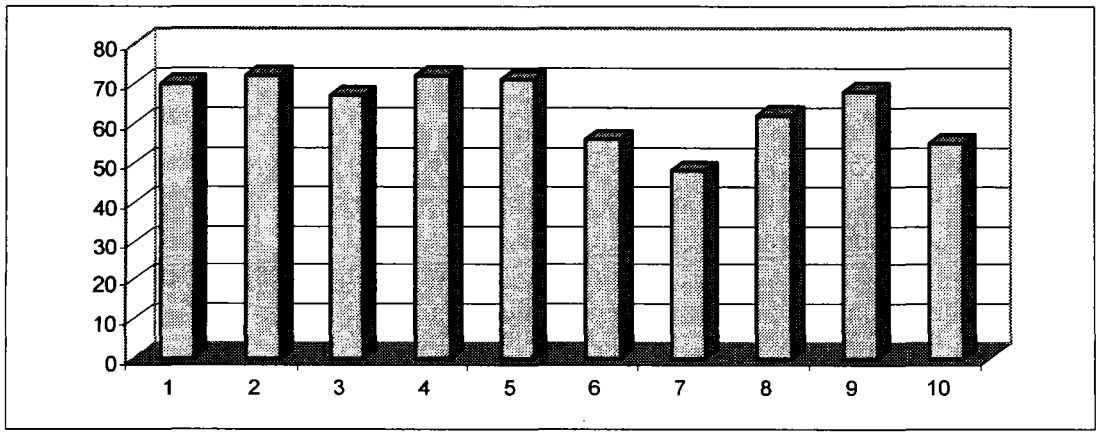
At present, the most actual directions in maintenance of reliable personnel activity are:

(a) Developing and perfection of the information supply system of NPP personnel work, taking into account psychological features of communications;
(b) Perfection of information strategy in maintaining safety culture;
(c) Perfection of training system and improving professional skills of chiefs and personnel in the human factor reliability field;
(d) Training in NPP safety culture and developing psychological aim at the safety priorities in the system of personal values for manufacturing activity;
(e) Measures of material encouragement during work with the personnel in the motivation field of the safety culture raising.

The monitoring of preferences and moral values of personnel allow to diagnose an attitudes in field of safety. Par example, safety attitude allocation (2), obtain in the socio-psychological monitoring of 2001's year, is presented in Fig.2.

Results of monitoring are necessary for the organization and perfection of administration work with the personnel in order to strengthen discipline and responsibility. As active methods of work with the personnel we can recommend further developing and application of social - psychological support methods and these of consultation of NPP workers for the personal problems solution influencing safety of their actions.

Fields of the work results application of ORC "Prognoz" – nuclear power engineering and industry. Besides, the "Prognoz" conducts researches of regional problems of the population of territories, affected by the Chernobyl disaster, and problems of the population of territories, located close to nuclear stations.



The conventional sings:

1. Unity in work
2. Priority of safety
3. Respect to each other
4. Diligent attitude to work
5. Mutual aid
6. Mutual responsibility
7. Personal sympathies to each other
8. Cooperation
9. Discipline
10. Interest to a specialty

FIG. 2. The comparative analysis (in %) of the estimations of factors – qualities, developed in group interactions. The selection – 1528 workers from all Russian NPPs.

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TOPIC 4:

CHANGING THE SAFETY CULTURE

Transforming the organization a systems approach: One nuclear power plant's journey

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Abstract. Change management continues to be an imperative for organizational leaders as they move into the 21st century; globalization, hyper-competition, advanced technology, employee expectations and a changing workforce significantly impact the way in which organizations operate. Unfortunately up to 75% of change initiatives fail. Nuclear power plants in the United States face the same challenges as manufacturing and industrial firms with the added challenge of deregulation. Faced with these new business realities, restructuring the electric utility has raised a number of complex issues. Under traditional cost-of-service regulation, electric utilities were able to pass their costs on to consumers who absorbed them. In the new competitive environment, customers can now choose their suppliers based on the most competitive price, quality and efficiency of service. The purpose of this study was to determine the degree of congruence between non-supervisory and supervisory personnel regarding the perceived implementation levels of high performance workplace practices at a nuclear power plant. In today's business environment it is those plants that can demonstrate integrated and aligned high performance workplace practices that will survive a deregulated and competitive market. The population for this study consisted of organizational members at one nuclear power plant. Over 300 individuals completed surveys on high performance workplace practices. Two surveys were administered, one to non-supervisory personnel and one to first line supervisors and above. The determination of perceived implementation levels of the high performance workplace practices identified was accomplished through descriptive statistical analysis. Results of the study revealed 32 areas of non-congruence between non-supervisory and supervisory personnel. Factor analysis further revealed the order in which the respondents place emphasis on the variables differs between the two groups. This study provided continuous improvement recommendations designed to build upon the existing change management strategy. The implementation of these recommendations can help the plant sustain the changes introduced through a major transformation initiative implemented in 1998.

1. Introduction

In response to shifting markets, the expectations of Boards and financial markets, technology, global competition, changing demographics, and consumer choice; many organizational leaders are attempting to diffuse innovations into their organizations in an attempt to keep pace with the competition. As discussed in Ref. [1], the problem lies in the failure rate of the adoption and diffusion of the innovations. Although the concept of change is nothing new it is often viewed as something to be endured rather than embraced. Change typically creates instability and disrupts the status quo; as a result it is often quite uncomfortable and disturbing for some. Building lasting and sustaining change is not an easy task; it has been estimated that up to 75 percent of organizational change initiatives are met with failure.

In attempts to quickly alter organizational cultures, many innovations are cast to employees with the expectation that they will "buy into" the change and produce management's hoped-for results. The problem, however, is that organizational members have often been conditioned through past experience to avoid the distress and instability that occurs when something new is introduced into the environment. Hence, when programs and initiatives designed to produce change are introduced, perception and past learning have taught employees to avoid the situation and in turn avoid the discomfort in the hope that it will eventually go away. The problem is confounded in that many change initiatives do go away, many are implemented in

such piecemeal fashion that they do not stick they become the program of the month. As a result of the current business environment increased attention has been focused on the effects of management styles, employee satisfaction, the values and norms of organizations, human performance factors. As discussed in Ref. [2], when planning for organizational change all of these factors should be negotiated, a systems perspective assists in alignment of the various activities occurring throughout the enterprise.

Based on this background and rationale, this study sought to discuss and determine the degree to which there was congruence or a lack of congruence between management and employee perceptions of the implementation of high performance workplace practices at one nuclear power plant. As described in Ref. [3], this study used as its foundation the practices identified in the *Road to High Performance Workplaces: A Guide to Better Jobs and Better Business Result* by the U.S. Department of Labor's Office of the American Workplace, as well as variables consistently identified in a review of the literature. Nuclear power plants face both the same challenges as industrial firms, with the added challenge of deregulation. With the onset of deregulation, a multitude of change occurring within the broader business environment, and extremely poor plant performance, a nuclear power plant located in the Midwestern United States set out to reassess its culture and change the way in which the plant was managed. The objective was to move from a predominantly technical and hierarchical culture to a participative and continuous improvement environment.

As described in Ref. [4], change that occurs in any organization, if indeed it does occur, is often superficial rather than substantive. An organization may adopt the words of an initiative designed to change the culture without internalizing what those words mean, espoused versus expressed change. When an initiative is implemented, then specific changes should be evident. Those changes revolve around the specific characteristics of an organization and the perceptions of the organization's members surrounding the adoption and significance of the change

2. Establishing the case for change, vision, skills and outcomes

2.1. Events triggering the transformation effort

From 1988 to 1996, a declining trend in personnel performance at the plant was documented in numerous Nuclear Regulatory Commission (NRC) reports, Institute of Nuclear Power Operations (INPO) evaluations, and internal and external audits and assessments. Prior efforts by plant management failed to identify and correct the reasons for the decline. The actions taken by the leadership team to mitigate problems were usually viewed as punitive and often ineffective in resolving generic problems that resulted from inadequate processes, procedures, and leadership. Although the senior leadership team attempted to resolve these issues, the changes were repeatedly met with failure.

According to the plant's Quality Assurance department, from 1994 to 1997 there were 70 external assessment reports, 16 internal assessment reports and eight quality-assurance audit reports documenting poor operational activities. The quantitative data were onerous; the plant had serious performance problems.

Historical review found a number of major areas, which were the cause of increased Nuclear Regulatory Commission scrutiny and the subject of several Notices of Violation (NOV) resulting in civil penalties by the NRC. The problems identified in the reports can be categorized into the following areas: procedure adherence, procedure adequacy, lack of

conservative nuclear safety decision-making, poor management decision-making, poor communications, poor equipment performance and material condition, lack of engineering rigor, operations training which was placed on probation by the National Academy for Nuclear Training, and an ineffective corrective action program. The plant was out of touch with the standards of acceptable performance for the nuclear industry; its operating future was at stake.

In order for any change initiative to occur, a clear and concise business case must be made. As deregulation was becoming a reality, the need for change was more important than ever. All nuclear power plants within the United States were facing the same basic market and environmental changes that were on the horizon. For this plant, adding to the case for change was the poor performance and impending threat of sale; combined, these realities became the impetus for significant change. The question for senior management was "where to begin?"

The leader's role cannot be overlooked when discussing organizational culture and change; the two concepts go hand in hand. Leaders create organizational cultures, and one of the most decisive functions of leadership may well be the creation, the management, and –if and when that may become necessary-the destruction of culture. As discussed in Ref. [2], culture and leadership, when one examines them closely, are two sides of the same coin, and neither can really be understood by itself. As identified in Ref. [4], a discussion on culture and change is often accompanied by a discussion on the leader's role in facilitating that change. In a study of 10 major companies implementing cultural changes that succeeded the single most visible factor was the leadership at the top.

2.2. Beginning the transformation – a description of the organizational intervention

In line with the literature findings and in order to expedite the change process, between 1996 and 1997 more than 17 key leadership positions were filled with personnel who possessed a new philosophy of leadership. This change allowed for a new approach to problem solving, clear expectations for performance and safety and the ability to communicate those expectations, experience in quality processes and new ways of engaging employees. The significance of this change cannot be overstated. In order for the plant to survive, a complete paradigm shift in management philosophy was necessary. The prior command and control style of leadership that was prevalent across the site was no longer tolerable. The new team brought to the station a fresh approach to leadership style, primarily an understanding of the significance of employee engagement and empowerment.

With a new leadership team and philosophy in place, a clear business case for change and an organizational vision, the next step was to rally the support of all station personnel, both non-union and union-represented personnel. In the United States, there is a heavy investment in training programs designed to improve human performance and train employees in the use and application of new philosophical approaches to business. As described in Ref. [5], in 1994 U.S. employers spent an estimated $52.4 billion on formal training. When indirect costs and expenses for informal on-the-job training are included, total annual expenditures are estimated to be in the $200 billion to $400 billion ranges. Yet as identified in Ref. [6], as little as 10 percent of these expenditures are believed to pay off in on-the-job performance improvements resulting from the transfer of knowledge, skills, and abilities.

Critical to the adoption and transfer of skills, knowledge and abilities to the workplace is the organizational environment and culture. If an individual is unable to put new skills to use and if the culture does not support the application of those skills, then they will quickly be forgotten. With the change in management style a campaign was put into place focusing on the organization's most important asset – the site's personnel. Over a three year period numerous

workshops were implemented site-wide to help employees understand the impact of their behaviors on others, their impact on the change process, transformational leadership techniques, and attention to detail and self checking. Sending the entire staff through the behavioral and leadership training was a huge investment, both financial and emotional. The success of this training was dependent on the new leadership team's recognizing the criticality of this foundation building and supporting the employees in the application of what they learned.

Many site personnel were skeptical of the proposed changes and anticipated outcomes. Many were leery of the new leadership team, as they had seen programs come and go before and for all they knew this was just another "flavor of the month." Part of an effective change plan is recognizing that people will go through emotional and psychological response to the change. Effective "change agents" develop strategies prior to implementation of the change and proactively help organizational members move through the change process. Accordingly, the significance and impact of the "soft skills" training became immeasurable.

In order to enhance the leader's ability to cope with potential resistance, 100 percent of the leadership team received additional training through a "Walk the Talk of Change" program; this included first line supervisors and above. Support groups were put in place involving change agents from across the site. These change agents comprised a cross section of the site population. So it was with the help of fellow co-workers, training interventions, and the progression of time, that many personnel were finally ready to assist in the continued transformation effort. This initial foundation building occurred in 1997 and 1998 and required a significant investment in time, money, energy and leadership focus.

In 1998 the site vice-president and organizational managers, with the help of the change agents and other site personnel, held a two-day offsite conference in which 650 personnel (about two-thirds of the station's personnel) took part. The purpose of the conference was to clearly articulate what the organization's transformation process would look like with the assistance of those directly affected – the employees. It was at this juncture that the significance of the foundation building became crucial in moving the organization forward. As stated previously, quite often employees are provided training to help assist in new philosophical approaches to business and never given the opportunity to formulate them in their own minds, as well as apply those learnings; the "Visioning" Conference was the opportunity for station personnel.

The conference started out with opening remarks from the company's senior leaders followed by a panel discussion of top executives from the electric, regulatory and automotive business. The executives shared their personal perspectives on the significance of change and the change process within their own industry. The discussion was followed by a video that portrayed the organization's future if significant changes were not made. The videotape presented a mock news broadcast in the year 2003 in which the decision is made to shut the plant down due to its inability to compete in a deregulated market

Throughout the conference, station personnel were encouraged to accept one another's contributions and to recognize that there are often many varying perspectives to a particular question and that there is no single answer. The participants focused on their past experiences and generated information to help learn about and appreciate their collective history, the changes they had experienced in life, and what the past meant to them. The participants then focused on commonality of experience, history, and values to provide a starting point for the preferred future. The remainder of the conference focused on identification of the steps needed to realize this new state.

As a result of the conference, employees developed an organizational vision statement agreed upon core values and identified strategic initiatives required to achieve the desired state. Organizational core values identified included ownership, high personal standards, people, ability to change, customer satisfaction, efficiency, honesty/trust, safety, and communication. Ten strategic initiative teams were formed using volunteers from all levels of the organization to focus on such areas as regulatory performance, communications, teamwork, safety and capacity factor, to name a few. These teams were composed of site personnel with a passion and interest around the topic. The role of management was to sponsor the teams' activities, provide resources and eliminate barriers – the employees were participating in the design of their destiny.

While the "Visioning Conference" itself can be viewed as a significant catalyst for organizational change, it was one piece of a larger transformation process that continues to date. Critical to the success of the conference was the foundation building that took place – the training and commitment by senior management to institute fundamental change. Crucial to the continued transformation would be the ability of the leadership team to follow through on their commitments, support the 10 strategic initiative teams, and rally support for continuous improvement.

Any transformation effort will require the senior leaders of the organization to continuously monitor the internal and external environment, and ensure the organization is heading in the right direction. It is those organizations that sit back and take intense satisfaction in their newfound success that will find themselves back where they started. Although a lot of good work had been done in three years, there was still much more to do. As described in Ref. [7], change sticks only when it becomes the way in which organizational members do things - when it seeps into the very bloodstream of the work unit or corporate body. True change, as discussed in Ref. [8], often requires metanoia and takes time; it is an ongoing process that typically takes three to five years to embed. The inability to scan the business environment and create an impetus for continued change often occurs among those organizations reveling in past accomplishments. It is often those that are weeded out through bankruptcy, takeover, or - in a worst-case scenario - organizational demise.

2.3. Measuring the results and determining next steps

With a major change initiative introduced into the culture and the desire to continuously improve the plant, the station's management team agreed to identify what was working well and what needed to course correct. The purpose of this study was to provide quantitative data to assist in identifying opportunities for improvement. Based on the results of this study, station management could refine the business strategy and course correct as needed. The intended results of this study would: (a) Provide insight to the nuclear power plant concerning opportunities to improve overall plant performance as the industry moves towards a deregulated environment. (b) Identify the relationship between the current level of implementation of the intervention and management and employee perceptions of its impact. (c) Identify areas for continued training and staff development. (d) Identify areas of alignment/misalignment of activities and allow for adjustments in strategy. (e) Serve as a tool to monitor the plant's vision and strategic planning.

This study sought to answer the following questions: (a) Was there congruence between management and employee perceptions regarding the implementation of the high performance workplace practices identified in *The Guide* and related review of the literature? (b) How many the principle components do non-supervisory and supervisory personnel identify when thinking about the workplace practices? (c) Based on the components, what factors are

identified by non-supervisory and supervisory personnel? (d) What was the relationship between the degree of congruence and factors identified?

This study was limited to one organization therefore generalizability is a limitation. This study utilized as its foundation the practices identified in *The Guide* and variables identified in a review of the related literature. Since consensus has yet been established on a single definition for a high performance workplace, a variety of practices were reviewed and incorporated into the final survey instrument. The *Road to High Performance Workplaces* recommendations was inclusive enough to encompass more specific practices so this limitation was minimized.

3. Description of methodology and survey results

3.1. Research methodology

Due to the nature of the study and the research questions posed, the population at one nuclear power plant was surveyed. In order to conduct a full assessment of the perceived levels of implementation of high-performance work practices, it was necessary to receive feedback from all levels of the organization. This approach assisted in identification of gap perceptions that existed between leaders and line personnel. The organization consisted of 1,200 contract and full-time employees. Only full-time company employees were sent a questionnaire. The company's human resources management system database was used to identify full-time company employees as well as distinguish between first-line supervisors and above and line personnel. A total of 808 surveys were mailed out. Of that population, 209 were identified as first-line supervisors and above and 599 were identified as line employees. A total of 266 usable surveys were completed and returned by line employees and 93 from first-line supervisors and above.

The questionnaire was constructed based on the items in The Guide, as well as those criteria identified in the literature reviewed as relevant to high-performance workplaces. Questions were grouped according to content, with demographic information requested last. Answers on the questionnaire were consistently formatted from strongly agree to strongly disagree to avoid any confusion to the respondent. The questionnaire was given to constituents for review of clarity, terminology, appropriateness, and design in order to identify any potential defects in the questionnaire. The questionnaire was anonymous and optional; there were no coercive measures in place requiring mandatory participation.

Data concerning the perceived level of congruence between management and employee perceptions of implementation of the practices recommended by the Department of Labor's guide were collected through an on-site mailed questionnaire. In addition to the questionnaire, historical documents and records were reviewed to assess this plant's performance beginning in 1995 versus its current performance. These written documents consisted of NRC reports, INPO findings, job satisfaction surveys, as well as innovation strategies and events that had been captured through photographs, feedback sheets, and documentation.

3.2. Research questions

Research question 1 sought to examine the congruence between management and employee perceptions regarding the implementation of the workplace practices as identified in the Supervisory and Non-Supervisory questionnaires utilized in the study. Two survey questionnaires were mailed out, one to first line supervisors and above, the other to line personnel. Data to answer the question were obtained from responses for each questionnaire item. The scale recorded information about the degree of implementation of high performance

workplace practices at one nuclear power plant. The response data were analyzed using descriptive statistics to indicate the implementation level for each practice as reported by the two groups, z scores were calculated to identify areas of congruence and non-congruence.

Research question 2 asked how many principle components do non-supervisory and supervisory personnel identify when thinking about the workplace practices. In order to answer this question respondents were asked to what extent they believe the following practices are important to a high-performance workplace. Again, these are practices that have been identified through the *Guide* and a review of the literature:

a) Training and continuous learning,
b) Information sharing,
c) Employee participation,
d) Organizational structure,
e) Worker-management partnerships,
f) Compensation systems linked to performance,
g) Supportive work environments,
h) Safety,
i) Organizational mission/vision,
j) Feedback on performance,
k) Strategic business planning,
l) Leadership, and
m) Human resource focus.

Each of the questions asked related directly to one of these aforementioned variables. The questionnaire recorded information regarding the importance level of high performance workplace practices. The response data were analyzed using frequency distribution to indicate the importance level for each work practice. The mean and standard deviation for each practice were analyzed. In order to analyze interrelationships among the variables and to explain these variables in terms of their common underlying dimensions, factor analysis was applied.

Research question 3 sought to determine, based on the components, what factors are identified by non-supervisory and supervisory personnel. This question was answered through factor analysis of survey responses.

Research question 4 sought to determine the relationship between the reported degree of congruence and the factors identified by non-supervisory and supervisory personnel. This question was answered through analysis of the results from the descriptive statistics and the components identified by non-supervisory and supervisory personnel.

3.3. Survey results

Research question 1 sought to determine whether there was congruence between management and employee perceptions regarding the implementation of the high performance workplace practices identified in *The Guide*. In order to answer this question, this research had to first determine the degree to which both non-supervisory and supervisory personnel perceived the variables as currently implemented. The questionnaire used a five-point Likert scale in which the following values were assigned: 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree.

Descriptive statistics were used to analyze question 1. The mean and standard deviation for each workplace practice were reported for both the non-supervisory group and the supervisory group. The minimum for each response is 1 and the maximum is 5; these were also reported.

When compared with one another, the data showed that for 32 of the high performance workplace practices, perceptions between management and employees were significantly different based on absolute values of z scores. The z scores were calculated to determine the number of standard deviations a corresponding raw score was above or below the mean.

When viewed against the practices identified in the review of the literature as contributing to high performance workplace, perceptions surrounding the implementation level of questions associated with: organizational leadership, the implementation of training and continuous learning, information sharing, employee participation, organizational structure and supportive work environments, there was a significant variance between the two groups. Based on a review of the data, the perceptual differences in the implementation of these aforementioned practices was significant enough to warrant further investigation into strategies that could be employed to reduce the gaps.

When management and employee perception regarding the implementation of the high performance workplace practices differ, there is often misalignment. Any perceived disconnect between the behavior of the senior leaders and the values of the organizational members will strongly undermine the commitment of the organization to those values in the minds of its members.

For research question 1, the related null hypothesis was there is congruence between management and employee personnel surrounding the perceived implementation level of the high performance workplace practices. Because 32 perceptual differences exist, the null is rejected.

Question 2 sought to ascertain how many principle components non-supervisory and supervisory personnel identify based on the high performance workplace variables. Based on the principle components, research question 3 sought to identify the factors. Descriptive statistics and factor analysis were applied to answer this question. Based on analysis of the data when presented with the 13 workplace variables, non-supervisory personnel identified two principle components. Variables associated with relationships and variables associated with organizational policies; two factors were identified. Organizational leaders, however, identified three principle components. Variables associated with organizational policy, variables associated with leadership, and variables associated with two-way employee engagement; three factors were identified.

The related null hypothesis for question 2 is non-supervisory and supervisory personnel will identify the same number of components. Based on the analysis of the data, the null is rejected. The related null hypothesis for research question 3 is non-supervisory and supervisory personnel will identify the same factors. Based on review of the data, the null is rejected.

Research question 4 sought to determine the relationship between the degree of congruence and the corresponding factors. Perceptual gaps were identified in the areas of leadership, training and continuous learning, communication and employee participation, organizational structure, compensation, supportive work environments, human resource policies, loyalty, and commitment. Based upon the results of the factor analysis, non-supervisory and supervisory personnel are interpreting the same set of questions differently. The differing perception employees and organizational leaders place on the variables associated with high performing organizations may influence this gap.

While all employees and leaders identify the variables as important, when thinking about the 13 practices, they place different emphasis on the identified factors. Employees emphasize variables associated with relationships while leaders emphasize policy and organizational structure. If the two groups are emphasizing different variables as important, it is likely to affect how they respond to the questions associated with each and could possibly explain the 32 areas of non-congruence.

For research question 4, the related null hypothesis was there were no relationships between the degree of congruence and the factors identified. The analysis and findings for this study indicate there is a relationship between the degree of congruence and factors identified at the nuclear power plant under study.

Analysis of the findings from this study can be summarized as follows. There were 32 areas of non-congruence identified between non-supervisory and supervisory personnel regarding the implementation level of the workplace practices. Non-supervisory personnel identified two principle components, while supervisory personnel identified three. Based on the components, non-supervisory factors were relationships and organizational policy. Supervisory factors were policy and structure, leadership, and two-way employee engagement. There was a relationship between the degree of congruence and the factors identified.

3.4. Identification of organizational deltas and next steps

What gets measured gets managed. This study was integral in helping the station's management team determine the next steps in their change management strategy. A lot of time, energy and money had been put into the Visioning Conference and the need to follow-up and sustain the momentum for change was critical. Based on measurable results, the leadership team was able to capitalize on what had been working well and re-think those strategies that were not. Organizational alignment is defined as the extent to which strategy, structure, and culture of an organization are able to combine to create a synergistic whole. Effective organizations are those that monitor all aspects of the organization ranging from leadership to organizational structure – they take a systems perspective. Successful organizations are those able to see the interconnections between programs and initiatives and the subsequent impact on all departments and levels of individuals in the organization.

4. High performance practices and alignment of organizational activities

4.1. The impact of leadership

Effective leadership has been linked to strong organizational performance. As described in Ref. [9], a key element to an organization's success is the leadership required to continually keep its vision of success in focus, translate that vision through a strategic plan with effectively aligned activities. Transformational leaders inspire others to action through their own personal commitment and practice; they are able to walk the talk. The single most visible factor for instilling change is the leadership at the top.

Core values associated with the Malcolm Baldrige criteria on leadership include commitment to the development of the entire workforce, participation, life-long learning, innovation and creativity, the ability to set clear visible values and high expectations, and the ability to build leadership initiative in all levels of the organization. Throughout the literature, a discussion on change is typically accompanied by a discussion on leadership; the two concepts are inextricably interwoven.

Perceptions are the crucial link between the incoming stimuli and a meaningful response. Additionally perception is an active and selective process that is influenced by attitudes and prior experience. If organizational members perceive their leaders as deficient in the ability to set clear and visible direction to move the organization forward, there will be hesitation to follow. In a time when companies are downsizing and life-long employment is no longer a certainty, the ability to effectively harness the collective genius of constituents is more important than ever. People are searching for satisfaction and meaning in their work; the leader is in the position of enabling an environment conducive to individual growth.

Six survey questions were related to organizational leadership. Of these items, perceptions between management and non-supervisory personnel differed significantly on the perceived implementation level for the following: (a) "I believe the quality of leadership provided by this organization is excellent"; (b) "Management is well trained and demonstrates leadership skills"; (c) "Management sets the direction that builds high performance organizations"; (d) "My management has an open door policy"; (e) On the supervisory survey, "I effectively communicate what I expect my employee to accomplish in their jobs"; and (f) On the non-supervisory survey, "My supervisor effectively communicates what he/she expects of me."

Based on these results, leadership development was an area identified for continued evolution. Survey results revealed significant perceptual gaps between non-supervisory and supervisory personnel regarding the perceived leadership competency at the plant. Supervisory personnel perceive their leadership skill and ability as stronger than the line personnel do. Factor analysis further revealed that when thinking about the 13 high performance workplace categories, non-supervisory personnel identified factors associated with leadership and relationships as important in high performance workplaces while supervisory personnel identified factors associated with policy and procedure.

This dichotomy reveals a management focus in line with the scientific approach to administration, while non-supervisory responses emphasize factors associated with participatory approaches to management. The participative approach to management and employee involvement programs is most often found within high performance organizations.

Based on the results, the plant under study decided to emphasize within their leadership training program, concepts and applications of empowerment, two-way communications, employee involvement, and teamwork to name a few.

4.2. Organizational mission

An organizational mission and, more important, the organizational members' understanding of that mission and their role in its success have been identified as critical elements in establishing a high performance workplace. If the organizational members do not understand how their work contributes to the success of the company, alignment is unlikely to occur because people do not know what path they should follow. As Ref. [10] describes, inspiring a shared vision and establishing an organizational mission is the least frequently applied of the fundamental practices of impeccable leadership. Based on the research, when leaders effectively communicate the organization's vision, constituents report significantly higher levels of job satisfaction, motivation, commitment, loyalty, clarity about the organization's values, pride in the organization, and organizational productivity.

Five survey questions were associated with organizational mission. Of those questions, perceptions differed between employees and management for two of the questions. (a)"I understand how my work directly contributes to the overall success of this company" for the non-supervisory survey, and "my employees understand how their work directly contributes to

the overall success of this company" for the supervisory survey. (b) Addressed employee familiarity with the company strategic plans.

A major step taken by this organization during the three-day conference event was the establishment of their organizational mission and core values. Based on analysis of the data, two areas for follow-up were identified: (1) linking the incumbents' day-to-day activities with the overall mission of the organization. A large part of understanding the mission of the organization is the understanding of the strategic plans in place designed to achieve that mission, and (2) clearly communicating those strategic plans.

Based on recommendations from *The Guide* to be truly successful, information must flow throughout the organization. Workers' ideas and knowledge are conveyed at all levels of the company, and the organization is fully responsive. In companies where this kind of internal communication system is in place, productivity, quality, and customer service improve.

In that this organization had an established organizational mission and strategic planning process, deployment of communications surrounding the employee's role in achieving those results became an area of focus. Many organizations have vision and mission statements hanging on their walls. Unless the organizational members know how their work directly contributes to obtainment of that mission and can articulate such, there is no value - it is simply another wall hanging. Through frequent town hall meetings, written reminders and day-to-day interactions the management team began implementing continuous updates on the plant's mission and strategy.

4.3. Training and continuous learning

According to *The Guide,* high performance organizations are those that view their workers as their most valuable asset and make the appropriate investments in them. Training is continuous and should have a life-long focus. A fundamental challenge for leadership is helping individuals learn from their performance as well as their personal life experiences.

In regards to survey questions associated with training, perceptual gaps existed for the following questions, (a) "training and development are valued in the work environment" and (b) "employees are provided with the developmental opportunities needed to keep pace with industry changes."

Much has been written on the subject of life-long learning and continuous improvement. Employees today, at all levels of the organization, must be in a frequent state of self-renewal and discovery. As described in Ref. [11], the andragogical model of learning posits: 1. The learner is self-directing; there is a need to be perceived by others and treated by others as capable of taking responsibility for ones-self. 2. Adults enter an activity with a wealth of experience; they want the experience acknowledged. 3. Adults become ready to learn when they experience a need to know or do something to perform more effectively in some aspect of their life. 4. Adults enter an educational setting with a life-centered orientation to learning. 5. While adults will respond to some external motivators (i.e. a promotion or salary increase), more potent indicators are self-esteem, personal development, and self-actualization.

Much of the training within nuclear power plants in the United States is based upon criteria set forth by the NRC and INPO; the majority is centered upon job-related tasks, skills, and knowledge. Developmental opportunities centered on personal growth and personal needs have been found to enhance the life-long learning process. Personal development activities based on the needs of the organizational members could serve to narrow the gap between perceptions surrounding training and continuous improvement.

In order to address this area an organizational needs assessment was administered to identify potential training, development, and educational opportunities.

4.4. Organizational structure and information sharing

High performance organizations are those that recognize the workers are often the ones closest to the customer and as a result, typically possess the most knowledge about the product, service, or equipment. The front-line employee is often in the position to make a significant impact on quality and efficiency. In high performing organizations, the workers solve problems, are self-directed and are a critical part of the decision making process.

Both vertical and horizontal communications exist within high performing cultures. Workers have access to information needed to execute the strategic plans and tactics of the organization. Information may include: business plans, operating results, competitor performance and plans for new technology, to name a few.

Survey questions associated with these facets of high performance workplace practices found perceptual differences existed for questions that addressed communications between station management and employees, and questions associated with feedback loops.

Perceptual differences existed for all questions associated with organizational structure: (a) "the plant has reduced the number of layers of management"; (b) "employees have the equipment they need to do their job"; (c) "employees can accomplish their work within their regular schedule"; (d) "employees are organized into teams with substantial team authority"; and (e) "cross-functional teams are used to increase innovation across the organizational boundaries."

Data obtained from the organization's human resource management database indicate there is a 1:4 ratio of supervisory to non-supervisory personnel. This type of ratio does not lend to an organizational structure in which decision-making can be pushed down and employees able to participate in self-directed work teams.

In order to address this area a thorough workforce plan was implemented. The plant aggressively benchmarked its staffing levels with others in the industry utilizing criteria similar to those associated with the plants design basis, and capacity factor. A sound workforce planning process allows the leadership team to make strategic hiring decisions based on the business strategy. Having the right people in the right place at the right time is critical to establishing an efficient and effective organization.

These gaps were further addressed through the formal establishment and utilization of an "open door" philosophy. As mentioned earlier, the management team began conducting regularly scheduled informational meetings and updates on organizational issues, as well as providing ongoing feedback to employees when they provided suggestions.

4.5. Worker-management partnerships

According to *The Guide*, high performance organizations work to end confrontational relationships between management and employees. They seek partnerships with workers and unions on a variety of issues. Perceptual gaps between supervisory and non-supervisory personnel exist for the following question "employees are partners in decision making."

High performance organizations have addressed these issues through the use of cross-functional teams, developmental assignments, and joint accountability between management and their constituents in decision-making. In order to foster an environment of mutual respect and trust, effective leadership skills are once again required; employees will be looking for congruence between espoused and expressed beliefs. The plant management and union leadership have made great strides in their partnership. Key union personnel are actively involved in priority projects and are a part of the site Vice Presidents regularly scheduled strategy sessions.

4.6. Compensation

According to *The Guide*, high performance organizations create innovative compensation systems tied to individual, team, and corporate performance. Compensation systems in high performance organizations focus on the skills and competencies of individuals while, at the same time, reinforcing the structure and design of the organization. Perceptual differences existed for the question "employees receive financial rewards for improvements they recommend."

As described in Ref. [12], new compensation systems are based on roles rather than on narrow job descriptions, have greater flexibility to reward contribution, and have variable pay incentives. According to *The Guide,* skill-based pay encourages a continuous learning environment as employees are rewarded for new skills they acquire. With regards to actions associated with closing this gap, the corporate office sets the strategic direction for compensation strategies, based on this, the plant management began focusing on innovative reward and recognition programs that they could control.

4.7. Supportive work environments, safety and human resource focus

High performance firms recognize the importance of safe and supportive work environments. Companies initiating family-supportive and quality of life programs are able to attract and retain a highly talented workforce. As described in Ref. [3], a survey of 60 fortune 100 companies, focusing on the period from 1966 to 1981, found that where employees perceive a high level of company concern with employee welfare and work conditions, the company tended to show a higher profitability, measured by average return on assets over 5 years, than companies where employees did not perceive such concerns.

Perceptual differences between supervisory and non-supervisory personnel existed on the following questions: (a) "the organization attracts a talented workforce" (b) "the organization is able to retain a talented workforce"; (c) "the accident rate is below the industry average"; (d) "employees can compete for jobs posted throughout the organization"; (e) "all positions to be filled are posted for competitive hire"; and (f) "the pressures related to my job are reasonable."

Based on survey feedback plant management was able to assess the data and identify areas in need of immediate attention. As discussed earlier, ten strategic initiative teams were formed as a result of the Visioning Conference. With additional data to support the need for continued action, the site Safety team became heavily involved in the establishment of a site-wide Safety initiative. Observing Workers Learn Safety (OWLS) was initiated by represented, non-represented, and management personnel. Through collaboration and a mutual desire to

improve the safety culture at the plant the program has become a way of doing business; it is embedded in training, communications and the industrial safety program.

4.8. Value, loyalty, and commitment

High performance workplaces are those where employees feel valued and in turn demonstrate commitment and loyalty to the organization. When organizational members operate from true commitment they feel a tremendous sense of responsibility and ownership for organizational success. With regards to perceptions of loyalty management and employee perceptions significantly differed.

Based on the feedback, the senior management team committed to the annual distribution of a site-wide employee engagement survey. Based on results of the survey adjustment to workplace practices are made. Each workgroup at the plant spends time discussing the survey results and identifying opportunities for improvement.

As described in Ref. [13] organizational alignment is the degree to which an organization's design, strategy, and culture are cooperating to achieve the same desired goals". It is this agreement that creates synergy and harmony within an organization and allows for enhanced efficiency and effectiveness of work processes.

The criteria put forth in *The Guide*, as well as additional criteria obtained from the review of the literature, can serve to monitor and enhance the effectiveness of an organization. The comprehensive questionnaire and subsequent results have identified areas in which one nuclear power plant was able to implement continuous improvement strategies based on quantitative results. The information obtained through the survey questionnaire provides an opportunity for management to develop sound strategies and tactics to address the identified deltas.

4.9. Level 3 results

Understanding how the organizational members view the plant's current condition is a key element in developing sound strategies and tactics in which employees will feel both capable and willing to head. When management and employees are aligned, communication is clearer and strategy implementation has the potential for greater focus and effectiveness. When there are differences of opinion among management and employees about their perception of the culture, there is often internal dissent and misalignment of activities.

According to Fermi-2's vice president since the transformation began in 1996 numerous trends indicating improvement have been observed: (a) On average, with scheduled outages taken into consideration, the capacity factor has increased from 62.3 percent to 93 percent. (b) Plant production costs have dropped from $36.6/MWh to $17.97/MWh. (c) Forced outage rates have dropped from 25.6 percent to 1.2 percent. (d) Maintenance backlogs have dropped from 800 to 200 job tickets.

In addition to these trends, station personnel have established numerous programs focusing on human performance. In 1999, a formal supervisor development program was initiated, with site management, including union leadership, serving as facilitators; they are "walking the talk." All departments on site now operate under a five-year strategic plan directly linked to the company's objectives through their department-specific business plans. The Nuclear Training Department, through its training excellence plans, has turned its performance around.

Through a concerted effort between the training department and plant personnel, the quality of training programs has improved across the board.

A key aspect to this plant's continued success will be its union-management partnership. According to Fermi-2's bargaining unit chairman, the level of grievances is far below what existed prior to 1997. Weeks will go by without issues resulting in grievances, and when they do they are usually resolved before an "interest-based bargaining session" (a process by which both parties find common ground). There have been only eleven numbered grievances in four and a half years. In 1996, the site developed Partnership Principles. In 1997, a new relationship between management and union personnel began, culminating in the formation of a Business Unit Partnership Team in 1999. The partnership process has been slow, but progress has been made.

The Fermi-2 organization continues its pursuit of excellence today. According to Ref. [14], it is the utility that will survive and succeed in the 21st century must take control of its own destiny. Nothing will preserve its right to exist, as yesterday's corporate dinosaurs confirm. Being a commodity provider always has a limited life when customers and competition demand change.

In the 2001 INPO plant evaluation, Fermi-2 was recognized for performance excellence. While numerous strides have been made, there is still much more to do. The journey continues.

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Safety and Human Factors impacts of introducing Quality Management into High-Risk Industries
A field study

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Abstract. The Institute for Radiological Protection and Nuclear Safety has undertaken a study[3] for getting a better understanding, especially in terms of Safety and Human Factors, of the changes caused by the progressive deployment of the Quality Management in French high risk industries. This study is based on both theoretical elements from the human sciences and management and practical elements from the field, collected from interviews in large French industrial sites involved in integrating this management method. The results show frequent discrepancies between theory, which is very positive and production-oriented, and reality, which is more complex and subtle, ever looking for trade-offs between production requirements and safety constraints. Thus, each step forward announced in the literature may be matched by possible steps backward in terms of safety on the ground. Where, in theory, processes enable practices to be mastered, in practice they can reduce autonomy and fossilize know-how. Where theoretically continuous improvement stimulates and strengthens performances, in reality it can also generate stress and deadlock. Where theoretically personal commitment and collective responsibility work towards all-out performance, in reality they can also operate to conceal safety deviations and infringements. The assessment of Quality Management processes in the nuclear field will benefit from these first results raised from theoretical review and confirmed by similar management changes.

1. Introduction

The French operator Electricité de France (EdF) has decided to gradually introduce a Quality Management policy throughout its facilities. It is an important organisational change that may have consequences, in terms of human factors, on the safety of nuclear installations. The Institute for Radiological Protection and Nuclear Safety (IRSN) has carried out a first study dealing with such managerial changes and their possible impact on safety from human factors point of view, through a bibliographical study and the analysis of experience carried out on ten or so French companies engaged in a similar approach.

2. The key points of quality management

Quality Management, as it is specified for instance by the EFQM[4] defines a strategy of continuous improvement of all performances, focused on two broad areas: customers – or

[3] Carried out under a contract with IRSN.

[4] European Foundation for Quality Management. The EFQM Excellence Model is widely used as an organizational framework in Europe. It is a non-prescriptive framework that recognizes there are many approaches to achieving sustainable excellence in all aspects of performance. Excellence, defined as a practice in managing the organization and achieving results, is based on a set of eight fundamental concepts: Results orientation, Customers focus, Leadership and constancy of purpose, Management by processes and facts, People development and involvement, Continuous learning, innovation and improvement, partnership development, public responsibility. In this EFQM model, nine criteria can be used to assess an organisation's progress towards excellence. This information is an extract from the information available in http:\\www.efqm.org.

more generally, all the actors involved in the company's activity, whether shareholders, managers, employees, suppliers, intermediate customers or consumers – and results orientation.

The customer-oriented approach involves rethinking the workings of the company by describing all the processes that characterize the activity and seeking to rationalize them with the object of eliminating all wastage – of raw materials, equipment, time, services, activities, etc. This type of management gambles on optimally exploiting human resources, in all their dimensions, by promoting universally recognized values such as respect, loyalty, trust, personal commitment, rigour, effort, sense of community, transparency. All the actors, whatever their hierarchical level, are involved in the dynamics of continuous improvement, by contributing new ideas for improving performances and working conditions, by communicating, by training, by being responsible for the overall operation of the company. This dynamics is created around a charismatic leader, capable of mobilizing people, giving them a sense of responsibility and ensuring the group's cohesion while maintaining a constant, consistent vision of the results to be achieved.

The results approach consists in managing through processes and through facts. It requires the introduction of performance indicators enabling the company to measure, assess its own performances, to have an accurate view of its operation and the satisfaction of all customers, and to be able to anticipate, plan and set realistic objectives.

Applying these theoretically promising principles is certainly more complicated to carry out than is described in the specialist literature. Before undertaking the field study, the main strengths but also limits were raised from a bibliographical review (cf. References [1] to [22]). Because an organization that institutes Quality Management commits itself to a long-term process of profound change, since it affects the very values of corporate culture and of people, this review considered several typical changes caused by the introduction of Quality Management model (for instance: flattening out of the organization, redefinition of rules between actors and managers, setting up of working groups related to processes, evolution of values in the company, etc.). One very general conclusion of the review was that before arriving at a complete, total and really systematic stage of quality, the organization must necessarily go through periods of instability, even periods of crisis which may weaken it on all levels, including those of safety.

3. Field study

In February and March 2002, a field study was conducted on 12 French industrial sites[5], predominantly Seveso classified, all characterized by strict safety constraints. On each of the sites, semi-directive interviews were conducted with actors of various levels of responsibility (Quality Managers, safety managers, senior management, shop foremen, field operators, etc.). In all, fifty accounts were collected regarding the introduction of Quality Management into a company and the consequences that arose from it, in terms of changes in the activity, in social climate, safety and corporate culture. All the information collected was supported by facts and was subjected to a cross-analysis carried out by three investigators to ensure the reality of the strong and weak points identified.

The methodology was based on semi-structured interviews. The framework for the interviews is built on fifteen main human and organizational dimensions raised from quality management

[5] Société Nationale Maritime Corse Méditerranée SNCM, Hydro Agri France, BP chimie, Les Chantiers de l'Atlantique, Poitou Foundries, Donges Refinery, Airbus Industries, IN SNEC, Legris Autoline, Naphtachimie, Nitrochimie, Oxochimie.

model (for example self-control, redefinition of rules, commitment of managers, processes analysis, workload, communication, etc.). For each dimension, one or several hypotheses about the possible human factors impacts of the statement were made. A list of questions is associated to these hypotheses. For example, one dimension was the concept of continuous improvement, about which the following hypothesis was formulated: "in medium or long term, the continuous improvement leads to instability, that can generate a feeling of insecurity, even stress, for the company's staff, and will be no more accepted by actors, whatever their level in the hierarchy. They will try to maintain some stability in using indicators in a way to hide this stabilised situation". Six questions are associated with this dimension, concerning the improvements mechanisms, rhythm of change of the procedures, feeling of interviewees about the instability of the situation, etc.

Another dimension was the workload. Because of evolution and increase of quality requirements, results are more and more difficult to achieve, people have the feeling to run without end. A first hypothesis is: facing with such a situation, staff people will build strategies to saving time (to the detriment of safety?). A second hypothesis is that the different actors will share these strategies, they'll be tacitly accepted but they'll be hidden. Eight questions concerned these two hypotheses.

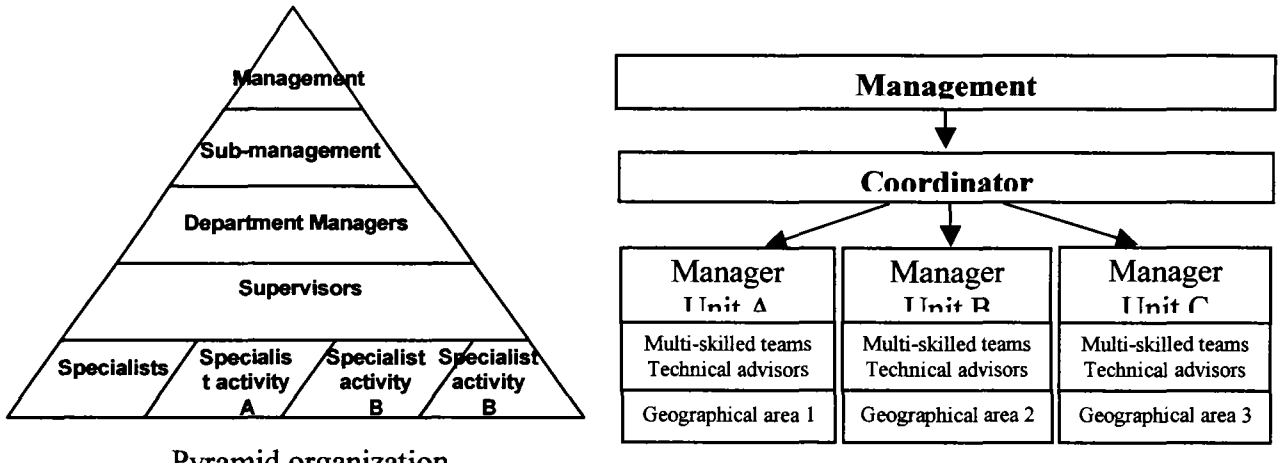
On the whole, the interviews were structured by a set of about 35 hypotheses and 100 questions.

4. Main results

The transition from a conventional type of management (pyramid structure, organization according to specialist activity logic, hierarchical control, vertical rules of communication), to Quality Management involves profound changes that are structural, strategic and cultural. The field survey identified the strong points of Quality Management, but also revealed negative effects for safety. A few results obtained from this field study are presented in this paper.

4.1 Structural Changes

Deploying Quality Management requires reorganizing the company by no longer necessarily following a specialist activity logic, but a customer-oriented, functional unit logic. Each unit guided by a customer process must determine who its customers and suppliers are and who is responsible for its results. Accordingly, organizations will pass more or less gradually from a pyramid structure to a flattened structure, like a rake, (see next figure No. 1).



Pyramid organization

Process-oriented organization

FIG. 1. Comparison of an example of pyramid organization (post-Taylorian) and an example of process-oriented organization.

Positive effects - Such a change may have a number of advantages. Thus, the formalization of processes and the search for better resource management strengthen the organization: they help the actors to have a better view of the overall operation of the company, give meaning to certain tasks, and especially to tasks associated with communications and the safety of the system. Furthermore, this work of construction makes the participants in the company aware of certain inconsistencies damaging to the company's operation, and sometimes to its safety. It also sometimes brings to light deviant (rules not applied, no respect of procedures, etc.) or illicit practices (fraudulent practices, embezzlement, etc.), which may have existed for a long time and threatened safety. This exposure can be accompanied by effective corrective measures. In addition, the autonomy given to teams in carrying out their assignments makes them more responsible, more involved in their work. The search for versatility within teams may help overcome some risks due, for example to absence, illness or other unusual circumstances.

Negative effects - On the other hand, a number of negative effects were noted. Thus, it was observed that the work of **formalizing processes** is almost routinely accompanied by a phase of rejection on the part of the field operators who do not subscribe to the objectives and fear a loss of autonomy. This resistance movement can cause deviant, inflexible behaviour and absences (especially sick leaves). The work of formalization is also accompanied by an initial phase characterized by an excess of procedures and bureaucratic functioning, not very compatible with the responsible activity that the actors have to perform in a system at risk. The rigid use of procedures can gradually break up an oral culture rich in lessons passed on to beginners by the most experienced. While they are criticized for complicating reality, procedures are actually bound to simplify it and do not cover all situations. For these reasons, they cannot completely replace human intervention in a complex incident context. Finally, some safety officers complain about the fact that safety procedures are merged with quality procedures, trivializing them and making them invisible, to the point of sometimes being regarded by the actors as pointless steps making an operating method more cumbersome.

The flattening out of the organization leads to a progressive withdrawal of middle management, thus eliminating a communications link between senior management and the shop floor. This withdrawal can help create a gap between management and shop floor and prevent the company from stepping back from its operations, necessary when dealing with safety problems. The risk is that of setting up an organization that operates with a management team directing far from the shop floor, via indicators, and shop floor teams too engaged in the work of production to stand back objectively, but responsible for self-inspection, etc. and endeavouring to make the indicators say what the management expects of them.

The **multi-skilled versatility** advocated by the approach poses serious problems. In order to standardize the skills within a team, training courses are generally given internally in the form of guidance or counselling by fellow workers, or externally with the issue of formal or informal qualifications. When badly administered, training may have very negative effects on safety. Very often, the coach / trainer does not have the resources (time, teaching equipment), or the training, or the reference framework, or the equipment for testing the skills acquired that would enable him to perform his work as a trainer suitably. Generally it takes up his working time to follow the progress of his "pupil", gives him responsibilities beyond his competence and makes him take risks. Moreover, such tutors sometimes teach deviant practices – by omitting to speak of the possible consequences of these practices – to meet the

demands of production. Badly managed training guidance has repeatedly been identified as the source of serious incidents or events. Versatility also poses the problem of loss of specialists in the company, actors possessing a highly specialized skill essential for sorting out an abnormal or incident situation. These specialists see their field of action widened, and they exercise their specialization increasingly rarely. Less used, the special skill loses its fine edge.

4.2. Strategic changes

The quality approach involves adopting a method of operation enabling the company to continuously plan for the future and anticipate situations. It makes the introduction of experience feedback inescapable (in theory).

Positive effects - This method of management favours risk prevention. When placed in general use, it can prove positive in tackling safety problems. In fact, continuous, honest reappraisal, which accepts making a true assessment, can lead the actors to embarking on their activity with a heightened awareness of the risks and a concern for safety that can place it at the same level as that of production.

Negative effects - In an economically and socially unstable context, if the improvement targets are over-ambitious, if the gap between the present situation and the objective to be attained in the short term is too wide, the actors are going to take risks to achieve it, stray from procedures and display deviant behaviour. In a more stable context, the risk is that of a deadlock, a refusal to join in, capable of ending up in a social crisis. In any case, if the context is too unsettled or the changes demanded are too great, the situation will quickly become untenable, being too unstable and causing stress. The actors will seek to introduce a routine "at any price" and will set out to redistribute roles and responsibilities by placing priorities where they may find recognition (generally in favour of production and at the expense of safety).

4.3. Cultural changes

Quality Management promotes a sense of personal commitment and collective responsibility. It advocates self-inspection based on the principles of trust and professionalism.

Positive effects - All the objectives of quality control are highly positive since they aim at excellence. Their strength lies first and foremost in their ambition to count on the quality of human relationships in the company and on recognized values outside the company. The key is to mobilize staff and give meaning to collective action. When it is really acknowledged and rewarded, personal commitment enables the actors to put great effort into the operation of the company, and it can produce excellent results. A team leader committed to his work carries his crew along, motivating them and drawing them together to achieve high levels of performance, in terms of both production and safety.

Negative effects - However, if production targets are very high, the team leader can also take his crew in the direction of accepted collective deviations and cover for the crew in the event of a problem. Personal commitment can lead to taking risks and deviant behaviour with respect to safety (deactivating a safety system to continue production, using non-compliant materials, taking short-cuts in restrictive operating methods, etc.). Collective responsibility is not always compatible with safety. That is to say that actors, at the limits of their competence, may hide behind the group and feel less concerned about safety. The principles of self-

inspection form no inducement to the company to take an outside look at itself. It has a tendency to check everything internally, without standing back, which is not compatible with safety. Moreover, the self-inspection system within a team may be very perverted and lead to deviant collective behaviour. Examples have been reported of concealment of negative safety results being accepted by all the actors in the company. The problems become even more acute when subcontracting is involved, which may combine quality management systems of differing levels of maturity.

5. Conclusion

Quality Management embraces far-reaching concepts. They can be interpreted and put into practice in many ways. The discrepancies that were discernable between theory and practice rest on the very basis of these concepts, which seem to ignore the variability of a company, a team or an actor. The grand ideals of total quality have been built upon the ideal representation of a company, existing over a long period, looking after its employees, trusting them and motivating them without recourse to financial incentives. On their side, individuals are seen as fundamentally good, capable of learning, but also capable of teaching, altruistic and trustworthy. The reality is much more complex. The area of quality is the scene of multiple compromises, which may sometimes take on the appearance of conflicts. The application of Quality Management can give amazingly positive results, but quite often comes up against cultural differences, conflicting interests and organizational routines, and generates deviations that are not always compatible with safety. In any case, it must never be lost sight of that this values-based system is fragile. A few inopportune discrepancies or "counter-actions" may suddenly destroy brilliant results.

One objective of the study was to bring out some impacts on safety from a human factors point of view, of the Quality Management approach. It was for the IRSN a first step for gathering information from experience in other industries than the nuclear industry. The results of this field study provided some positive facts in favour of the Quality Management approach, but also some difficulties that may have a negative impact on safety. Regarding the assessment of Quality Management application in the nuclear field, the study provided a number of important issues to be considered. A next step will be to carry out a more detailed qualitative analysis, to understand more precisely what happens during the application of management models. Another further step would be to extend this field investigation, using the same semi-structured interviews methodology, to other countries where risk industries are engaged in similar managerial changes, in partnership with national organisations involved in nuclear safety in these countries.

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Enhancing the Safety Culture of Non-Power Nuclear Installations: Initiatives within the Forum for Nuclear Cooperation in Asia

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Abstract: The development and application of safety culture principles has naturally focused on nuclear power plants and fuel cycle facilities and has been based on studies in Europe, North America, Japan and Korea. However, most radiation injuries and deaths have resulted from the mishandling of radioactive sources, inadvertent over-exposure to X-rays and criticality incidents, unrelated to nuclear power plant operations. Within the Forum on Nuclear Cooperation in Asia (FNCA), Australia has promoted initiatives to apply safety culture principles across all nuclear and radiation application activities and in a manner that is culturally appropriate for Asian countries. The major focus has been on research reactors and to a lesser extent on fuel cycle facilities. The process has been motivated by annual workshops, where participants have reported against agreed indicators and shared their experiences in initiating safety culture programmes in these non-power nuclear activities. This paper provides a summary of some of the outcomes and conclusions on the effectiveness of these initiatives and some experiences from reviews of incidents in the participating countries.

1. Introduction

Safety culture has been defined in various ways [1, 2] and most accepted definitions emphasize that safety culture is attitudinal as well as structural, relates both to organisations and individuals, and concerns the requirement to match all safety issues with appropriate systems, perceptions and actions. Some definitions also emphasise behaviour [2] which are not always well-correlated with attitudes [3].

It relates not just to the organisation responsible for nuclear plant or radiation equipment but also to that organisation's corporate body; to supporting activities for design, manufacture, construction, inspection and research; to regulatory bodies; and to the relevant policy and legislative activities of Governments. The operating organisation and its senior management do, however occupy the central role in achieving a good safety culture.

Although some definitions specifically emphasise nuclear (and nuclear power) safety, the principles are generally applicable to research reactor operation and utilisation, the safe use of sources of ionizing radiation and general industrial and personal safety. In this regard, safety with respect to radiation protection of workers and the public cannot be divorced from other aspects of safety. A good safety culture must permeate all activities of the organisation.

Assessing the level of safety culture has been an elusive goal, although many tools have been developed (e.g. the INSAG 4 report [1] and ASCOT [4] processes, as well as attitudinal surveys [5, 6]). The results of the work have provided practical suggestions for developing safety culture and examples of good safety culture practices [7, 8, 9, 10].

Among the participants of the Forum for Nuclear Cooperation in Asia (FNCA)[1], the three countries with nuclear power programs, China, Japan and Korea, have significant programs in safety culture in nuclear power plants (NPPs). Other countries without nuclear power did not previously have programs but have recognized the need for implementing safety culture in their nuclear and radiation facilities. Even among the three NPP countries, there are other nuclear facilities where safety culture programs have not previously been well established.

The authors have previously examined some of the data on radiation incidents and on other occurrences that have safety culture implications and discussed initiatives taken by Australia at the Australian Nuclear Science and Technology Organisation (ANSTO) in Sydney and within the FNCA [6,7]. This paper summaries some of the outcomes from initiatives within the annual FNCA workshops.

2. Safety Culture Workshops within the FNCA

Five workshops organized by ANSTO and the host country have now been held under the auspices of the FNCA with the objectives:

- To provide a forum for exchange of information among countries on safety culture developments in nuclear operations and radiation activities.
- To encourage the adoption of safety culture principles in each country in national policies for non-power reactor facilities.
- To develop methods for evaluating safety culture implementation and to report on such indicators of safety culture on an annual basis.
- To encourage the application of the nuclear safety convention principles to research reactors.
- To discuss and implement collaborative activities for developing and strengthening safety culture within the region, with a focus on non power reactor nuclear and radiation applications.

The workshops have generally had the following format:

(1) Country reports, reporting on indicators.

(2) Working groups on various topical areas, and

(3) Review of incidents and lessons learned.

Outcomes of the workshops are reported in the following subsections under these headings.

2.1. Country reports

Country reports consist of reports on the agreed activity indicators, selected articles of the Nuclear Safety Convention and more recently, on agreed benchmarks.

[1] The FNCA was formerly the International Conference on Nuclear Cooperation in Asia (ICNCA). The members are Australia, China, Indonesia, Japan, Korea, Malaysia, Philippines, Thailand and Vietnam

2.1.1. Activity indicators

At the second workshop, several indicators of activity in safety culture (rather than safety culture indicators themselves) were agreed. These were:

- Meetings between management and employees to discuss and enhance the safety culture of the organisation.
- A system for analysis of incidents to determine human factors and lessons learned to improve safety culture.
- Training activities related to improving safety.
- Meetings or activities with regulators, contractors and reactor users to discuss safety culture.
- Surveys, behavioural studies etc carried out to determine employee.
- Adequacy of resources allocated to promote safety culture activities.

It became clear that the last indicator is really an issue for the individual organisation. Among the outcomes from these reports have been:

- Most countries have developed communication mechanisms on safety culture. One organisation uses a regular newsletter, while others have regular meetings with employees to discuss safety culture. Several countries have developed or re-issued their safety policies to give greater emphasis to safety culture commitments. Several organisations reported having prepared some safety related or safety-culture related brochures or pamphlets for staff.
- Most organisations have extensive systems for incident investigation. Few have specific human factors experts involved in these investigations. Countries that do so have reported the effectiveness of this process. Most incident reporting systems, whether national or international, allow good information on safety culture to be captured. It is regrettable that the major attention to safety culture in the INES approach is used to uprate the INES rating due to poor safety culture. One country highlighted an incident where sectionalism and treating the safety review function as a formality had led to an incident, and this was related to discussions at the previous workshop where these phenomena had been associated with signs of a declining safety culture. Another organisation highlighted an incident that recurred several times because of inadequate root cause analysis.
- Training in safety culture is not usually separately done. It is part of general safety or not mentioned directly. However a few organisations have initiated this specific training and use it for new starters and as part of the refresher process for operators. A proposed contents of a safety culture course was developed.
- Meetings with regulators and reactor users are an important part of safety culture enhancement. A few organisations meet regularly with regulators to discuss joint goals, but in some countries the interaction with regulators is very formal and distant. Regulators need to see progress in safety culture as something that is strongly in their interests,
- A safety culture attitudinal survey was developed in Australia and has now been used in Japan, Korea, Indonesia, Philippines and Vietnam. This has highlighted the different cultural approaches to safety. In particular the willingness to criticise managers was different between the countries. While such surveys only give an assessment of the

perceptions of safety, they have been useful in pointing to areas that need follow-up at the local levels.

2.1.2. Nuclear Safety Convention Articles

From the fourth workshop onwards, countries also agreed to report on articles 7-10 of the Nuclear Safety Convention (NSC) and later also on articles 14 and 16. These relate to the regulatory body, priority to safety and to emergency planning, issues that are relevant in assessing the importance of safety in organisations. All countries have regulatory bodies (Article 8) although these vary greatly in their structure, scope of coverage of activities (nuclear facilities alone or all nuclear and radiation activities) and position within Government structures. In several cases there is not effective independence of the regulator from Government application or promotional activities or regulation does not extend to Government activities. The need to improve this situation was recognised by the countries concerned. The resources available to the regulatory bodies also vary greatly and in some cases are very limited, raising questions about practical effectiveness.

The principle of the licensee having prime responsibility for safety (Article 9) is recognised in all countries although one country recognised a need to make this explicit in its legislation and regulations. In several countries a close involvement of the regulator with the safety activities of the licensees or unlicensed operator created a de-facto situation of shared responsibility.

The development and implementation of policies that give due priority to safety by organisations with activities directly related to nuclear installations (Article 10) is at different stages of development among the participant countries.

In terms of NSC indicators 14-16, several countries reported that there was either no national emergency plan or that there has not been a major emergency exercise in that country or an exercise of the national plan for many years.

2.1.3. Benchmarks

The following benchmarks were adopted at the fourth meeting as elements of a good safety culture process.

1. Top level policy statement outlining commitment to safety culture and giving top priority to safety. Adopted by all facilities.
2. There is an active nuclear safety review committee that reports its findings at corporate level.
3. Formal meetings of the top management board (or equivalent) include agenda items on safety.
4. Effectively independent and active regulatory organization that establishes standards and regulations.
5. Safety assessment process for all activities with approvals reviewed on an annual basis.
6. Mechanism to promote safety culture in the organization – e.g. task group or committee.
7. A system of regular reporting against safety performance and safety culture indicators with a program for the improvement of performance.
8. System for allowing feedback from employees on nuclear safety.
9. The assignment of safety responsibilities at all levels of the organization has been clearly enunciated, through for example, a delegation document, or set of duty statements.

10. Regular training courses on safety culture for all nuclear facility employees.
11. Accident/incident investigation process, conducted independently of operating group and involving assessment of organisational and human factors.

3. Working groups on various topical areas

Over the five workshops, working groups have been held on

- Communicating a high-level management commitment to safety in the research reactor environment; establishing a safety culture task group, its membership and responsibilities
- Identifying indicators of safety culture for use in the research reactor environment; whether the indicators were sufficient or practical
- Promoting safety culture at research organisations and new facilities by regulatory authorities
- Identifying early signs of deteriorating safety culture; threats to safety culture particular to research organisations; and communication of safety culture matters with the public.
- Identifying warning signs of declining safety culture
- Organisational factors in safety culture
- Training staff in safety culture and safety awareness and safety consciousness
- Undertaking peer reviews of research reactors.

Some highlights from a few of these working groups are identified below.

3.1. Role of the regulator

Regulatory processes vary considerably from country to country and are in themselves culture dependent. It was agreed that safety culture should not, and probably could not, be mandated. The role of the regulator should be to facilitate and encourage the development of a strong safety culture in nuclear facilities and activities rather than to try to enforce it. It was also essential that there be a strong safety culture within the regulatory organisation. The operator "owned' the responsibility for safety and the regulator should not become the operator's decision maker. The independence of the regulator was essential and should be reflected in a "healthy tension" between regulator and operator. However, the regulators safety culture should exhibit a preference for non-punitive approaches to achieving regulatory objectives.
With respect to safety culture indicators, several issues were identified as deserving close attention. Various types of indicators were available but they needed to be auditable to be of regulatory use. For example, the extent and effectiveness of the operators application of ALARA could be a useful and measurable indication. Other questions to be answered included whether the regulator should prescribe indicators, whether the indicators of most use to the regulator were the same as those useful to the operator and whether the regulator should adopt an active or passive approach to the application of indicators.
The group identified a special responsibility for regulatory bodies to foster and provide guidance on the development of a strong safety culture in operating organisations where nuclear programs are newly established or prospective. A similar responsibility should be recognised by regulators where licensees have small scale or diverse operations, are inexperienced, or where radiation safety is a minor or incidental part of the operators activity.

Finally, it was agreed that in fostering a strong safety culture in a nuclear organisation, the nuclear safety regulator must take appropriate cognisance of the fact that radiation, industrial and occupational safety are also involved, but, depending on the regulatory regime, these may be regulated by other authorities.

3.2. Essential elements of a good safety culture

The following elements were suggested:

- Safety Culture should be declared by the top level management, including the government and regulators if appropriate, but certainly by the Board or president of the operating company
- A Safety Culture Promotion Committee (SCPC) should be set up involving all aspects of the organisation's management structure.
- Safety Culture activities should be implemented through a task force or working group.

The activities of the SCPC or the working groups should include:

- Setting guidelines
- Establishing a Safety Culture Promotion Plan
- Fact finding, including looking at root causes
- Solutions for problems
- Reviews of the results and lessons learned
- Feedback for improvement of Safety Culture
- Involving everyone in team work, including unions and contractors.
- Covering all issues.

The group emphasised the high level commitment needed, the requirement for a promotional committee with the aim of implementing an agreed programme and the need to involve everyone in the process.

3.3. Indicators of decline

The group considered indicators that might be relevant to nuclear power plants and to research reactors.

Five indicators were proposed by the group on nuclear power plants:

- Loss of expertise, low morale and no new people entering the industry.
- Overly-prescriptive regulation leading to a reactive culture - lack of innovation and no new development of processes. The group noted that de-regulation in the U.S. had improved safety and performance.
- Lack of adequate resources to safety from downsizing and economic downturns.
- Poor plant performance – exemplified in poor housekeeping, more abnormal reports, low availability, more incidents etc.
- Poor communication leading to people not being involved, not being consulted, lack of feedback from staff and not getting support from engineers and design into operations.

For research reactors, the indicators were:

- Increasing number of scrams or abnormal events due to human error, procedure deficiencies or procedure violations reflecting complacency, inattentiveness or lack of belonging;

- Lack of, or deficient processes or criteria for accepting plant back into service after maintenance reflecting a lack of control of maintenance work;
- Lack of or deficient safety training for contractors;
- Poor documentation or record keeping associated with maintenance;
- Poor communication between operators and reactor users;
- Increasing collective doses reflecting poor housekeeping and poor work environment; and
- Fewer meetings, or decreasing attendance at meetings, of operators of similar reactors reflecting an increasing sense of isolationism (a sense that our reactor is unique and we cannot learn lessons from others).

4. Review of incidents and lessons learned

Reviewing incidents has been a strong focus within the FNCA workshops. Countries indicated the importance of having systems for learning from experience. In Japan, direct benefit was received from applying lessons learned from the TMI accident. These lessons had been incorporated into simulator training for the Mihama NPP and were influential in safely terminating a steam generator tube rupture at the Mihama-2 SGTR in 1991. The simulator training had allowed the operators to feet at ease and confident when the accident arose. Learning from experience was a key element in training in JAERI and Hamaoka.

A comprehensive presentation was given on the JCO accident and the lessons that had been learned. The direct cause was the pouring of an excessive amount of uranyl nitrate (16.6 kgU) into the precipitation tank. This was an unapproved use of the precipitation tank, caused by lack of adequate training and education of the operators. The two principal root causes were deduced:

- Degradation in safety culture – with contributing factors being commercial pressures, insufficient regulatory oversight and insufficient quality control over modifications.
- Failure to give appropriate attention to the infrequent, small scale and specific tasks.

An update on the source accident in Thailand in February 2000 revealed that contributory factors were the lack of a disposal route for the spent source and no notification of the disposal by the licensee; there were no warning signs in the local language on the source to alert the scrap metal worker; the national regulations were not sufficiently clear on source long term storage or disposal and there were inadequate resources to do inspections. The accident emphasized the need for continued attention to safety culture, especially the need for active and effective regulatory systems and thorough training of users of radioactive materials.

5. Peer reviews and national reports

At the fifth workshop it was recommended a national report format and voluntary peer review process to foster safety culture in research reactors by identifying good practices and areas for improvement. The review should commence with the preparation of a report that identifies the research reactor organisations and facilities and that focuses on factors affecting safety culture. Following the meeting, Australia and Japan drafted a list of topics for discussion. This was agreed and endorsed by the FNCA project coordinators meeting in March 2002. Countries will be asked to complete some information on a selected research reactor and this information will serve as a basis for peer review visit. Vietnam has agreed to such a visit to coincide with the holding of the next workshop.

6. Conclusions

Some recent initiatives in safety culture in Asian countries participating in the FNCA have shown the need for cultural issues to be clearly addressed in implementation of safety culture. The experiences of the nuclear power countries have provided useful information for beginning an application of safety culture to non-power reactor facilities. Initial collaboration has focused on exchange of information and on reporting activities against an agreed set of safety culture activity indicators. These exchanges have stimulated new initiatives in nearly every country.

7. Acknowledgment

The authors acknowledge the contribution of the many participants in the FNCA Workshops.

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Eletronuclear's Safety Culture Assessment and Enhancement Program

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Abstract. The present paper describes the Eletronuclear's safety culture assessment and enhancement program. The program was launched by the company's top management one year after the creation of Eletronuclear in 1997, from the merging of two companies with different organizational cultures, the design&engineering company Nuclen and the nuclear directorate of the Utility Furnas, Operator of the Angra1 NPP. The program consisted of an assessment performed internally in 1999 with the support and advice of the IAEA. This assessment, performed with the help of a survey, pooled about 80% of the company's employees. The overall result of the assessment was that a satisfactory level of safety culture existed; however, a number of points with a considerable margin for improvement were also identified. These points were mostly related with behavioural matters such as motivation, stress in the workplace, view of mistakes, handling of conflicts, and last but not least a view by a considerable number of employees that a conflict between safety and production might exist. An Action Plan was established by the company managers to tackle these weak points. This Plan was issued as company guideline by the company's Directorate. The subsequent step was to detail and implement the different actions of the Plan, which is the phase that we are at present. In the detailing of the Action Plan, special care was taken to sum up efforts, avoiding duplication of work or competition with already existing programs. In this process it was identified that the company had a considerable number of initiatives directly related to organizational and safety culture improvement, already operational. These initiatives have been integrated in the detailed Action Plan. A new assessment, for checking the effectiveness of the undertaken actions, is planned for 2003.

1. Introduction

The present paper describes the Eletronuclear's safety culture assessment and enhancement program. The company's top management initiated the program. The main motivation to start the referred program arose from the formation of the company Eletronuclear in 1997, from the merging of two companies with different organizational cultures, the design & engineering company Nuclen and the nuclear directorate of the Utility Furnas, Operator of the Angra1 NPP. The merger faced a strong opposition by the several workers unions. The merger process itself was complex, being stopped several times by court decisions. When the merger was finalized, Eletronuclear's top management was seriously concerned that the animosity resulting from the merger process could have spread throughout the company. Several immediate top down actions were taken, such as frequent meetings of the top management with the managerial level of the company, for discussion and establishment of the mission and goals of the new company; performance of managers training emphasizing teamwork; issuance of the company Quality Assurance policy; issuance of the company Nuclear Safety policy and initiation of a Safety culture self assessment program. This program, was conceived as an assessment to be developed internally by Eletronuclear, with the support and advice of the IAEA, to be followed by a safety culture enhancement program and a further assessment for checking the effectiveness of the adopted measures.

2. Eletronuclear's safety culture self-assessment

The conception and execution of the self-assessment phase of the program have already been described in references [1] and [2]. The main points of this work were:

- Obtaining support from the IAEA for program development, advice and supervision;
- setting up a multidisciplinary group with people from the different levels of the Company hierarchy, to conduct the work;
- Definition and agreement, by this group, of 22 safety culture categories, taking into account the situation of the new company (conflicts, organizational changes, cultural differences, etc.);
- Development of a survey instrument with 70 statements; a specific set of 2 to 5 statements was conceived for assessing each of the above mentioned safety culture categories;
- Application of the survey through a specific program;
- Collection and statistical treatment of the data;
- Evaluation of the results.

This assessment, performed with the help of the referred survey, pooled about 80% of the company's employees.

The overall result of the assessment, shown in Table I, was that a satisfactory level of safety culture existed in the new company. This result "per se" was not unexpected. Both companies, Furnas and Nuclen, were well acquainted with the concepts of INSAG-4 [3] for quite some time before the merger: the implementation of INSAG-4 recommendations was done as early as 1991 in the Furnas nuclear directorate and one of the INSAG-4 co-authors was Technical Division Manager at Nuclen. On the other hand a number of points with considerable margin for improvement were also identified in the assessment, as shown at the bottom half of Table I.

TABLE I. MAIN RESULTS OF THE SELF-ASSESSMENT PHASE

The self-assessment at ETN addressed 22 Safety Culture Categories. The overall assessment was "satisfactory" (67%), where "satisfactory " is defined as the range 75%> X > 65% of the safety culture oriented answers.

The 7 safety culture categories with the worst performance were the following,

- Motivation and Job Satisfaction (50%)
- View of Mistakes (51%)
- Absence of "Safety versus Production" conflict (51%)
- Good working conditions with regard to Time Pressure, Workload, and Stress (57%).
- Handling of Conflicts (59%)
- Management of change (59%)
- Organisational Learning (62%)

It should be mentioned that some of the problems identified in the assessment, as presented in Table I, were already known to Eletronuclear top management, and actions were already initiated for their resolution. Some the activities resulting from these actions are listed in section 4 of this paper.

3. Safety culture action plan

The step following the evaluation of the results of the self assessment, was to establish an Action Plan for improvement of the identified weak points and have it formally approved by the company's Directorate. This Action Plan, in accordance with IAEA advice, was to address not more than 5 to 6 points and to be prepared by the company managers, the ultimate responsibles for the Action Plan implementation. This was done in the first quarter of 2001, in a series of meetings involving the company managers at the Division and Department levels. One of the first joint decisions was to select the items to be improved bottom up, that means, the safety culture categories with the worst evaluation. The 5 selected categories are shown in bold in Table I above. The Action Plan was reviewed in a Safety Culture Seminar for Managers held by the IAEA, in June 2001, at Eletronuclear's premises. The resulting Eletronuclear's Action Plan is summarized in Table 2 below.

TABLE II. SUMMARY OF ELETRONUCLEAR'S MANAGERS ACTION PLAN

- Motivation and Job Satisfaction (50%)

  Proposed Actions:
  a) Training Plan and Career Evolution Program.
     -Improve personnel evaluation system
     -Implement training for career evolution.
     -Implementation of Plan for employee education enhancement (participation in post-graduated, MSc and Doctorate programs).
  b) Managers development plan
     -Specific managerial skills training;
     -Safety Culture training;
     -Improvement of company communication;
     -Regular contacts of managers with directorate.
  c) Rewards
     -Implementation of bonus system for rewarding of individual performance.

- **View of Mistakes (51%)**

  Proposed Actions:
  a) Development/ improvement of Plan for analysis of human errors with influence on plant safety;
     -Establishment/training of working groups for this purpose (emphasis on "understanding what happened").

- **Absence of "Safety versus Production" conflict (51%)**

  Proposed Actions:
  a) Improvement of information on Safety Policy of the company
     - Training on Safety Culture fundamentals
     - Managers/employees monthly meetings to discuss examples of safety vs. production conflict either internal or external to their areas;
     - Training and information on Nuclear Safety subjects, and in particular on the company's Safety Policy through internal communication channels, information to new employees, courses, seminars etc.

- **Good working conditions with regard to time Pressure, workload, and stress (57%).**

  Proposed Actions:

  a) Plan for reducing of stressing conditions at the work place
     - Improve definition of responsibilities, material and human resources planning;
     - Strategic long term planning for the individual areas and the company as a whole;
     - Re-evaluation of administrative routines and work processes.

- **Handling conflicts (59%).**

  Proposed Actions:
  a) Training of managers in the techniques of conflict handling

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The above Action Plan was approved by the Directorate and formally issued as Company directive in July of 2001.

4. Detailing of the action plan

The subsequent step of the program was to detail the different actions of the Plan, which was done in close cooperation with the company managers. Insights derived from the IAEA Safety Culture Managers training Seminar referred above as well as from Ref. [4] were extensively used in the detailing of the Action Plan. In this detailing, special care was taken to sum up efforts and avoid duplication of work or competition with existing programs. This was particularly important considering the large number of initiatives, already operational in the company, directly related to the organizational and safety culture improvement categories of the Action Plan shown in Table II. Several of them were inherited from the mother companies, other were running in parallel with the program described in this paper, for example,

- Issuing of the Company Safety Culture Policy, based on INSAG-4 [3].
- Development of material and training on safety culture fundamentals at the Site;
- Employee performance evaluation and career program;
- Human performance training;
- Teamwork training;
- Organisational Culture Enhancement program;
- Several work processes assessment initiatives;
- Knowledge Management program;
- Development and use of safety and performance indicators,
- Evaluation of internal/external operating experience,
- Improvement of external/internal information program etc.

The integration of these initiatives in the detailed Action Plan was a natural decision. The detailed Action Plan was ready by end of September of 2001.

5. Implementation and follow up of the action plan

This is the present phase of the Eletronuclear's safety culture enhancement program. For every safety culture category of Table 2 there are actions in development, some new and some from activities previously in development. Every activity of the Action plan in development, is being continuously monitored and if necessary, modified in accordance to the received feedback.

The overall coordination, planning and follow up of these activities is being done by a team composed of four senior staff members from the Technical, Nuclear Operation and Administrative Directorates, respectively. The dissemination and follow up of the Action Plan activities within each Organizational Unit is performed by a designated safety culture facilitator. Presently, most of the Units have a facilitator; the goal is to have a facilitator for all Units in the Company. The pre-requisites set for the facilitators were that they should be preferentially front line supervisors, and most important, wanted to work with the subject of safety culture.

With the objective of harmonizing the knowledge throughout the company a concentrated training package with emphasis on safety culture fundamentals, is being conducted at Eletronuclear's Headquarters, where personnel, particularly from the non technical areas, has less acquaintance with the basic safety culture concepts.

Another activity to be highlighted refers to the local organization of the IAEA International Safety Culture conference to be held in Rio in December of 2002.

A new overall company safety culture assessment is planned for mid 2003. This will be an opportunity to compare the results with the ones obtained during the first safety culture self assessment. This will also permit to verify the adequacy of the measures being taken within the frame of the present Action Plan, and to modify them as needed.

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Assessment of Safety Culture from the INB Organization
A case Study for Nuclear Fuel Cycle Industry

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Abstract. The present article describes strategies, methodologies and first results on the Safety Culture Self-assessment Project under way at INB since August 2001. As a Brazilian Government company in charge of the nuclear fuel cycle activities,. the main purposes of the Project is to evaluate the present status of its safety culture and to propose actions to ensure continuous safety improvement at management level of its industrial processes.
The proposed *safety culture assessment* describes INB's various production sites taking into account the different aspects of their activities, such as regional, social and technical issues.
The survey was performed in March/2002 very good attendance (about 80%) the employees. The first global survey results are presented at item 4.

1. Introduction

As a nuclear fuel cycle company, the INB Safety Culture Project carried out with the methodology recommended by the IAEA, becomes a worldwide pioneer effort, as this concept was applied before only for nuclear power plants. The fact that INB assembles several activities within the nuclear fuel cycle, including mineral exploitation and rare earth processing, along through five different production sites made the assessment more complex. Such as multiplicity led to distinctive aspects of work force, and created a real challenge to determine a common safety culture for the organization.
This paper presents the boundary conditions, scenarios and first results of the INB Safety Culture Project Assessment; meanwhile this paper was in preparation, the latest data analysis was concluded and the survey executive report outlined

2. INB Organization

INB (Indústrias Nucleares do Brasil S/A) is the Brazilian Government Company responsible for uranium exploitation and development of the nuclear fuel cycle technology (see Figure 1), which also include activities in relation to rare earth processing. The Organization as a whole comprises five different production locations besides the administrative headquarters, as shown on Figure 1 and table 1. INB activities correspond to 4 out of the 6 nuclear fuel cycle stages, namely: mining, powder and pellet production, enrichment (in implantation) and fuel assembly. In the near future (one year approximately) the enrichment stage will be complete. At that time INB will then reach 95 % of the nuclear fuel cycle.

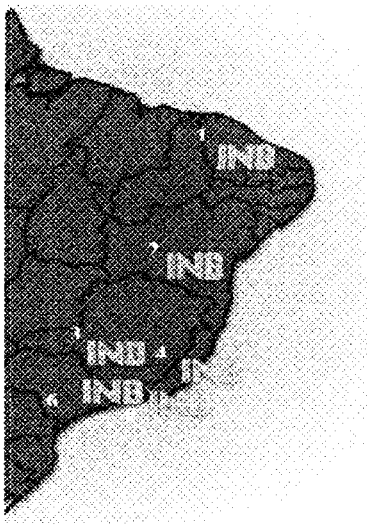

FIG. 1. INB Sites – Reference MAP

TABLE. 1. INB ORGANIZATION SITES ACCORDING TO THE REFERENCE MAP

INB ORGANIZATION BY SITES		
MAP Reference	**INB SITE**	**STATE**
1	Itataia - New Mine.	CE
2	Caetité – Mining and uranium concentrate processing.	BA
3	Caldas - Monazite and other minerals chemical processing.	MG
4	Buena – Rare earth and monazite sand physical processing.	RJ
5	Rio – Headquarters and Board of Directors.	RJ
6	Resende - UO_2 Powder and Pellet Fabrication.	RJ

3. Safety Assessment Methodology Applied

There is no prescriptive formula for improving safety culture. In any case, the first step is check and find *"what is the status-quo of the organization safety culture"*. In this connection, INB has started its own Safety Culture Assessment Project assisted by the IAEA Member's State Support Program. The main project structure is shown on Fig. 2.

a- INB Self-Assessment Project Structure

1- Organization Awareness Raising Stage

1.1- Top management safety culture enhancement program launch.;
1.2- Top management workshop – safety culture understanding seminar [with INB CEO presence]. (*)
1.3- Medium management, facilitators and leaders of people workshop - safety culture understanding seminar. (*)

2- INB Safety Culture Self-Assessment Stage

2.1- Appointment of an assessment team (A.T.) to perform the task.
2.2- Training of the assessment team. (*)
2.3- Development of assessment tools (**).
2.4- Execution of self-assessment, analysis of results and assessment reports preparation.
2.5- Presentation of findings - AIEA Peer Review. (*)

3- Development of an Improvement Program Stage – based on the Organization Self-Assessment

3.1- Top management, medium management, facilitators and leaders workshop - assessment understanding seminar [Organization with CEO presence]. (*)
3.2- Development of an improvement program. (**)
3.3- Execution of the improvement program.
3.4- Follow-up of the improvement program effects 2 years after is beginning by means of a new safety culture self-assessment
3.5- AIEA Peer Review.

The assessment team (A.T.) structure shown in Fig. 2 was implemented considering all INB production activities and sites, aiming at better approach to the organization assessment. Each INB site had two people assigned to the assessment team, one acting as the base leader, with the responsibility for the assessment actions themselves and reporting to the main base at INB-Resende.

The first stage of the Project was concluded after two safety culture seminars, on September 2000 and March 2001, respectively.

The second stage is still in process Actions 2.1 to 2.4 are already concluded. The Action 2.5 is expected to be concluded no later than June 2002.

Actions 3.1 to 3.3 are expected to be concluded until the end of 2002, whereas the other two (3.4 and 3.5) until - August 2005.

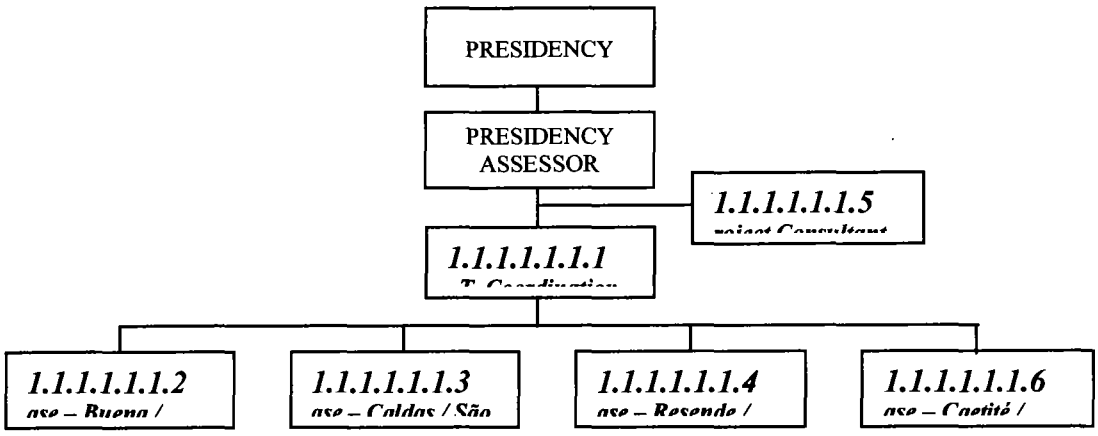

FIG. 2. INB Safety Culture Assessment Structure

(*) Support mission from AIEA expertise.
(**) INB and AIEA.

b- INB Safety Culture Self-Assessment Stage 2 Remarks

Since there is no specific approach applicable to all purposes measuring, simultaneously, all the intangible aspects of the INB safety culture, such as norms, values, beliefs, attitudes or behaviours, the A.T. elected as the assessment tools ***Interviews and questionnaires.*** Considering the model created by Schein – Three Level Model [3], the A. T. decided on the use of that tools accordingly.

"Artefacts (including behaviours)"
Architecture, greeting rituals, dress, form of address – visible.

"Espoused Values"
Strategies, goals, philosophies – can be elicited.

"Basic Assumptions (or underlying)"
Human nature, basis on which people are respected – unconsciously held and usually tacit.

After accomplishing a training step (actions 2.2 and 2.3), established by AIEA experts in August 2001, the A.T. planed the following strategy to perform the assessment survey:

- Definition of Safety Culture categories considering the Artefacts, Espoused Values and Basic Assumptions levels.
- Assessment team meetings (all INB base members) to develop guidance strategies and to prepare the questionnaire
- Revision of selected categories and questions together with IAEA consultant to check their compliance with the project objective (minimum of three sentences per category, including negative and not applicable statements.
- Piloting step – A selection of statements from the survey questionnaire (1/3) was submitted to a population sample, in order to check their comprehension terminology, sense, difficulties, ambiguities, etc. Another purpose of this step was to motivate people to help improving the questionnaire. An A.T. small group also interviewed the sample

group (observed by a psychologist), in order to obtain feedbacks on possible questionnaire weaknesses as well as other feelings and/or perceptions that could affect the survey effectiveness.
- Questionnaire final revision and edition.
- Planning and implementation of the awareness raising survey (on the job speeches, folders distribution, small slogan gifts, bottoms, shirts, INB intranet propaganda, etc,).
- Safety Culture Assessment survey implementation.
- Survey forms validation and database load and check.
- Analysis of results/ statistical handling and assessment executive report elaboration.
- AIEA peer review of the INB Safety Culture Assessment.
- Final INB Safety Culture Assessment Report issuance and organization widespread presentation of results .
- Preparation of INB Safety Culture Project stage 3

4. Survey assessment follow-up and main remarks

4.1. Survey scenarios

During the survey preparation and implementation employees' statements and opinions about scenarios a were collected, being noteworthy:
- Interest in participating, and in following the project phases, (advertising survey's results and the action plan;
- Wish to express personal opinions by written comments on the survey questionnaire;
- Fear of being identified;
- Some scepticism on the actions to be taken by the company as a survey results function.

4.2. Global survey results

There were 19 categories chosen to assess the Safety Culture of INB: High Priority to Safety, Top Management Commitment to Safety, Relationship Between Managers and Employees, Visible Leadership, Clear Roles and Responsibilities, Good Working Conditions with Regard to Time Pressure, Workload and Stress, Sufficient and Competent Staff, Collaboration and Teamwork, Quality of Documentation and Procedures, Handling of Conflict, Compliance with Regulations and Procedures, Relationship to Regulators and other External Groups, Openness and Communication, View of Mistakes, Motivation and Job Satisfaction, Absence of Safety versus Production Conflict, Management of Change, Proactive and Long Term Perspective and Organizational Learning.
Only three of them were evaluated as regular by the employees. The majority was considered as satisfactory or good. Correction measures will be proposed after the diagnosis, aiming at improving safety conditions, practices, documents, norms, etc.

5. Conclusion

Although, safety conditions and procedures are properly defined in the nuclear sector, also at the INB organization, they can always be improved. The self-assessment of Safety Culture project at INB is still on its way to do it. Based on statistical diagnosis, the survey proposed categories which requires improvement for a better safety practices are already identified. A resulting action plan will be developed by INB managers to achieve this goal. In order to have

a successful Plan implementation and to avoid difficulties, it should contain a limited number of measures considering a short and long-term basis.

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Safety culture in nuclear installations : Bangladesh perspectives and key lessons learned from major events.

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Abstract. Steps necessary to be taken to ensure safety in nuclear installations are suggested. One of the steps suggested is enhancing the safety culture. It is necessary to gain a common understanding of the concept itself, the development stages of safety culture by way of good management practices and leadership for safety culture improvement in the long-term. International topical meetings on safety culture may serve as an important forum for exchange of experiences. From such conventions new initiatives and programmes may crop up which when implemented around the world is very likely to improve safety management and thus boost up the safety culture in nuclear installations. International co-operation and learning are to be prompted to facilitate the sharing of the achievements to face the challenges involved in the management of safety and fixing priorities for future work and identify areas of co-operations. Key lessons learned from some major events have been reported. Present status and future trend of nuclear safety culture in Bangladesh have been dealt with.

1. Introduction.

Life and property are in jeopardy for lack of safety in any scientific and technological enterprise. So the popular saying "Safety First". But safety is a matter of culture. Culture again develops from long practices which ingrain it in an installation making it part and parcel of it. It is equally true for safety in nuclear installations. It is worth mentioning that the concept of safety culture in nuclear installations was first introduced following the Chernobyl mishap. Since then safety culture has been an issue that the nuclear community has striven to understand, develop and improve. The very use of the term presently all over the world discloses the fact that it captures the insight gained through years of experiences and that safety is reached through the people managing and operating nuclear installations. Again leadership, commitment and management strategies applied set the frame work for how people will behave and think relating safety. Now since nuclear installations are facing new challenges imposed both externally such as political as well as economical and internally created ones such as reorganizations hence it has become quite clear that success depends on a safety culture and efficient safety management founded on insight, knowledge and capacity to manage the unique interaction between technology, economics, human factors as well as safety in an ever changing environment. The said challenges put into confrontation the management teams of nuclear power plants, the governments, regulators, owners, operators and staff having a role to ensure safe and successful handling of the changes.

It is necessary to develop programmes by international organizations such as the IAEA to enhance safety culture in the nuclear installations with objectives to gain a common understanding of the concept itself, good management practices, leadership to improve long-term safety culture, etc. International topical meetings on safety culture in nuclear installations is likely to serve as an important forum for exchange of experiences. New initiatives and programmes may crop up from such conventions which when implemented around the world will improve safety management and thus enhance safety culture in the relevant organizations. International co-operation and learning are to be prompted to facilitate

sharing of the achievements and thus face challenges involved in the management of safety and safety culture as well as fixing priorities for future work with identification of areas requiring further international endeavor.

2. Safety culture : Bangladesh perspective

Since establishment and promotion of an effective safety culture in nuclear installations is a vital pre-requisite for continued growth of nuclear science and technology, Bangladesh is also adherent to the concept of nuclear safety culture like many other countries. It has formulated a national policy and set up action plans to enforce the safety culture in various nuclear installations both at organizational and individual levels under the guidelines of a national regulatory framework. The present status and future trends of nuclear safety culture in Bangladesh are depicted below :

2.1 Present nuclear activities and nuclear installations in Bangladesh :

Bangladesh is presently using nuclear technology in the fields of medicine, industry, agriculture and research and development. A 3 MW TRIGA Mark II research reactor, a radioisotope production laboratory, a nuclear agricultural institute, scores of nuclear medicine centres, two commercial irradiation plants, a 14 MeV neutron generator, a 3 MeV Vande Graaf generator, etc. form the present coterie of nuclear installations here. A central radioactive waste processing and storage facility (CWPSF) is now in the final stage of construction and an SSDL is in active operation.

The concept of safety culture is yet to take a universal shape ever since its introduction after the Chernobyl accident. Bangladesh shares the common views prevailing among most of the IAEA member states in this regard. It is strongly emphasized that safety culture is attitudinal as well as structural, relates both to organizations and individuals, and concerns the requirement to match all safety issues with appropriate perceptions and action plans.

In order to ensure and promote an effective safety culture, Bangladesh mainly follow the guidelines provided by the International Nuclear Safety Advisory Group (INSAG). A 'defense in depth strategy' and a 'quality assurance' approach form the essential components of the national nuclear safety culture. Figure-1 illustrates the scheme of safety culture and Figure-2 shows the 5-level defense in depth strategy.

2.2 Implementation of nuclear safety through defence in depth strategy :

A 5-level defence in depth strategy as described in INSAG-10 is followed to ensure safety in nuclear installations. Rigorous training both at managerial and operating staff levels, periodic mock up exercises, emergency response plan along with a sound QA programme in each nuclear installation constitute the general scheme of things to implement the safety objectives.

2.3 Present experience and future developments :

At present a safety culture regime is in existence in the safe management of the TRIGA research reactor facility, radioactive wastes, sources of industrial and medical radiation sources. INSAG documents and IAEA Basic Safety Standard Series form the core of the existing safety practice and safety management in nuclear installations in Bangladesh. A rigorous and regular training programme is in force both at management and operating staff level. A well prepared and well reviewed emergency response plan is awaiting implementation in each nuclear installation to maintain a constant state of vigil and preparedness. Safety analysis on present safety performance is carried out regularly and future

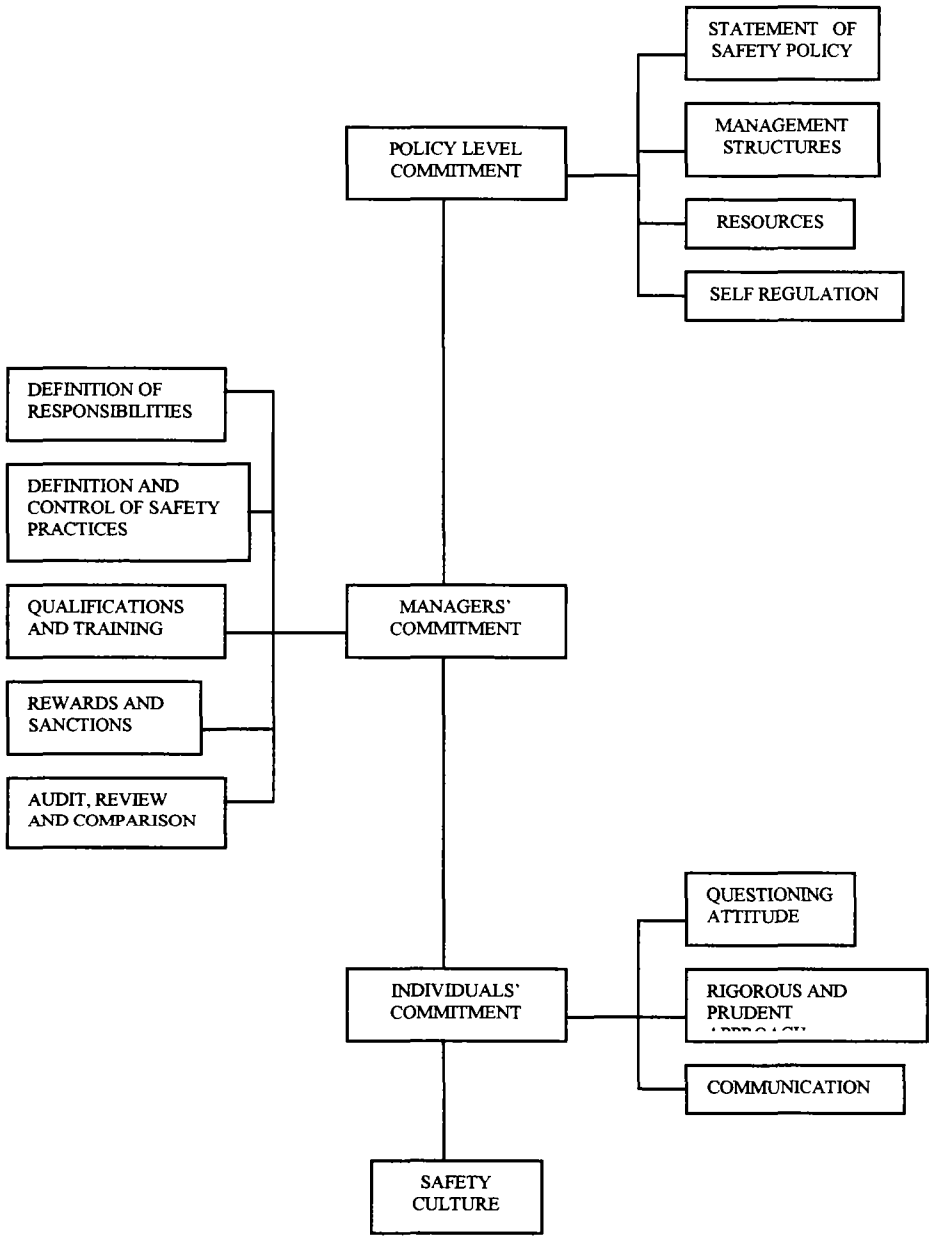

FIG. 1 : Illustration of the presentation of safety culture.

LEVELS OF DEFENCE IN DEPTH

Level 1 : Prevention of abnormal operation and system failures

Essential : Conservative design and high quality in construction and operation, including in particular well trained operators.

Level 2 : Control of abnormal operation and system failures

Essential : Control, limiting and protection systems and other surveillance features.

Level 3 : Control of accidents within the design basis

Essential : Engineered safety features and accident procedures.

Level 4 : Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents

Essential : Containment building, complementary measures and on-site accident management procedures.

Level 5 : Mitigation of radiological consequences of significant releases of radioactive materials

Essential : Off-site emergency response procedures, such as evacuation plans.

FIG.2: 5-Level defense in depth strategy.

improvements are outlined. Greater efforts are dedicated to learning from experience and sharing good practices of worldwide use is the mode of 'predictive risk analysis' or 'risk assessment methodology' during the preparatory phase of an activity. Future developments are strived for on the basis of learning approach.

3. Steps necessary to be taken for safety in nuclear installations :

Site Safety :

While establishing a nuclear installation enough consideration should be given in respect of siting such as that it should not be located in a densely populated area or near a public place or busy roadside as well as near an earthquake zone because a regional or national catastrophe could possibly turn into a global one.

Operation Safety :

Utmost care should be exercised for safe operation of nuclear procedures. The procedures should be written and operations carried out systematically with strict pursuance of a check list.

Fire Safety :

Adequate steps should be taken to stop fire. Fire fighting accessories must be available near at hand.

Material Safety :

There should be regular accounting of nuclear material stock. This will ensure that nuclear materials do not find their way into wrong hands. There are instances that radioactively contaminated materials have been used in furniture and utensils. Besides, there are instances that materials used in nuclear facilities and materials of containers of abandoned sources have gone to junkyard, picked up and dismantled by unskilled people thus contaminating man and environment leading to several deaths such as the mishap in Gionia in Brazil and elsewhere. Hence it is essential that radioactive sources must be kept in safe custody and their transfer recorded in movement registers showing the issuance and return data in details.

Safe handling :

There must be set procedures for safe handling of radioactive materials to avoid contamination of people and the environment. No breach in the set procedure of handling should be allowed.

Safety culture :

Practices bring perfection. So there should be long-time practices and mock exercises on implementation of safety procedures in nuclear installations. Long time practices ingrain things into habits and eventually form part and parcel of culture which ensures execution of safety plans with utmost perfection.

4. Lessons learned from major events :

There are many reports of casualties and loss of properties due to accidents on account of nonobservance of safety procedures in operation and maintenance of nuclear facilities. One such to mention is that occurred in EL Salvador (1989) due to mishandling of the irradiation source and another example is the abandoned source at Gionia in Brazil (1987) (both events have been reported by the IAEA). One other example is the overexposure of an unskilled worker during handling of an industrial radiography source in Bangladesh. The said worker

had neither radiation survey meter nor any personnel monitoring devices during work (Reported in Health Physics Vol. 57, No.1, P.P. 117-119, (1989), Vol. 62, No. 1 PP 74-76, 1992, Vol. 66, No. 5 P.P. 589-590 (1994). This event led to the enactment and enforcement of Nuclear Safety & Radiation Control (NSRC) Law, 1997 in Bangladesh. These events taught us that there should be adequate law and regulations to control radiation exposures and that definite set rules and procedures must be followed in using radiation and radioactive materials to avoid casualties and contamination of the environment. There are more then 160 large gamma irradiation facilities and over 600 electron been facilities in operation around the world in almost every member state of the IAEA. Experiences over 40 years have shown that such technology is generally safely used. Nevertheless there have been instances as in Italy in 1975, in Norway in 1982 and at Soreq in Israel in 1990, when safety systems have been circumvented and serious radiological accidents have ensued. On June 21, 1990 at Soreq in Israel an operator entered the irradiation room and received overexposure with fatal consequences. In this case the intensely radioactive Co-60 source in a movable' rack stuck up in irradiation position. The operator having misinterpreted two conflicting warning signals bypassed installed safety system and contravened procedures in order to enter the irradiation room to free the blockage. He felt burning sensation in his eyes and pounding in his head in a minute or so and left the room. These accidents occurred due to violation of established operating procedures. These accidents demonstrate that it is required to maintain close supervision over operation of nuclear facilities and training of operators and indicate the need for research into the contribution of human factors to such events. Yet two other accidents worth mentioning are the Chernobyl accident (1986) and the criticality accident in Japan about two years back that happened due to serious breach in operation procedures by the operators.

5. Conclusions :

Safety culture and safety management embrace all the activities, interfaces and processes necessary for the establishment and maintenance of safety. However, it also needs the added ingredients of proactive approach to safety which characterizes the practising organization. The ever increasing demand, and risks facing the nuclear industry dictate that safety must be managed professionally and competently with due emphasis being given to human and cultural factors.

Safety can no longer be treated as a separate issue that belongs only to the experts in the nuclear safety field. All organizations need to re-examine their approaches to, and expectations from, a comprehensive safety process that minimizes risk, maximizes resource and optimizes the performance of all its staff. New ideas and initiatives should emerge from the past experiences through a concerted effort from all the members of an organization.

Finally international topical meetings on problems encountered in safety of nuclear installations should be convened frequently with audience from all IAEA member states exchanging ideas and sharing experiences. As a result new initiatives and programmes may crop up which when implemented will improve safety management in nuclear installations all over the world.

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Safety Culture in Nuclear Installations
Management of Safety & Safety Culture In Indian NPPs

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1. Introduction

Nuclear Power Corporation Of India Ltd. (NPCIL) is a company owned by Government of India and is responsible for Design, Construction, Commissioning, Operation and Decommissioning of Nuclear Power plants in India. Presently, a total of 13 Nuclear power Stations are in operation with an installed capacity of 2620 MWe and 2 VVR type PWR Units of 1000 MWe capacity each, 2 PHWR type units of 500 MWe capacity each & 4 PHWR type 220 MWe capacity each are under construction. NPPs generation capacity has been increased from 70% to 85% in the span 0f last 7 years with high level of safety standards. This could be achieved through Management commitment towards building a strong Safety Culture.

2. Safety Culture

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

This definition of safety culture brings out two major components in its manifestation.

- The framework within which individuals within the organisation works.
- The attitude and response of individual towards the safety issues over productivity and economics in the organisational work practices.

3. Safety Management & Safety Culture within Nuclear Power Industry in India

The above two attributes of safety culture are built in and upgraded in each individuals through special training at the time of entry in the organisation and later through in built procedures in the work practices, motivation and encouragement for free participation of each individuals. Individuals are encouraged to participate in Quality circle teams at the sectional level and review of safety proposal originated by individuals in "Station operation Review Committee at Station level. In addition to this to continuously enhance the safety culture, refresher training courses in the following areas are being organised at regular intervals:

- Emergency operating procedures
- Simulator training
- Industrial safety
- Radiation propection and radiation procedures
- Re-licensing of each licensed staff by regulatory authority every three years

❖ The safety related proposals are categorised in to two namely

(a) Proposals from Operating Plants, and
(b) Proposals from projects & Design

- All the proposals from operating plants are reviewed at following levels in sequence

  - Review by "Station Operation Review Committee"
  - Review by "Safety Review Committee at NPCIL head quarters"
  - Review by " Station level Safety Committee at AERB"
  - Review by "Safety review committee for Operating Plants at AERB"

- Proposals from Design and Projects are reviewed by

  - "Reactor safety analysis experts"
  - "Safety review committee for Projects and Design"
  - "Project Design safety committee appointed by AERB"

- In addition to this inspection of operating plants and projects is also carried out by a team of experts appointed by Atomic Energy Regulatory Body and other government statutory authorities like Pollution Control Board, Explosive Hazard Control Board etc.

❖ Each station has an independent official to maintain a record of safety recommendation made by various agencies. These recommendations are followed up by him on regular basis with responsible agencies and are being reviewed by station management for compliance once in three months.

❖ Station management and headquarter management has an attitude to demonstrate a great respect for the reactor core and conservative approach towards plant operation – for reactor safety –in all decision & action. Management also encourages free and fair communication at all levels to identify problem area and gives priority to safety items over productivity and economics.

❖ In last 7 years, a marked change in characteristics and attitudes of individuals has been observed in the Nuclear Power Industry in India. A mindset of individual in the organisation on "higher safety level means low productivity" has been changed to a new concept of "**higher productivity goes with higher safety level** ". NPCIL has been improving its capacity factor progressively since last 7 years, from as low as 70% to as high as 85% during 2001-2002, along with improvements in the safety standards. This could by achieved by adopting principles of safety management and safety culture in each individual through training, work practice monitoring of safety issues on priority and the safety oriented behavior of managers.

❖ NPCIL has enhanced safety culture and safety management through:

➢ Events like Spurious dousing at Rajasthan Atomic Power Station Unit-1 and a Major fire incident in Turbine Building at Narora Atomic Power Station.
➢ Internal Safety Review of Operating Plants And WANO Peer Reviews.

- Adopting Pre job Briefings

- The concept of safety culture is being used and continuously being upgrade in:

  - Training
  - Work procedure
  - Work practice
  - Internal information exchange Seminars/Workshops/event analysis reports sharing between various units in the country.
  - International information exchange programme through IAEA & WANO programmes
  - Information exchange through e-network of IAEA/WANO

- The detailed paper on Safety Management and Safety Culture will be forwarded on confirmation of selection of this extract.

Improvement of Operational Safety the Self-Assessment at the Russian Npps

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1. The Need to Improve

The self-assessment is an integral part of person's vital activity. All people make self-assessment from a certain criterion standpoint: appearance, state of health, feasibility to conduct particular work, etc. As far as managing procedure, the activity self-assessment is a relevant factor to enhance efficiency of the work performance. The assessment of the administration activity and the activity performed by the enterprise under his managing is a part of the managing procedure the realization of which needs to have definite idea of the sequence, methodology and implementation criterion. The self-assessment provides for detecting and solving NPP problems and creates the necessary prerequisites for finding, analyzing and following problems and defining trends. However, detection of problems contributing to decreasing of operating safety and reliability is of first priority. That is why safety/reliability-related activity is the first priority in the self-assessment.

The administration self-assessment in Russian NPPs is performed as routine daily meetings, detours, control of partial progress and personnel training. Moreover, Annual Safety Reports are issued; current safety level, experience, safety culture are analyzed, and internal quality audits are performed. However, recently the worldwide self-assessment experience providing for more effective process from safety enhancing has been pooled. To make self-assessment at all managing levels: from the top structural unit to the executives, is of great importance. A wide-implemented "safety culture", the assessment of which is of great importance now as well, is one of vital aspects in enhancing the self-assessment efficiency. Thereby, there is the possibility to improve the self-assessment at the Russian NPPs.

Considerable personnel are involved in the self-assessment and therefore the development of the self-assessment program (guidelines) describing "who" makes "what" and in which sequence as well as which indices are used in the course of the procedure, is especially important. This has the effect of detecting the available safety shortage and elaborating the corrective actions. The self-assessment and corrective actions programs are the tools for detecting and further realizing of required modifications to enhance NPP managing efficiency and to decrease the probability of likely events.

For an early detection of problems the self-assessment of both the administration and executives is of particular importance. Thereupon the self-assessment culture takes on great significance, when the personnel are motivated for the independent and permanent self-assessment of their activity. Thereby, the self-assessment in the Russian NPPs should be improved by the following two ways: development of detailed instructions to conduct the self-assessment and arrangement of conditions to develop the self-assessment culture.

2. Activity in Support of Self-Assessment in NPPs

Different International Self-Assessment Programs (e.g. IAEA OSART, ASSET and ASCOT Programs) have been developed to support the self-assessment in NPPs. The experience gained in realizing of the programs together with the experience in conducting quality audits (together with VNIIAES experts) available in "Rosenergoatom" provides for the development of an individual efficient self-assessment methodology for all activities performed in NPPs.

At that it should be taken into consideration that the self-assessment methodology depends, first of all, on the qualification of the personnel using the methodology. So the top administration self-assessment may be expressed in auditing both internal and external (between partners). Managers of operating level (heads of divisions and their deputies) may make self-assessment by means of internal audits and analyze personnel's proposals. The operating level (operators, engineers, workers) should have the tool, first of all, for the direct self-assessment like STAR (Stop, Think, Act and Review).

Thus, the top administration self-assessment takes a kind of "strategy". The "strategy" should result in improving the design characteristics and decreasing NPP event recurrence. During the self-assessment of managers of the operating level they realize tactical schemes, namely: decreasing a number of non-conformances detected during the external audits, work off maintenance backlog, etc. As a result of the self-assessment the personnel directly involved in the implementation of the work should develop proposals on improving the organization and implementation of work. In this case a share of personnel participated in the self-assessment, a quantity of proposals on the improvement and, that is not less important, the results of the response to the personnel's proposals may be the indices for the self-assessment efficiency.

The self-assessment, being the tool for the effective administration provides for the NPP administration confidence in supporting safety operation of the plant. The methodology and controlled parameters should be developed to have more effective tool for understanding current safety operation conditions and for detecting the ways of its improvement.

3. Perfection of the Self-Assessment

Since 2000 the self-assessment improvement of the NPP operation safety has become the first priority activity in "Rosenergoatom". On February 2001 "Actions for Perfection of the Self-Assessment System for "Rosenergoatom's" NPP Safety Operation" were developed and signed by the President of "Rosenergoatom". The Actions were targeted at the analysis of documentation and experience gained from the application of the self-assessment in Russian and Western NPPs in order to obtain the best experience and to develop the effective-operating self-assessment system for NPPs in Russia. In the result "Rosenergoatom"'s Self-Assessment Standards should be developed and NPP personnel should be trained.

At the initial stage of the Actions realization in March 2001"Rosenergoatom" organized and held, jointly with WANO-MC and VNIIAES, a coordination meeting on NPP safety self-assessment. 26 experts from different organizations involved in the operation and supporting of Russian NPPs, took part in the above meeting. Representatives of the seven nuclear stations, RC GAN RF(Research Center NRC RF) , ORC "Prognoz" (Research Center "Prognoz", RRC KI (Russia Research Center "Kurchatov institute") and even MEI (Moscow Energy institute) have participated in the meeting. Papers describing various self-assessment approaches were represented by the participants from "Rosenergoatom", VNIIAES, WANO-MC, RRC KI and ORC "Prognoz". In the course of discussions there was made a decision to form a Working Team that includes the representatives from NPPs, VNIIAES and some supporting organizations. The Working Team's mission is to acquire and process information of best self-assessment experience, activity optimization and also to develop the self-assessment methodology and indices for each activity.

In compliance with the Actions the two integrated quality system documents in the form of NPP safety self-assessment standards, with titles "NPP Self-Assessment Methodology in Respect of NPP Operating Safety" and "NPP Self-Assessment Criterion in

Respect of NPP Safety", should be elaborated for a year. The IAEA documents (IAEA-TECDOC-1125 "NPP Operating Safety Self-Assessment", IAEA-TECDOC-1141 "Safety Indicators in Nuclear Stations Operation" and IAEA-TECDOC-632 "ASSET Guidelines"), INPO ("The Way for Assessing Experience Use" and "Principles of the Effective Self-Assessment Programs and Corrective Actions"), and risk assessment by the probabilistic safety analysis Technique. But it should be noted that the self-assessment differs from the independent assessment performed by a third-party organization, and has much in common with the internal audits conducted in NPPs. Consequently, the internal audit methodology may be a basis for the development of the self-assessment methodology.

In addition, the lines of NPP activity should be chosen that are related to the utmost to the operating safety, and the self-assessment of which is the task of the first priority. Own self-assessment matrix and criterion for its realization (self-assessment indices) should be developed for the activity specified. Having regard to the fact that the self-assessment methodology is a document of a common nature and is used to assess different NPP activities, the Annex describing examples of the assessment of some activity is required. In the final analysis, all NPP activities should be provided by their own self-assessment directions representing the sequence of the self-assessment procedure and persons responsible for this stage.

Personnel's training is a subject of importance as well as the development of the documents. The personnel involved in the self-assessment should know well enough the self-assessment methodology and indices in proper lines of activity. To this end the NPP personnel training within the "Rosenergoatom's" activity of "The Quality Training Center" is envisaged by the Actions. The Quality Training Center is a relatively recently established division in VNIIAES, equipped with the required computers and office equipment. Nuclear experts with the experience of NPP operation and elaboration of quality assurance documentation are involved in the Center's activity. All experts have taken a course of quality audits training and implementation that was organized by the English Party.

4. Conclusion

The operating organization has scheduled for the forthcoming year to elaborate the NPP safety self-assessment standards and to settle precise criterion for its performance. Toward this end it was decided to form a Working Team including of NPP and VNIIAES representatives to elaborate major tasks on the self-assessment improvement, development and implementation of new documentation and training the personnel in new methodology. Actions developed by "Rosenergoatom", one of its items is the participation of "Rosenergoatom" and VNIIAES representatives in the workshop, contains the sequence of Russian NPP safety self-assessment improvement at the first stage.

Approach to the Safety Culture in the Slovak Republic

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Abstract. The Nuclear Regulatory Authority of the Slovak Republic was established on January 1st, 1993, after division of former Czech and Slovak Federation Republic to two independent states - Czech Republic and Slovak Republic. As there were inherited four units on the site Jaslovske Bohunice and Interim Spent Fuel Storage on the same site under operation and four units under construction on site Mochovce it was necessary to keep on regulatory activities from very beginning of regulatory authority existence. The new regulator has been all time co-operating closely with IAEA and countries with developed nuclear power to cover all nuclear safety related areas including the safety culture. It is, however, to be said, that the issue of safety culture begun to be an object of considerations of Czechoslovak NPPs as early as in 1986 after issue of IAEA INSAG 1. Since that time the NPPs try to enforce the safety culture principles as a part of nuclear safety into their daily work in consensus with an utility Slovenske elektrarne, nuclear power plants and Nuclear Regulatory Authority. A purpose of the article is to provide an overview on safety culture practices at nuclear installations in the Slovak Republic./

1. Introduction

Immediately after the creation of the Slovak Republic on January 1st, 1993, all necessary state authorities had to be constituted. As there were nuclear facilities either under operation or construction on Slovak territory it was also needed to establish a relevant regulatory authority not to brake supervision upon nuclear safety of nuclear installations. Therefore the Nuclear Regulatory Authority of the Slovak Republic (UJD) was created on the same day as an independent authority on the level of ministry and started to work. Consequently the Slovak Republic joined the International Atomic Energy Agency the same year, on 27 September 1993.

At present following nuclear installations are under supervision of UJD:

Nuclear facility	Power/Type	Start up (shut down)	
- NPP A-1 Bohunice	HWGCR 150 MW	1972 (1978)	under decommissioning
- NPP V-1 Bohunice	2x VVER 440 MW/230	1978, 1980	without bubble condenser
- NPP V-2 Bohunice	2x VVER 440 MW/213	1984,1985	with bubble condenser
- NPP Mochovce	2x VVER 440 MW/213	1998,1999	with bubble condenser
- Interim Spent Fuel Storage	wet pool	1987	
- Conditioning Centre for RW: (cementation, incineration, bituminization, compaction)		1999	
- Bituminization line – experimental facility		1984	
- Incineration facility – experimental facility		1986	
- National RW disposal facility – near surface		1999	

In spite of the fact that UJD started its work in 1993 issues of nuclear safety and than safety culture have been always of main concern of NPP operators in former Czechoslovakia and

continuity had not been broken by political events and separation of the both, Czech and Slovak republics.

2. History of Safety Culture

The history of implementation of principles of safety culture can be divided in two periods. An issue of the IAEA document INSAG 1 [1] in 1986 started the first period which lasted up to approximately 1995. The management of each NPP was aware of their responsibility for the nuclear safety and an effort had been made to inform the staff of Slovak NPPs on basic documents on nuclear safety related to the safety culture area, i.e. documents INSAG 1, INSAG 3 [2] and INSAG 4 [3]. These documents were treated particularly and in frame of an education and training process the main stress was put on human factor and its links to the safety culture. To clarify the staff the main role of the individual in his approach to the safety culture was the main objective of these activities. Three main basic attributes of the safety culture – questioning attitude, a rigorous and prudent approach and communication in relation to the nuclear safety were explained. Also requirements of the NPP management to the staff in the light of safety culture were treated and clarified by both NPPs, Bohunice and Mochovce.

The second period of the safety culture implementation beginning in 1993 can be characterised by preparation of "Safety Culture Programme" at the NPP Bohunice in 1993 and issue of the "Safety Strategy" declaration related to start up preparation in NPP Mochovce. IAEA document INSAG 4 – Safety Culture was used as a basis for issue of these safety culture leading documents in both NPPs. In frame of these documents following actions were taken:

- Nuclear safety committees were created
- Task group to prepare the basic safety culture action plan was nominated
- Internal orders of the NPP directors concerning the safety culture were issued
- Safety culture self assessment groups were established
- Many explaining articles on safety culture were published in periodic NPP journals

The large inquiry on current level of the safety culture was made using a questionnaire prepared by IAEA which was used before at different nuclear installations over the world. As many as 1400 employees of NPP Mochovce were engaged to answer the questions covering eleven areas of safety culture. Based on results of the inquiry principal objectives to be achieved were determined. To reach these objectives a special training on safety culture was provided to selected staff members who now have a role of safety culture lecturers.

3. Action plans

Every year each NPP prepares the Safety Culture Action Plan [4], [5] where the activities in the area of nuclear safety and safety culture are planned. These activities are targeted to particular issues related to operation of NPP and are based on experience coming from the preceding performance of NPP. An example of the contents of one of the action plans is introduced bellow it contents may, however vary from year to year:

Safety culture plan of NPP for a current year:

1. To issue the Order of NPP director on safety culture;
2. To carry out a Safety Culture Status Analysis at NPP;
3. To organise a conference on "Approach to Safety Culture Management";

4. To organise a seminar on safety culture with a support of UJD;
5. To issue a booklets with the topic of Safety Culture for operation and maintenance personnel;
6. To incorporate continuously topics of safety culture into the training days of the shift personnel;
7. To publish a statement of NPP management on safety policy as the basic priority of all NPP activities;
8. To carry out self assessment of safety culture at individual departments and sections of NPP.

The action plan is a commitment for every organisational unit and every employee of the NPP. For each task a dead line is set down which is then controlled and evaluated. Criteria for evaluation of results are based on safety culture indicators introduced in INSAG 4. The indicators chosen are oriented to the measurable results achieved by individuals and working teams, correctness of prescribed activities, compliance with regulations and procedures, phenomena with positive motivation and comparable within determined time scale. Altogether following eleven areas were selected by safety self-assessment group:

1. Highlighting safety
2. Definition of responsibility
3. Selection of managers
4. Relations between plant management and regulators
5. Review of safety performance criteria
6. Training
7. Local practices
8. NPP supervision by management
9. Work load
10. Attitudes of managers
11. Attitudes of individuals

For each indicator a responsible person or guarantee is appointed and the way of his or her work is defined. After the evaluation of results of the action plan a proposal to improve particular areas with unfavourable development is prepared and enforced in coming period.

4. International co-operation

To further increase the nuclear safety level and strengthen the safety culture in Slovak nuclear installations international workshops were organised in co-operation with IAEA. During these seminars the lecturers of IAEA presented new trends in safety culture over the world. The main stress was put particularly on safety culture indicators - procedures of self-assessment, effectiveness of corrective actions programme and also the role of regulatory authority in the area of safety culture. The human factor and its importance in operation and complicated way to evaluate its impact in case of some operational event was analysed. These workshops have confirmed the strategy of Slovak NPPs in the area of safety culture and at the same time indicated the areas where further improvement could be achieved. Based on conclusion of the workshop the management of NPPs decided to include further tools into the process of safety culture improvement and particularly the group for self-assessment was strengthened.

5. Complementary means to improve and support the safety culture - good practices

Not only the orders, directives and action plans and similar documents are the means how to improve safety culture. Many materials supporting safety culture has been developed. Based on the safety culture action plan a booklet, based on movements „STAR" (STAR: Stop-Think-Act-Review), has been issued, where the right approach to work is explained in a simply way pointing out the fact that in many case the a work became a routine and can lead up to the failure of the human factor. There are NPP journals issued on a regular base semi-monthly or monthly where the articles on safety culture issues are published. Wall-boards are utilised to show the results of activities and achievements of the safety culture in the plant as well as evaluation and comparison of safety culture indicators. Issues of safety culture are also put to the INTRANET so that everybody has an access and may be acquainted with the news of safety culture. The pictures on appropriate places and sites are also very useful. It is sometimes better to see something than to remember it. Discussions between management or work leaders and manpower are of a great importance too because the requirements and stand points of both sides related to the objectives of nuclear safety can be clarified.

5. Conclusion

Maintaining and improvement of safety culture is the process of permanent development. It is one of principal objectives of NPP management. The efforts are focussed to keep the highest level of nuclear safety as well as personal safety. The enforcement of new elements of safety culture to daily practice through the yearly action plans helps the plant to achieve good production results. Attitudes of individuals are impacted by their working atmosphere. Clearly defined operation regulations, rules and procedures are the key to the efficient application of the safety culture and they contribute to a formation of this atmosphere and support attitudes of individuals directing to the high level of nuclear safety. The approach of Slovak NPPs to the safety culture implementation was appreciated by IAEA and representatives of Slovak NPPs are invited to participate in activities of IAEA in the area of safety culture. This is the confirmation of a right way towards economical and safe production of electricity and acceptance of public.

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Operation of TRR-1/M1 for 25 Years and Lessons Learned in Management of Safety and Safety Culture

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Abstract. The first Thai Research Reactor, TRR-1, was installed and put into operation in 1962. In 1975 the reactor was converted to a 2 MW TRIGA Mark III by replacing of the reactor core and the control system. The renamed TRR-1/M1 research reactor went critical again in November 1977. TRR-1/M1 has been operated safely for 25 years with its main utilization in research, isotope production and training. Safety management and safety culture have been implemented for 25 years both in the legislation level and the operation level. There was no nuclear incident and there were a few radiological incidents during the 25 years of operation of TRR-1/M1. The lessons learned from the incident events such as the release of N-16 and Ar-41, the release of radioactive Bromine gave valued opportunities to improve our operation procedure, safety procedure and safety culture. All type of activities with respect to safety culture such as individual awareness, commitment, motivation, supervision and responsibility have been seriously reviewed and being set as normal practices.

1. Introduction

The Office of Atomic Energy for Peace (OAEP) was established in 1961 in order to promote the nuclear for peaceful uses and conduct research. The first research reactor, TRR-1, was then built to support such activities. The TRR-1, pool type reactor, is designed and constructed by Curtiss-Wright, U.S.A. and then put into operation in 1962. In 1975, the reactor stopped operating and the core was replaced by TRIGA Mark III type of General Atomics, U.S.A. The reactor was named TRR-1/M1 and went critical in 1977. To date, this 2-MW reactor has been used for 25 years. The main purpose of the TRR-1/M1 is isotope production for the country use. Additionally, a number of research, analysis and training have been conducted.

The safety management has been implemented since the establishment of the reactor both in the legislation level and operation level.

2. Safety Management and Safety Culture

2.1 Nuclear Safety Policy

The organization chart of nuclear safety policy in Thailand is represented in Fig. 1 and responsibilities are described below.

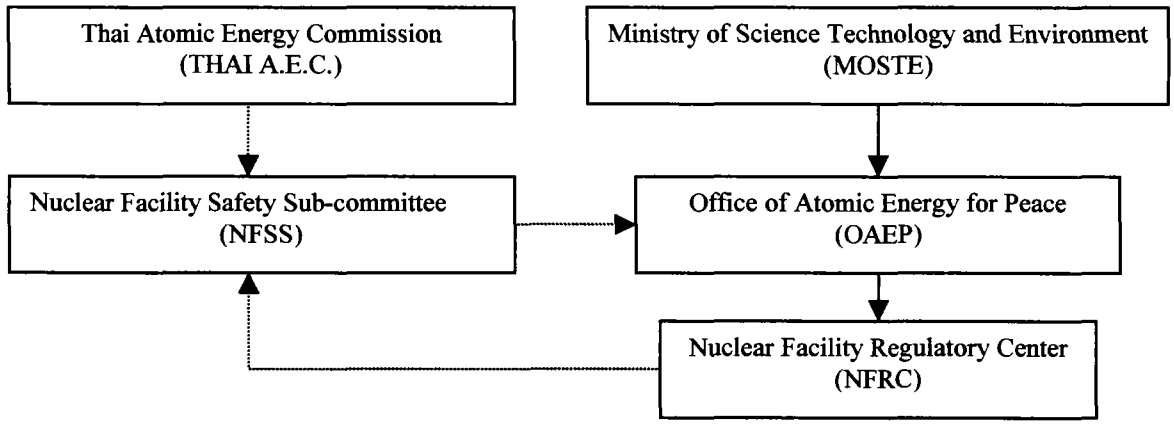

Fig. 1 Organization Chart of Nuclear Safety Policy in Thailand

2.1.1 The Thai Atomic Energy Commission for Peace (The THAI A.E.C.)

The Thai Atomic Energy Commission is a governing board (policy making body) of the government of Thailand. The Thai A.E.C. is chaired by the Prime Minister of Thailand and at present consists of 14 sub-committees.

2.1.2 The Nuclear Facility Safety Sub-committee (NFSS)

In accordance with the Atomic Energy for Peace Act of 1961 and the Ministerial Regulation No.6 of 1974, a license from the Atomic Energy for Peace Commission must be obtained for the establishment of a nuclear reactor, hereinafter referred to the "operating license". In order to carry out regulatory activities for the nuclear reactor, the commission assigns the authority through a sub-committee, established in 1994, with the Nuclear Facility Regulatory Center (NFRC) as the secretariat of the Sub-committee. At present, the Nuclear Facility Safety Sub-committee is composed of 17 members (only 3 are OAEP personnel) chaired by the well-known and well-recognized person outside OAEP; at present the president of Chulalongkorn University.

2.1.3 The Nuclear Facility Regulatory Center (NFRC)

The Nuclear Facility Regulatory Center, as a functioning arm of the Nuclear Facility Safety Sub-committee, is responsible for the assessment of safety features of a proposed reactor and related facilities, undergoing licensing deliberation, physical inspection and audit of licensed facilities to ensure that prescribed safety measures are strictly complied with safeguards of nuclear materials in accordance with national regulation and international commitment.

2.2 Duties and Responsibilities

The operating organization of the facility is the Reactor Operation Division, which is composed of 4 sections: Technical section, Operation section, Maintenance section and Non-destructive Testing section. The qualified staffs in each section are assigned to operate the reactor every week. Health physicists from Health Physics division are responsible for radiation safety. In each shift, 2 operators and 2 technicians operate the reactor under supervision of a shift supervisor and a health physicist. The responsibilities of operating staffs are described as follows:

2.2.1 Director of the Reactor Operation Division

The Director of the Reactor Operation Division is responsible to the Principal Scientific Officer for the safe operation and maintenance of the reactor, for the safety and good order of the reactor area and for carrying out the agreed reactor operation programmed. He will issue Reactor Operating Instructions for the guidance of his staff and these operating instructions must fall within the framework of the principles laid down in these standing orders. He will issue instructions of a temporary nature in the form of "Temporary Operating Instructions" which will be valid only for a stated period.

2.2.2 Shift Supervisors

The Shift Supervisor accepts responsibility for the safe operation of the reactor at all time during his shift. He should recognize when reactor components are operating normally or abnormally and should know what action to take in order to prevent any dangerous incidents. He supervises the activities in all phases of reactor operation and makes certain that all procedures are followed. He carries out the daily checkout and appropriate safety checks of the reactor and its associated equipment. He supervises the keeping of records and log and ensures that all records are complete and accurate on all phases of reactor operation and maintenance.

2.2.3 Reactor Operators

Reactor operators on duty are responsible for the safe operation of the reactor and its associated equipment within the term of the operating procedures and under the direction of the shift supervisor. On each shift of reactor operation two reactor operators are on duty; one manipulating the reactor control in control room, the other works outside the control room. The two will be designated as the inside control room operator and the outside control room operator respectively. They interchange roles at regular interval, normally at every two hours.

2.2.4 Maintenance Engineer

The maintenance engineer is responsible for the efficient maintenance of the reactor plant and equipment. He will issue detailed maintenance instructions and will ensure that no work shall begin without written permission of the Director of the Reactor Operation Division.

2.2.5 Health Physicist

The health physicist is responsible for advising the Director of the Reactor Operation Division on all aspects of radiation protection. He is responsible for making an independent regular check on the radiation and contamination levels in the reactor area, and for providing adequate equipment to enable the operation staff to carry out surveys on all radiation and contamination hazards at any time.

In the event that an operation is to be performed, or is being performed, which, in the opinion of the health physicist is hazardous, he is authorized to suspend operations, pending review and resolution of the hazard.

2.3 Safety Culture

Although the safety culture issues have not been published in the operating manual, operators and technicians are trained in such issues from operator training course and radiological training course. They are emphasized on safety awareness, knowledge, responsibility and communication. For example, operators will report any incidents to the director of reactor operation via the in-shift supervisor. Operators have to work strictly in accordance with the overtime work policy. They are not allowed to operate the reactor more than 8 hours a day. The reactor operating procedure is rigorously performed in order to ensure maximum safety.

Observation method has been introduced to monitor behaviors of operators and technicians. This is a very applicable method because the safety culture is developed continuously. For instance, operators and technicians sometimes forget to bring film badges with them when they work in the reactor hall because they keep the film badges individually. Therefore, compartments for film badges are provided in front of the reactor hall entrance to ensure that operators and technicians will not forget to bring film badges with them into their working area. These film badges are also collected and sent to the Health Physics division every 3 months to check for the dose rates.

Nuclear Facility Regulatory Center (NFRC) is the regulatory body that conducts the external inspections for safety operation and safety culture. The inspections will be performed in both pre-notification program and un-notification program. These combined programs will ensure that the real situation of reactor operation and operators' behaviors will be inspected.

3. Lessons Learned from Events

No nuclear incident occurred since reactor commissioning and there have been very few radiological incidents during 25 years. One example of radiological incidents is the release of N-16 and Ar-41 above the reactor pool. This incident happened when the diffuser pump, the pump used to disperse heat at the core, did not work. Normally, the RAM channel above the reactor pool can monitor the radiological gases. Unfortunately, there was electrical problem with the absence of one phase of the

power supply, so the diffuser pump using that absent phase did not work. The reactor still ran but the diffuser pump did not work. Radiological gases accumulated and dispersed above the reactor pool. The RAM channel used the same phase of the power supply as the diffuser pump. As a result, the RAM channel did not work either. Thus, it could not detect the Ar-41 and N-16 released. This situation was reported to the director of Reactor Operation Division. As the result of the lesson learned, operators are always taught to be aware of such situation.

The release of radioactive Bromine is another good example regarding safety culture. It happened on the last operating day before annual maintenance. The user wanted to use radioactive Bromine during the shutdown period. So he put a large amount of Bromine in the container without a wrapper. He also punctured a hole on the top of the container because he was concerned and worried of the gaseous expansion during irradiation. The container was then loaded into the reactor core. From the carelessness of the user, the container was accidentally dropped on the floor when the sample was unloaded. The powder of Bromine was released and dispersed on the floor. As a result, the reactor hall was contaminated and operators and technicians were evacuated. The reactor was then stopped operating before scheduled time. It is concluded from this scenario that the user lacks of safety culture and experience caused the contamination and related problems. The incident was then reported to the Director of Reactor Operation Division to figure out the solution. It was thereafter concluded that the experiment loading procedures have to be revised and the safety culture training should be conducted by Reactor Operation Division to all the users rather than individual training by other divisions.

4. Current and Future Challenges That May Impact on Our Safety Culture

Reformation of the Office of Atomic Energy for Peace is due to complete before October 2002. The office will be divided into 2 organizations: the operating body and regulatory body. Unlike the current organization, the regulator will be obviously separated and will result in more effective safety management. For legislation level, the Atomic Energy for Peace Act has also been revised and supposed to enact in the near future. In addition, safety policy has been revised to cope with the new organizations.

5. Conclusion

Safety management and safety culture are very important issues that must be studied and developed. Safety culture must be taken into account both at policy level and operation level. For Thailand, all type of activities with respect to safety culture: individual awareness, commitment, motivation, supervision and responsibility, have been seriously reviewed and being set as practices. There should also be a safety culture training to provoke individual awareness both users and operators. Furthermore, the safety culture questionnaires have to be established to encourage self-examination in organizations and for individuals.

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Management of Safety and Safety Culture at the NPPs of Ukraine

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(Synopsis of the report)

Introduction. Contains general aspects of safety and safety culture. The brief description of operational characteristics and basic indexes of atomic power plants at the Ukraine are represented. The information referring to structure of NPP's of Operation organization license-holder, safety responsibility of both Regulatory and Utility Bodies also is given.

The main part of the report includes seven sections:

1. "Practical application of safety management models" In the first section of the report is shown principle scheme's model of the operational safety management NPP's at the Ukraine. The basic results of changes in nuclear power branch management and its impact to safety condition are presented.

2. "Perspective on the relationship between safety management and safety culture" The information about role safety culture at safety management area and influence safety culture basic features to the effectiveness of safety management is given at this section. The basic elements and characteristics of a perspective interaction of those two aspects: - safety management and safety culture inhering of an atomic power branch structures at the Ukraine are represented. Development of Performance Indicators System.

3. "The role of leadership in achieving high standards of safety" Leadership's role in the progress of safety and safety culture level at the NPP's of Ukraine is shown on an example of relations NPP's stuff to specialist of experience – "production manager". Role of leadership at the state body and operation organization levels for achievement high safety standards in the nuclear power also is discussed. The information about leadership's role in management of safety and reliability improvement programs are presented.

4. "Current and future challengers that impact on safety culture and safety management (e.g. the impact of competition, changing, economic and political circumstances, workforce demographics, etc.)" The important current economic and political problems bound with management of nuclear power branch, their analysis and impact to safety and safety culture management in a point of view of workforce demography are also described at fourth sections. The brief results of competition between Ukrainian NPPs on the basis operation indexes that were developed by USA INPO are given.

5. "Key lessons learned from major events" Results of the root cause analysis of three events that have occurred at the NPPs of Zaporozhye, South-Ukraine, Rovno and Khmelnitsky and brief results of an experience performances extracted from an estimation of these events ere given at the fifth section.

6. "Practical applications of safety culture concepts (e.g. learning organizations, training staff communications, etc.)" The results of an improvement operation organizational process at the Ukrainian NPP's units on the basis of the experience study and analysis obtained at visiting foreign NPPs and examples from a point of view safety culture on interaction of the management and operation personnel at all hierarchies levels are considered.

7. "Advance in human performance" The information on advance in human performance is shown on examples of the operational and repair personnel work during reactor installation control and repair work. The results of an estimation of operation safety level, safety culture state both of the administrative and operative personnel at the Ukrainian NPPs are given. Some of the main pending safety and safety culture problems that is necessary to execute on the proximate perspective are cited.

Safety Culture and the Accident at Three Mile Island

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Abstract:
Prior to the accident at Three Mile Island, little attention was being paid to the human role in the safe operation of civilian nuclear power plants. The investigation of the TMI accident showed that its root causes were primarily human-related. The Kemeny Report on the TMI accident does not use the term "safety culture"; however, it fully identifies all relevant aspects of safety culture.
It was only after the accident at Chernobyl that the term "safety culture" came into widespread use. However, it should be noted that, during the years after TMI and before Chernobyl, already major changes had been instituted concerning human factors and human reliability in the civilian nuclear energy programs of many countries. Greater credit should be given to the remarkable insights developed by the Kemeny Commission as contained in the Kemeny Report.

1. Introduction

Until the accident at Three Mile Island (TMI), little attention was being paid to the important role of human factors and human reliability in the operation of nuclear power plants. The prevailing opinion (mindset) at that time was that the many safety systems were capable of terminating and stabilizing any and all safety-related operational events in a timely and safe way. The human role was largely ignored and, if considered at all, the operators were assumed to only undertake actions favorable to safety. This mindset is the probable cause that, at that time, human errors (of commission and omission) were given little or no attention.

The Reactor Safety Study (WASH-1400, usually referred to as the Rasmussen Report [1]) which was the first probabilistic safety assessment of civilian nuclear plants, should have been a warning. However, the insights gained in this study that human factors play an important role in safety did not penetrate into the nuclear establishment until after the accident at TMI. This situation was in large measure a consequence of the reticence of the U.S. Nuclear Regulatory Commission (NRC) to give credence to the results of the Rasmussen study. In fact, at that time, a letter was issued by the chairman of the NRC warning all NRC employees to refrain from using probabilistic safety considerations in reaching licensing decisions.

During the investigation into the root causes of the TMI accident it was found that, while some design deficiencies and system malfunctions were contributory, the main causes were human-related. The well-known Kemeny Report [2] presents the results of one of the main investigations into the TMI accident. It does not use the term "safety culture"; however, it fully identifies all relevant aspects of safety culture, including the important role of the mentality (culture) existing in organizations from the highest level of management down to the individual workers. Subsequent probabilistic safety assessment studies confirmed these findings and concluded that human factors constitute the main contributor to the overall risk of nuclear power plants of the current generation. The realization of this fact has become the driving force in the search for innovative reactor designs that are more forgiving of human errors and component/system failures.

It was only after the accident at Chernobyl that the term "safety culture" came into widespread use. However, much had already happened during the years after TMI and before Chernobyl: Major changes had been instituted in many countries based on the findings gained from TMI concerning the important role of human factors and human reliability in the safe operation of nuclear power plants.

This paper intends to show that important advances had been made in the area of human factors and human reliability as a consequence of TMI; specifically, attention will be focused on the important contributions made by the Kemeny Commission in this respect. To that end, the paper briefly discusses the sequence of events that resulted in the TMI accident, identifying some of the main design deficiencies, mechanical failures and human-factor deficiencies that were the cause. It then reviews the Kemeny Report and highlights its major findings, showing that the basis for safety culture had already been laid before the accident at Chernobyl occurred. In this connection, it is important to note that the Kemeny Report attributes serious shortcomings to all parties involved, including design/construction organizations, operating organizations and regulatory organizations.

3. **Brief Description of the TMI Accident**

The accident at Three Mile Island started on March 28, 1979, at about 4:00 AM and evolved over about six days until April 2, 1979. It took place near Middletown, Pennsylvania, USA. Two weeks after the accident, the President of the United States - Jimmy Carter - established a Presidential Commission under the chairmanship of John G. Kemeny with the task to conduct a comprehensive investigation into the accident. This investigation was to include (a) a technical assessment of the events and their causes, (b) an analysis of the role of the managing utility, (c) an assessment of the U.S. Nuclear Regulatory Commission's emergency preparedness and response capability as well as its licensing, inspection, operation and enforcement procedures.

In order to identify some of the human-related aspects of the TMI accident, a brief summary of some of the main points of the sequence of events is presented in the following:

(1) A plant malfunction caused the pumps of the main feed water system to be tripped automatically at a time when TMI unit #2 was operating at 97% of nominal power;

(2) As a consequence, the steam generators (being of the once-through type and having a small feed water inventory) started to boil dry, resulting in increased pressure of the primary cooling system;

(3) In response to this increased primary pressure, the pilot-operated relieve valve (PORV) of the pressurizer opened (as required by design), allowing release of primary coolant into the quench tank;

(4) Because the primary coolant pressure continued to rise, the automatic protection system of Unit #2 tripped the reactor 8 seconds after the first feed water pump had tripped, thus terminating the nuclear fission chain reaction;

(5) Three pumps of the emergency feed water system started automatically as required by design. However, no feed water was delivered to the steam generators, because the block valves on the two emergency feed water lines had inadvertently been left closed (*human error*). Furthermore, the operators did not notice for some 8 minutes that these valves were closed (*human error*);

(6) The primary pressure decreased (because of the reduced reactor power level and the loss of primary coolant to the quench tank) to the point at which the PORV should have closed automatically. However, the PORV remained mechanically stuck open.
(7) The operators assumed that the PORV had closed because the status lights on the control board erroneously indicated so (*design deficiency*). As a consequence, the PORV remained open for 2 hours and 22 minutes, resulting in a loss-of-coolant accident draining the primary system;
(8) As a consequence of the loss of primary coolant, the primary coolant pressure decreased to the point where the emergency core cooling system (ECCS) started automatically;
(9) The liquid level in the pressurizer increased because saturation temperature had been reached in the core, resulting in a steam bubble at the core outlet.
(10) The ECCS was shut down by the operators because they had been trained to do so when the liquid level in the pressurizer became too high (*training deficiency*).
(11) The operators had not been adequately trained to recognize the prevalent plant conditions. Under most operating conditions, if the liquid level of the pressurizer is too high, the primary system could "go solid", thus incurring a risk of over-pressurization. However, in this case, there was a large steam bubble at the top of the core, so that there was no danger of the primary system "going solid".
(12) The continued loss of primary coolant through the open PORV and the shutting down of the ECCS resulted in uncovering of the fuel assemblies, and eventually in the melting of approximately 50% of the core.

If the TMI operating staff had refrained from shutting down the ECCS (*error of commission*), the automatic safety systems would have prevented core damage by establishing a feed-and-bleed mode of operation and the accident could have been terminated without major consequences. However, the operating staff is not to be blamed for their actions because, at that time, the action of shutting down the ECCS for high pressurizer level was in full compliance with the (then) existing operating instructions. Similarly, if the operators had stopped the loss of primary coolant in the early part of the accident sequence by closing the pressurizer block valve (*error of omission*), the accident would have remained a minor incident.

We shall not follow here in detail the entire further evolution of the accident. Suffice it to say that the accident resulted in melting of the core for about 50% and that many lessons were learned, in particular in the area of human factors.

4. **Discussion**

This paper will draw mainly from the Kemeny Report, highlighting by direct quotations the important insights that were gained by the Kemeny Commission from its TMI investigation.. Some of these main findings and recommendations are as follows:

Findings:

"To prevent nuclear accidents as serious as TMI, *fundamental changes will be necessary in the organization and practices* of the Nuclear Regulatory Commission and the nuclear industry";

Safety Culture and the Accident at Three Mile Island

"Equipment can and should be improved to add further safety to nuclear power plants. But as the evidence accumulated, it became clear that *the fundamental problems are people-related problems* and not equipment problems";

"When we say that the basic problems are people-related, we do not mean to limit this term to shortcomings of individual human beings....We mean more generally that our investigation has revealed *problems with the "system" that manufactures, operates and regulates nuclear power plants*. There are structural problems in the various organizations, there are deficiencies in various processes, and there is a lack of communication among key individuals and groups".

The (TMI) equipment was sufficiently good that, except for human failures, the major accident at TMI would have been a minor incident. But, *wherever we looked, we found problems with the human beings who operate the plant, with the management that runs the key organization, and with the agency that is charged with assuring the safety of nuclear power plants.*

"....*we are convinced that regulations alone cannot assure safety.* Indeed, once regulations become as voluminous and complex as those regulations now in place, they can serve as a negative factor in nuclear safety....This Commission believes that *it is an absorbing concern with safety that will bring about safety* -- not just the meeting of narrowly prescribed and complex regulations".

"....we find that *the approach to nuclear safety had a major flaw*....Some potentially serious scenarios, such as the break of a huge pipe....were studied extensively and diligently....the attitude developed that *we need not worry about the analysis of 'less important' accidents* if such large-break accidents could be controlled. Large-break accidents require extremely fast action that therefore must be automatically performed by equipment. Lesser accidents may develop much more slowly and their control may be dependent on actions of human beings. *This was the tragedy of TMI*, where the equipment failures in the accident were significantly less dramatic than those that had been thoroughly analyzed, but *where the results confused those who managed the accident*".

"The most serious 'mindset' is the preoccupation....with the safety of equipment, resulting in the *down-playing of the importance of the human element* in nuclear energy generation. We are tempted to say that *what the NRC and the industry have failed to recognize sufficiently is that the human beings....constitute an important safety system*"

"*The control room*, through which the operation of the TMI-2 plant is carried out, *is lacking in many ways*. The control panel is huge, with hundreds of alarms, and there are some key indicators placed in locations where the operators cannot see them"

"The WASH-1400 Reactor Safety Study (the Rasmussen Report) analyzed events, equipment failures and human errors that could happen during reactor accidents, including those

associated with the TMI accident. However, *NRC has not made systematic use of WASH-1400 in its design review analyses*"

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Recommendations:

The nuclear industry must dramatically change its attitude towards safety and regulations:

- The industry should establish a program that specifies appropriate safety standards including those for management, quality assurance and operating procedures and practices;
- There must be a *systematic gathering, review and analysis of operating experience* at all nuclear power plants coupled with an industry-wide international communications network to facilitate the speedy flow of information to affected parties;

Although the Commission considers the responsibility for safety to be with the total organization of the plant, *we recommend that each nuclear power plant have a separate group that reports to high-level management;*

Clearly defined roles and responsibilities for operating procedures and practices must be established to ensure accountability and smooth communication;

Since, under our recommendations, *accountability for operations during an emergency would rest on the licensee, the licensee must prepare clear procedures* defining management roles and responsibilities in the event of a crisis;

5. **Conclusions**

Although the importance of the human role in the safe operation of nuclear power plants had already been established in 1975 by the Rasmussen study, this insight did not penetrate into the nuclear establishment until after the accident at Three Mile Island.
The investigation of the Kemeny Commission into the TMI accident firmly established that the root causes of the accident were primarily human-related. The Kemeny Report does not use the term "safety culture"; however, it fully identifies all relevant aspects of safety culture, well before the Chernobyl accident subsequent to which the term safety culture came into widespread use.
Greater credit should be given to the groundbreaking work performed by the Kemeny Commission in the area of safety culture and to the remarkable insights that are contained in the Kemeny Report which established the concept of "safety culture" well before it became part of the accepted terminology.

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The Role of the Regulator in Promoting and Evaluating Safety Culture

Operating Experience Feedback Programme Approach

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Abstract. Promoting and Evaluating Safety Culture (S.C.) in Operating Organizations must be one of the main Nuclear Regulator goals to achieve.
This can be possible only if each and every one of the regulatory activities inherently involves S.C. It can be seen throughout attitudes, values, uses and practices in both individuals and the whole regulatory organization [1].
One among all the regulatory tools commonly used by regulators to promote and evaluate the commitment of the licensees with safety culture as a whole involves organizational factors and particular attention is directed to the operating organization. This entailed a wide range of activities, including all those related with management of safety performance. Operating Experience Feedback Programme as a tool to enhance safety operation is particularly useful for regulators in the evaluation of the role of S.C. in operating organization [2].

Safety Culture is recognized as a subset of the wider Organizational Culture. Practices that improve organizational effectiveness can also contribute to enhance safety.
An effective event investigation methodology is a specific practice, which contributes to a healthy Safety Culture [3].

1. Background

The role of the regulator is presented in this paper according to the inherent responsibilities (promoting / evaluating) using different approaches:

Promoting Safety Culture (S.C.) basically has its origin in the regulatory organization safety culture.

Evaluation of operating organization safety culture is focused in specific fields related with the normal activities developed by the author of the report.

In fact, even when other subset of regulatory commitments with S.C. are not included here, it does not mean that such activities are not carried out.

2. Regulatory activities carried out to promote and evaluate S.C.

2.1. Promoting Safety Culture

One of the basic points to take into account was to be aware of how different regulatory strategies could influence positively the operator's safety culture

However, regulators were inherently using most of the strategies. At this point, the main modification was to distribute separately those strategies in order to clarify written concepts.

2.1.1 Through its own performance

Evolution and growing up through the years proved that one of the most valuable ways regulators can apply to promote operator's S.C. is the use of regulator's own proficiency.

- Proficiency of regulatory organization involves:

- Organizational and individual commitment with safety issues.

- Clear responsibilities and roles within the regulatory organization

- Being technically competent. It implies continuous training to maintain regulatory staff capability.

- Attitudes, policies, professionalism as well as an environment in which workers set high Safety Culture standards for themselves.

- Teamwork: clear concepts about the importance of acting and working as a team. Efforts made by individuals are not effective enough. Clear goals like "Safety is never compromised" are inherently involved in all team 's attitudes. Also managers are involved to help motivating people to work, act and think as a team

- Comprehensible instructions to lead inspections

2.1.2- Relationship regulator – operator

- Polite and professional attitude in verbal communications

- Honest dialogue particularly focused to accomplish safety objectives more than on strict compliance with rules.

- Promote good practices: Providing constructive support for high performance in plant activities

2.2. Evaluating Safety Culture

2.2.1. Direct evaluation

Performing on-line evaluation of S.C. of the operating organization is something difficult to achieve for our regulatory body, despite of the presence of on-site inspectors.

However, day to day operation follow up is a good approach we use through resident inspectors, some of whose activities to detect early sign of declining S.C. are included in check lists based on those given in [2] and [4].

2.2.2. Evaluation through follow up of Operating Experience Feedback (O.E.F.) Programme

Additionally, safety analysts from Argentinean Regulatory Organization, apply a different perspective throughout assessments. The main goal to be reached by analysts is the evaluation of the influence of organization and management (organizational factors) in root and direct cause of events.

These assessments include, among others, surveillance of operating feedback programmes followed by the Utility. Some regulatory tools are used to indirectly evaluate S.C.
The use of the commonly defined regulatory approaches [2] highlight the importance of the aspects considered in the follow up of the O.E.F. programme.

"Process based approach" takes specific account of the fact that the safe operation depends on the effectiveness of the organizational processes established to operate, maintain, modify and improve a facility.

The advantage of processes based regulation for areas of organization and S.C. is that assessment can be applied to major organizational processes.
In this point, one of the most important facts we recognize is that Argentinean Utility has analysts teams in headquarters as well as in the N.P.P's. Characteristics of those groups are experience and qualification both to find root causes of events and to make recommendations concerning to corrective actions

The use of "performance based approach" requires understanding organizational factors, which are important to safe performance in plants: As an example, lack of communication between plants and other external organizations can be seen as an alert. Follow up of O.E.F. programme shows that both Utility and N.P.P's are not isolated as they use external and internal operating experience for corrective actions and training.

S.C. is an underlying cause of performance based events. Consequently, it is important to recognize early signs of declining S.C., such as accumulated corrective actions, unidentified root causes and recurrence of minor events. For events with human performance causal factors, the lessons learned may be useful to increase human or organizational reliability in plants, regardless of the type of reactor. (In next point some examples will be shown).

Furthermore, practices that improve organizational effectiveness can also contribute to enhance safety. An effective event investigation methodology is a specific practice, which contributes to a healthy S.C. For that reason, it is important to specify those events subject to complete event investigation. These include non-consequential events or near misses [3]. Regulatory analysts verify that every event is evaluated, and in some specific cases, regulators analyze events themselves.

Other routinely activities developed by regulatory analysts include:

- Check out that corrective actions resulting from O.E.F. programme are executed. Revision of operators ability to identify, prevent and correct problems.
- Review of trends in event report (one of the regulatory tools used is "Safety Performance Indicators").

2.2.3. Examples of influence of S.C. in root causes of events

Some examples of analyzed events (taken the wide range from near misses to significant events), showed safety culture as one of the root or contributing causes. Due to the fact that in our country there are only 2 operating N.P.P's, only a small amount of information will be showed in this report, excluding details about where those events happened.

Type of event	Year of occurrence (1)	S.C. related causes (2)
Operating event	1998	Root causes: Lack of double-checking, not enough training for the job
Significant event	1999	Root causes: Management: not well defined policies of work, risks associated with implemented changes not evaluated. Secondary causes: System operation: operation out of limits, effects and consequences not evaluated. Surveillance: erratic performance of the system not analyzed.
Operating event	1999	Recurrence of failures during the last past years, corrective actions never implemented
Minor events (4 different)	2000	Lack of double-checking, lack of supervision, procedures violations
Minor event (a)	2000	Root cause: lack of Safety Culture
Significant event	2001	Root causes: Risk associated to job not evaluated, lack of Safety culture
Operating event	2001	Multiple event: 1: recurrent, 2: possible precursor of accidents.
Minor events (2 similar events)	2001	Root causes: Lack of S.C., recurrent event
Minor event	2001	Inadequate operation of a component: recurrent.
Minor event	2001	Recurrent (a). Lack of S.C.

(1) These are only a sample of the events happened during the mentioned years
(2) Mentioned are not the only root causes of the events

3. Conclusions

Regulatory activities in progress to promote and evaluate Safety Culture in N.P.P's were briefly explained in point 2. Therefore, those are part of the activities carried out by one group of inspectors and evaluators. More different activities are carried out in other areas and by different personnel.

Nevertheless, activities to promote and evaluate S.C. are still in evolution, adding more new tools continuously.

To the activities in progress at the moment (like follow up of O.E.F. programmes), some others will be added during the next months. The scheme includes the development of a set of Indirect Safety Culture Indicators and improvement of regulators training to deal with "organizational factors".

Despite of all the objective remains unchanged; these new steps will be only a way of adding new resources to achieve the main regulatory goal: Improving Safety.

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Safety Culture and public acceptance

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Abstract. After the Chernobyl NPP accident a public acceptance has become a key factor in nuclear power development all over the world. Therefore, nuclear safety culture should be based not only on technical principles, responsibilities, supervision, regulatory provisions, emergency preparedness, but the public awareness of minimum risk during the operation and decommissioning of NPPs, radioactive waste management, etc.

1. Introduction

It is interesting to analyze the situation with public acceptance on the example of Belarus. Republic of Belarus, as a part of the Soviet Union, having highly energy-intensive economy and few indigenous fuel and energy resources has been initially oriented towards nuclear power. Four nuclear power plants with total capacity of about 12GW have been constructed near the borders of the Republic. In Belarus the constructing of nuclear CHP not far from Minsk and the planning of NPP construction in Vitebsk region have been begun. The Chernobyl NPP accident has stopped this Program.

On the other side the Republic of Belarus has been suffered from the Chernobyl accident most of all other countries including Russia and the Ukraine. About a quarter of its territory and population had turned out in the radioactively contaminated zone (Caesium-137, over 37 kBq/sq. m). The attitude of a considerable part of the Belarus population towards the nuclear energy is aggravated with the consequences of this accident. Therefore the work on the public opinion formation is to be stated long in advance the beginning of NPP construction.

2. Results of sociological survey of the perception of nuclear power in Belarus

During 1995-1999 the sociological monitoring of public opinion about nuclear safety of the existing NPPs and further nuclear power development were provided in Belarus. The first poll was conducted among 1164 inhabitants of the more "pure" region in the Republic - the Vitebsk one (34.8% respondents), as well as in the regions contaminated with radionuclides - the Gomel region (32.7%) and the Mogilev region (32.5%). 38.8% of the polled persons declared in favour of nuclear power development and 20.3% of the polled ones declared decommissioning of all operating NPP in the territory of CIS. The opinion about the level of NPP safety was as follows: more than three fourth of the polled respondents (75.8%) consider the increased safety of operating not only the Chernobyl NPP but also all other NPPs located close to Belarus is necessary to be provided with; 63.8% respondents said that only NPPs with the increased safety are necessary to be constructed in Belarus.

Approximately half of the opponents of nuclear power (50.5%) explained their negative attitude, in some way or other, by the apprehension of risk increasing for people's health

becoming worse. It is clearly seen in the regions having been subjected to the affect of the Chernobyl NPP accident consequences: 55.5% of the polled persons consider radiation contamination of the territory to be the main reason of their health becoming worse last time, whereas 41.8% - decreasing of family income and 36.6% - the absence of ecologically pure and qualitative nourishment.

The second sociologic survey involved the inhabitants of the whole territory of Belarus including the capital of our Republic - Minsk city. From the total number of respondents (999 persons) 83.6% constituted townspeople, 43.3% - engineering and technical personnel, 15.5% - workers, 13.6% - the pupils and the students; 54.9% had higher education, 23.9 - specialized secondary education; 68% were at the age from 21 to 50.

The main question of the questionnaire "Should the project of NPP construction be adopted in Belarus?" was answered in a following way: 40.9% of the respondents answered "Yes", 39% - "No" and 19.2% of the respondents were embarrassed to answer.

Thus, on the whole, the respondents are accepting the idea on NPP construction in Belarus calmly, but the next question "Nuclear Power Plant could be constructed close to your town, settlement, couldn't it?" revealed that only 23.5% of the respondents take it normally, 32.1% - with anxiety, but 47.7% - negatively (Fig. 1).

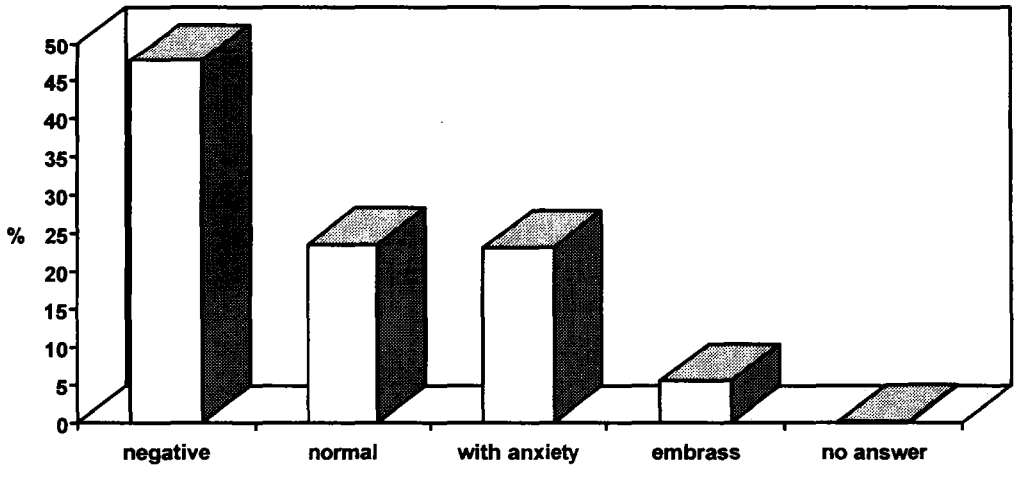

FIG.1. Attitude towards possibility of NPP construction close to respondent's city/settlement

The situation, as a matter of fact, is a typical one, it answers the natural desire of the population to have and chemical industries, and prisons, and other potentially troubled affairs, only "at the neighbour's", what concerns nuclear power, such approach is scarcely of common sense because exactly in Belarus, as nowhere else, the people could be convinced of the fact, that the distance is not a reliable protection from the accident at the nuclear reactor. In this connection , it is interesting to examine the distribution of opinions as to various categories of the questioned persons (Fig. 2).

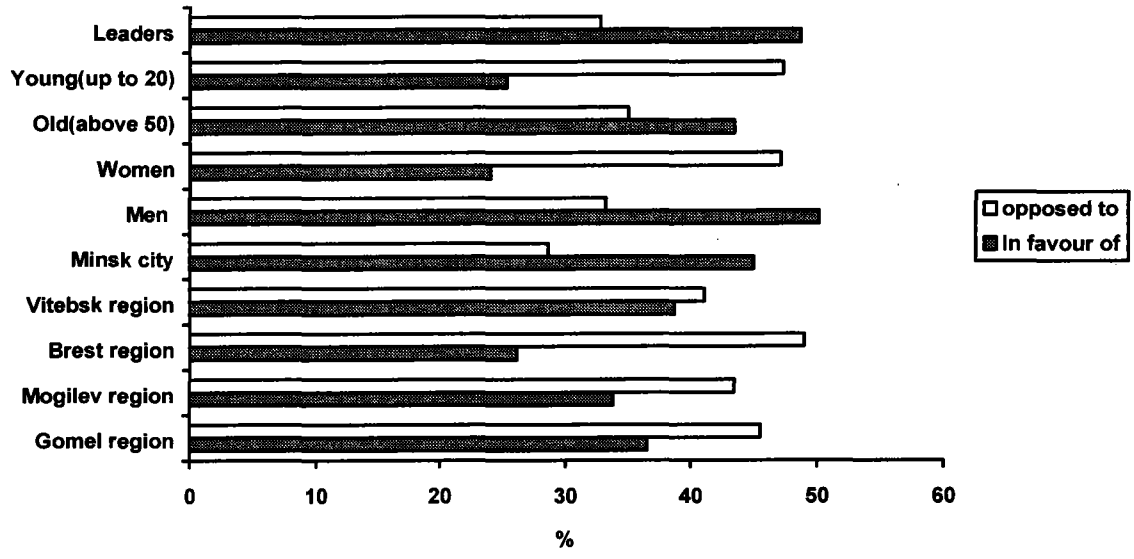

FIG. 2. Opinion on the NPP construction in Belarus

The more negative attitude towards nuclear power has the inhabitants of the Brest region which has been partially suffered from the Chernobyl NPP accident, opinions of the inhabitants of "pure" Vitebsk region and the more contaminated Gomel and Mogilev regions are less negative and vary between themselves a little bit, the more positive attitude is shown by the respondents living in the capital of the Republic. Supporters of nuclear power are absolutely more among men, and relatively - among the leaders of different ranks and persons older than 50, less- among women and the youngest participants of the inquest at the age of up to 20.

As it is seen from the results above-given, they have turned out to be not logically adequate in all to the situation having been established in Belarus. One of the explanations of this phenomenon is the answer on the question "Is the population informed on the problems of nuclear power sufficiently?". An absolute majority (89.1%) of the interrogated persons answered "No".

Among the sources the information we received from the IAEA and other specialized international organizations (Fig.3) is trustworthy most of all among the participants of the inquest, home scientists and specialists are trusted less than the foreign ones, and mass media has extremely low rating of confidence.

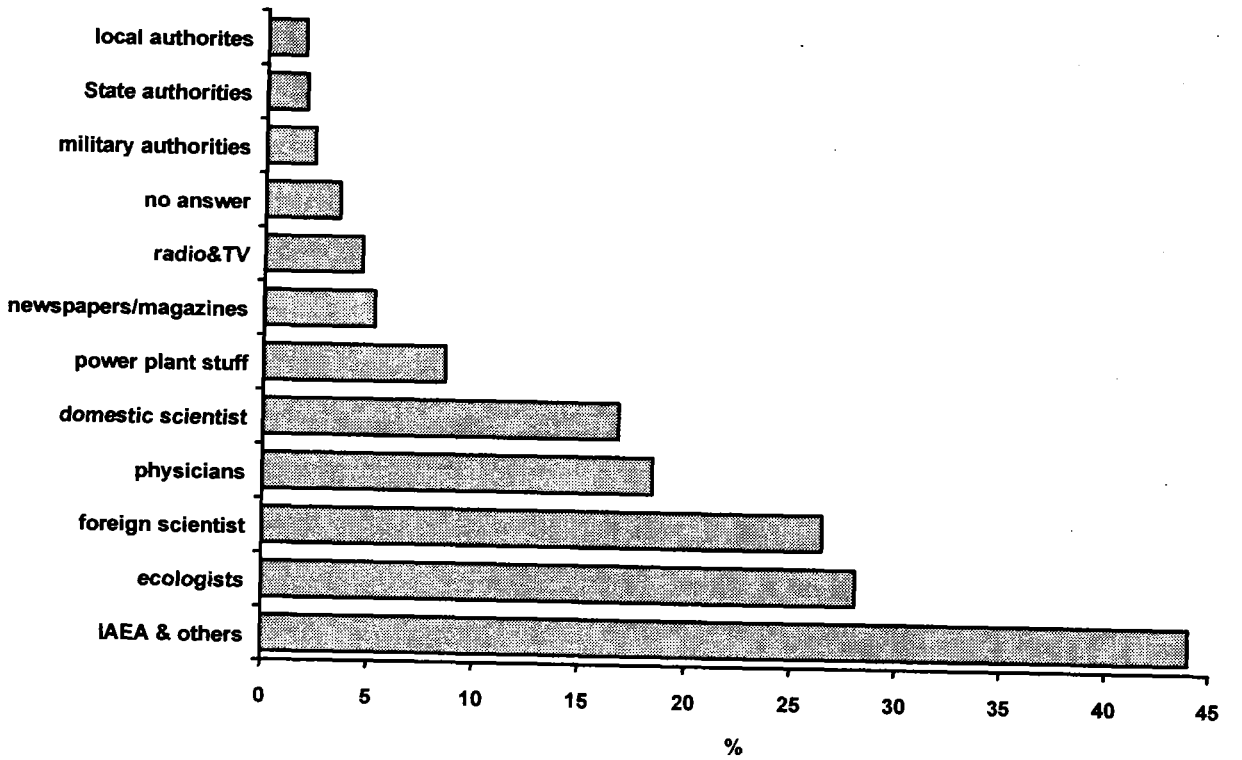

FIG. 3. Whose Information on NPP Performance is Trustworthy in Belarus?

3. Conclusion

Nuclear safety culture must include the following aspects connected with public acceptance:

- ***Openness.*** All the elements ensuring nuclear safety (technical, organizational and others) must be completely open not only for specialists, but also for general public. Just the absence of such openness is one of the reasons of the Chernobyl accident.
- ***Clearness*** of safety principles for general public. As it has been shown above, the population trust journalists little on questions of nuclear safety. Therefore, the task to make safety culture clear for general public must be solved by specialists in this field first of all.
- ***Information.*** Safety culture must include the information system for population, which contains exhaustive data on safety level at all stages of fuel cycle, as well as on all incidents or accidents in nuclear installations.
- ***Competitiveness.*** Public opinion must be sure that the main solutions on nuclear safety are accepted on a tender basis, that in this case monopolies and lobbyism do not play a sufficient role.

Development of safety culture at Kozloduy NPP The role of the regulatory body

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Abstract. An evolution is made upon external factor that accompany the development of safety culture at Kozloduy NPP (KNPP). The two basic stages and the major results achieved independently and with external assistance were considered in the process of development of safety culture. The areas in which the regulatory body insists on having active participation were defined.

1. Introduction

The significance of nuclear safety issues may vary among countries and reflect particular needs. It will always be necessary to decide which are the pririority issues, using the recourses available. The efforts made to enhance safety culture can benefit plant performance through improved organization, analyses and work processes. The particular development and improvement of safety culture is a dynamic, progressive process and the time scale required cannot be predicted.

The evolution of safety culture at KNPP occurs with the existence of several external factors that are particularly topical for the beginning of the 90s of the previous century. They are:

- Essential political and economical changes; severe economical break down, new market interface and high rates of unemployment accompanied with lack of clearness about the future progress of professional career;
- Intensive usage of Russian operational rules; To some extent limited relation of KNPP with other NPPs and international organizations as IAEA and WANO;
- The design safety of the existent units with reactors VVER-440 in KNPP is a subject of concern by the international community. The Bulgarian government is put into political pressure for their shut-down (that problem is present till these days).

2. First stage of the development of safety culture

Conditionally two stages of the development of safety culture may be determined at KNPP. At the first stage (1991-1996) some measures were taken to ensure appropriate personal motivation of the staff, its training in the principles of strong safety culture and its deep involvement in the implementation of the measures for increasing the safety.

By the proposal of the operating organization and the regulatory body additional payments of the KNPP staff were approved by the government according to the riskful factors and the influence of the executed functions to the safety. This led to the employment of highly qualified specialists in broad range of technical and scientific branches of knowledge. Now 76 per cent of KNPP staff is with technical and university education and 29 per cent – with university degree.

With WANO assistance a "twinning" program with Bougue NPP France was developed and implemented. Prominent specialists from KNPP were trained in the evolution and realization of contemporary approaches for ensuring the quality, experience feedback and safety management. That practice appeared to be especially valuable because of the convergence of both national cultures and with insignificant breaks continues till nowadays.

A special team wit WANO specialists was created to assist the KNPP management. That team was working on site and participated in the everyday work of the units. The significant results achieved with that assistance are:

- Quality assurance program was developed and implemented;
- Council on safety and quality as consultancy body to the management was created;
- System for experience feedback was realized;
- Training of management and executive staff was made on the principles of strong safety culture;
- System of "work in team" was applied;
- Step by step procedures were developed for functional tests of systems and equipment important to safety;
- Requirements for housekeeping were determined.

A special model was created for interfaces between the regulatory body and operating organization under the principle "2 + 2". The developed program by KNPP and WANO team for improving the safety of units with VVER-440 reactors was evaluated by the Bulgarian regulatory body with the assistance of Consortium of western regulatory bodies and expert organizations. By that a transfer of western methodologies and practices was provided in order to evaluate the safety.

The implementation of the measures from that program for improvement of the safety was with the active participation of the whole staff. In the realization of the complex tasks an interaction between the various organization units is sought, the role of every single participant was considered and appreciated. The management actively took part in those activities and with its attitude to the safety stroke with respect others.

The regulatory body realized the role of the contractors in the implementation of the activities important to safety and changed the system for license. The usage of contractors by KNPP is done after issuing of permissions by the regulatory body based on:

- Set by a contract interrelations;
- Justified qualification of the executive staff and existence of the necessary equipment and devices;
- Quality assurance program;
- Determined responsibilities for auditing activities by KNPP staff.

3. Second stage of the development of safety culture

The second stage of the development of safety culture at KNPP is characterized with the admit ion of long-term policies and strategies, with strengthening the organization structures for management and control of safety, wit profound assessment of the role of the human factor and with the applying of the self-assessment methods. The major results achieved at this stage are as follows:

- The management declared its anticipations and goals in the document "Policy for safety and quality";
- A department "Safety and quality" was created under the direct subordination of the executive director. The staff of the new creation has large authorities for management and control of safety and quality including the power to cancel the implementation of activities when this measure is in interest of safety;
- All operational events and failures of equipment including near-miss events are put into systematical assessment according to approved by the regulatory body methodologies for determination of the root causes. A special procedure was developed for assessment of the role of human factor in initiation and evolution of operational events. The PSA results are used in the training of the staff;
- The potentialities and limitations of human factor are put into consideration in the technical measures for improving the safety. New diagnostic systems are installed for controlling the equipment important to safety, symptom – based emergency procedures are developed for management of design and beyond design accidents, analyses of man-machine interface are conducted and improvement of main control rooms are implemented;
- The concept "ZONE" which is the Bulgarian acronym of STAR (stop, think, act, review) is widely spread in the implementation of activities significant to safety;
- Large scale programs for modernization are under implementation in all units of KNPP, although the political decision taken to shut down two units till the end of 2003;
- A system of performance indicators for self-assessment was developed. Some of performance indicators are compared to WANO indicators and on that grounds long-term goals are settled. During the implementation of the system problematic areas are not fixed which require urgent measures.

The major motivations for KNPP staff are the given positive conclusions from the conducted in 2000-2001 OSART, FOSART and the special IAEA mission for evaluation of organizational structure. The achieved operational level of safety is in accordance with the international practice, the organizational structure of KNPP ensures adequate management, the priority of the safety is realized by the management.

4. The role of the regulatory body for the development of safety culture.

The role of the regulatory body for the development of safety culture depends to large extent on existent legislation, national culture and the nowadays social-economical circumstances. In the process of seeking its own place in the development of the safety culture the Bulgarian regulatory body had to consider those factors while simultaneously had to contemplate on the existent international practice. For that reason some of the decisions of the regulatory body may not always be in context of the common rules but in reality they have their own significance for ensuring the safety.

Typical example is the approach of the regulatory body in the usage of the contractors by KNPP. Nowhere permissions are issued for the usage of contractor only once. But during the period when the old foundations are ruined and the new grounds are not dressed in the legislative requirements, this measure was the necessary solution. Nowadays when KNPP has created an internal system for election and control of the contractors and the national legislation determines the responsibilities and duties on the concluded agreements that seems a needles measure.

The same thing is valid for the licensing of the activities important to safety. The licensing system foresees issuing of permissions for every single stage, while between every of which time is needed to present the compulsory justifications of safety and for analyses by the regulatory body. This procedure was not significantly presented when the measures had to be accomplished during the plant outages of the units for refueling and at the same time the design as well as the delivery of the equipment were late because of external reasons. That imposed to be developed special procedures for licensing which gave some flexibility to the operating organization to do technical modifications I accordance with the conditions of the issued permissions.

Factors in which the regulatory body insists on having active participation in the development of safety culture:

- Expertise of the high-level management. The role of the management is essential for the evolution of strong safety culture and in accordance of that fact the regulatory body changed its requirements on the high-level staff that has to be examined by The State Qualification Commission (SQC – a commission to the regulatory body that bestows certifications to the chosen staff). 31 positions were determined that have to pass an exam through SQC. During the exam are discussed topics as safety management, safety culture, defense in depth concept, self-assessment methods, long-term planning and configuration management;
- Knowledge of duties and their adequate implementation. The regulatory body approves the job descriptions of the staff that is directly involved in the fulfillment of leading and control functions. According to that functions are determined the positions that have to be certified by SQC. The adequate fulfillment of duties is checked during discussions of the staff with SQC and during regulatory inspections;
- Preservation of the technical support in the field of nuclear energy. In the process of continuing changes in the social-economical area significant alterations emerge in the ensurance of adequate technical support in the field of nuclear energy. The problem is particularly important for the countries with small nuclear programs and limited possibilities to serve nuclear fuel cycle. In this direction the regulatory body has chosen the practice to participate in the internal examinations of the staff and to determine the areas in which the necessary expertise maybe done. With the available funds the regulatory body assigns the analyses and expert ices connected to the safety problems and investigations for perspective development. The experience shows that there is a plenty of room for future improvements.

Creating a Safety Culture in the regulatory authority: the Cuban experience

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Abstract. The Cuban regulatory authority has been working during several years for the fostering and development of a high Safety Culture level in nuclear activities in the country. As starting point to achieve this objective the assessment of the Safety Culture level in the regulatory authority performance was considered an important issue. For this purpose a preliminary diagnosis was carried out by means of a national survey that allowed identifying some areas of the regulatory activity that required improvements in order to achieve a higher Safety Culture and to immediately implement appropriate actions. Two of the most important actions undertaken were: the statement of the regulatory authority Safety Policy which governs and determines the performance of this organization and its staff and also the implementation of a new interaction practice at top level between the regulatory authority and the utilities of the nuclear sector through the Annual Regulatory Conference. The present paper summarizes these two introduced practices into the Cuban regulatory activity.

1. Introduction

The fostering and development of a Safety Culture in the Cuban nuclear program have been a purpose of the regulatory authority after the appearance of this concept as a result of the investigations of the accident in the Chernobyl Nuclear Power Plant, in the former Soviet Union. From the beginnings the Cuban regulatory authority understood the role that it should play in the creation of a national climate that foments and develops the Safety Culture in all the organizations involved in the Cuban Nuclear Program. For this reason first efforts were focused toward the assessment of Safety Culture in the regulatory authority styles and work methods. To achieve this objective a revision of the available information on Safety Culture was made and the steps to be executed were determined.

Based mainly on the documents published by the International Atomic Energy Agency (IAEA) [1, 2], a survey was organized to know the opinions of specialists and managers of the regulatory authority and of the utilities with regard to essential topics of safety and to regulatory authority performance during the fulfilment of its task: regulations, licensing, inspections, enforcement, accident investigation and dissemination of safety information, among others. This poll, carried out at national level [3] resulted in a valuable information that allowed identifying aspects of the regulatory performance that could be improved to achieve a strong Safety Culture.

2. Statement of the Safety Policy of the Cuban regulatory authority: the first step.

As a result of the national survey [3] it was obtained that more than 70% of those interviewed persons had not a clear understanding of the roles and responsibilities of the regulatory authority with regard to safety and more than 56% did not know the Safety Policy of this body. For that reason the first action undertaken was the formulation of a public document with the Statement of the Cuban regulatory authority Safety Policy. This document openly defines the regulatory authority commitment to achieve a high safety level during the use of nuclear energy inside the national territory and it also determines the framework, which governs the performance of this organization and its staff.

The main aspects included in the Statement of Safety Policy are:

(a) *Organization commitment to safety,* aimed at ensuring the safety of personnel, public and environment due to possible risks of the use of nuclear energy. This commitment constitutes the basis for its performance as organization and for its decisions that have fundamentally a preventive character This should be reflected in its style and work methods in regulatory activities like:
   — establishment of legal and regulatory framework
   — licensing process
   — inspections and enforcement
   — research and development
   — experience exchange on safety topics
   — periodic corporate self-assessment
   — international relations
   — training of human resources

(b) *Managers' Commitment to safety* that defines the styles and attitudes that should characterize their acting to achieve a high Safety Culture. Also it defines their responsibility with the creation of an organization climate that propitiates the development of that culture in each one of their subordinates and in the whole organization.

(c) *Personnel commitment to safety* that describes the behaviour that should characterize specialist's performance in their regulatory functions reflecting an appropriate Safety Culture.

(d) *Ethics and Competence,* that emphasizes the need for managers and specialists of the regulatory authority to have safety as their overriding priority.

(e) *Interaction between the regulators and the institutions using the nuclear energy,* that defines the basis that should govern the interaction of the regulatory authority and it personnel with the rest of the Cuban institutions that use the nuclear energy. In this interaction should prevail a favorable climate to safety, a mutual respect and trust based on the recognition of the responsibilities and functions with regard to safety that correspond to each part.

(f) *Commitment to the Public*, to maintain an open communication with all the institutions and members of the Cuban society. It should contribute to the development and maintenance of a public trust on regulatory authority actions.

(g) *International Co-operation,* that expresses the will to actively cooperate and participate in regional and international activities related to safety, with special emphasis on the activities promoted by IAEA.

This document was established in 1998 by Resolution No. 11/98 of the Director of the National Center for Nuclear Safety. It has been broadly disseminated through publications, events and meetings with the institutions of the nuclear sector.

At present, as part of the National Program for the Fostering and Development of a Safety Culture in nuclear activities in Cuba, the Safety Policy is under revision by means of surveys and interviews. This will allow identifying possible aspects of improvements in a permanent effort to contribute to a higher Safety Culture of the regulatory authority.

3. The Annual Regulatory Conference: the second step

The national survey on Safety Culture [3] mentioned above reflected that more than 50% of the interviewees considered that the contacts and working meetings between the utilities and the regulatory authority on safety topics should be more frequent. Near 74% had not a clear understanding about communication lines to contact with the regulatory authority and also about other regulatory issues.

To contribute in the solution of this situation, the regulatory authority introduced into its work style a recognized good practice [4] with the aim at providing the nuclear sector with an open and effective means for the information exchange and feedback on safety topics. This new kind of contact has been named the Annual Regulatory Conference (ARC) and it was defined as follow:

"It is a top-level annual meeting between the Cuban regulatory authority and the Organizations using sources of radiation for presenting information and exchanging views on safety topics such as new regulations and the most frequent problems found in the different practices, based on the recent results of licensing, inspections and radiological events."

In order to meet the purpose of these meetings, its main characteristics were previously defined:

(a) They are requested to participate the top-level managers of bodies and institutions of the nuclear sector (decision-makers), because they can have an important influence on Safety Culture of their respective organizations. This is essential for the success of these meetings but some difficulties have been existed due to the tendency of some managers to send only the Radiation Protection Officer.
(b) In fact, this meeting is short in time and scheduled so to facilitate the attendance of as many managers as possible.
(c) The meetings consider several safety topics or are focused on just one current issue.
(d) There is a Central Conference Report that is the basis for discussion. This report is prepared by the regulatory authority or by any other of the participating organizations in accordance with the central topic of the ARC. This report is send in advance to all of the participants to achieve a better preparation of the assistants and higher quality of the debates.
(e) The meeting promotes an open discussion of both technical and procedural or methodological issues.
(f) Responsibility for the problems discussed in the ARC are not sought from any of the participating organizations. The results of the meeting discussions in no way become an obligation for any of the participating organizations.
(g) Lectures on the most relevant issues or trends, national or international, related to safety, are presented at the end of each Conference. This way the regulatory authority contributes to disseminate this information amongst managers and decision-makers.
(h) A poll of the type PNI (Positive, Negative, Interesting) is taken from the participants to know their opinions, in order to enhancing the future ARCs.

The first ARC was carried out in February 2000, with a favorable acceptance on the part of the participants. The second was carried out in May 2001. Both ARCs discussed the situation of the radiological safety in national facilities through the results of the licensing, inspections, new regulations and other related topics. For special lectures topics like "Analysis of radiological incidents and the lessons learned", "Role of the management in safety", "Control

of the Sources of Radiation" and "Project for the National Prize of Radiological Safety" were chosen. Both Conferences had a high participation of managers, although it is still necessary a wider attendance. The third ARC is foreseen for June 2002 that will be focused on radiological safety in medical use of source of radiation.

4. Conclusions

The strategy followed by the Cuban regulatory authority to contribute to the creation of a national climate for the development of Safety Culture in nuclear sector starting from it own Safety Culture assessment has had an important effect on personnel of the regulatory authority and on the whole nuclear sector. This process has allowed a wider knowledge of the Safety Culture related issues and the introduction of practical methods that enhance the regulatory performance. At present the regulatory authority continues working to detect other possible areas of improvement and to begin new actions through the National Program for the development of Safety Culture in nuclear activities in Cuba.

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Assessment of Safety Culture: Changing Regulatory Approach in Hungary

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Abstract: Hungarian Atomic Energy Authority (HAEA) is changing its inspection practice and assessment methods of safety performance and safety culture in operating nuclear facilities. The new approach emphasises integrated team inspection of safety cornerstones and systematic assessment of safety performance of operators.

1. Introduction

Regulatory assessment of the improvement of safety culture in operation of nuclear installations requires new methodologies and evaluation techniques from Regulatory Bodies. HAEA is implementing a new inspection philosophy following the recommendations of an International Regulatory Review (IRRT) mission and the RAM-G project of the European Union in order to provide a good basis for assessment of safety culture.
Inspection and assessment have been governed by detailed internal guidelines in the framework of HAEA's Quality Management System. The guides cover following areas:

- core inspection program for planned inspections of operation, maintenance, refuelling, technical support etc. (elements of the earlier inspection program)
- integrated team inspection program for new, general inspection areas
- safety indicator evaluation and assessment program
- new event investigation program (under development).

This paper introduces the new elements of the inspection program.

2. Integrated team inspections

- Integrated team inspection program was introduced in 2001 as implementation of the following IRRT-recommendations: strengthening of the inspection department, utilisation of the corporate knowledge, implementation of a middle term inspection plan, inspection experience feedback etc.
- Mean features of the program are as follows:
  - detailed guidance for preparation, execution, documentation and utilisation of inspection results
  - 3 inspections per year
  - 12 selected topics (average inspection period: once in 4 years – rearrangement between topics is possible)
  - inspection time:1 week with 6–8 participants from all departments of HAEA
  - "mild" enforcement (An evaluation report is sent to Licensee within 3 weeks after the inspection. A response with the intended corrective actions is expected. Regulatory actions are taken on the base of the aforementioned documents.)

- Inspection topics for 2001–2002:
  - Operations management
  - Documentation handling
  - Strategic maintenance planning
  - Waste management
  - Fire protection strategy
  - Safety analyses

- An example of the integrated inspection: operations management:
    - 12 areas of inspection were identified: external influences, goals and strategies, management functions and overview, resource allocation, human resource management, training, co-ordination of work, organisational knowledge, proceduralization, organisational culture, organisational learning, communication.
    - A questionnaire of about 80 items was prepared for the inspection, which is going to be a guide for inspection of the management self-assessment required by the Requirements for Quality Assurance.
    - Typical findings of the inspection
        a) The Licensee has no plans for substitution of important subcontractors
        b) The list of positions important to safety is not complete – it only consists of shift personal.
        c) No strategic plan exists for preventive maintenance program.
        d) There exists shortage of personnel at the Safety Directorate and at the Technical Support Directorate.
- Licensee's response: the Licensee agreed most of the findings and sent a proposal for corrective actions.
- HAEA actions: The proposal was agreed with, some remaining activities were prescribed to the Licensee.

3. Operational Safety Performance Assessment

- The program relies on all relevant information gathered by HAEA:
- results of inspection activities (including assessment of databases through on-line access to computer network of the Licensee),
- quarterly, annual and other regular reports of the Licensee,
- event investigation reports and their analyses,
- results of evaluation of licence applications,
- results of Licensee's self-assessment including its own safety performance assessment program.

- The structure of the program is based on the IAEA-TECDOC-1141 recommendations.

- HAEA tried to collect its own set of performance indicators (PI). PI used by the utility are considered as supplementary information for the HAEA.

- Every specific indicator (the lowest level of the system) has evaluation criteria for ranking it in green, yellow or red field. The meaning of evaluation criteria are as follows:
- green: everything is "ok", no deviations
- yellow: small deviations identified within the approved limits or conditions
- red: deviations exceeded the approved limits or regulatory expectations— there is a need for corrective actions from the Licensee or Regulator.

- Strategic indicators are painted according to the colour and trend of their specific PI (trends are established for the last five years).

- Overall indicators are not coloured. Their assessment takes in consideration not only PI values but also other information gathered by HAEA.

- Overall indicators are collected in three safety attributes: characteristics of smooth operation, risk characteristics and safety attitude of operation. Safety attributes have a rather detailed evaluation with recommendations of the HAEA for corrective or improvement measures. HAEA understands that safety culture can be assessed only by both quantifiable and non quantifiable characteristics, and no one of them can be nominated as a single mark of safety culture.

Current situation

- A safety performance assessment manual has been elaborated. It identifies
    - the purpose of every PI,
    - the methodology of calculation,
    - the source of input information,
    - the evaluation criteria,
    - the responsible person for obtaining or confirming the input information,
    - the responsible person for evaluation,
    - the documentation requirements,
    - the date of introduction of the PI (some of them will be introduced only after having reliable input information by the HAEA)

- The tasks (the indicators) were distributed among the whole staff of the HAEA and a team leader was appointed.

- The first official report on 2001 year was issued recently. HAEA intends to issue the report every year in April-May in order to give an explanation for the Licensees about the regulatory evaluation of their safety performance.

- Only the safety indicators of the Paks Nuclear Power Plant have been elaborated yet, but HAEA is planning to introduce a set of safety indicators for research and training reactors and also for the dry spent fuel storage facility.

- The results of the first-year-report should be handled very carefully. Measurement of safety performance should be in accordance with goals of whole performance assessment: improvement of performance, identification of weaknesses etc. That's why both quantitative and qualitative **comparison** of safety performance indicators of the Licensee with it's similar indicators at an earlier assessment or with widely recognised good practices are necessary. (In other words: some times not the values are most important but the trends.)

- However there is a significant finding in the first-year-report on safety performance evaluation of Paks NPP: the safety indicators of smooth operation and the risk characteristics are very good, but in the third area (safety attitude of operation, which is part of safety culture) there are numerous "red" indicators and both the Licensee and the Regulator have to investigate this results and take necessary measures.

4. New approach to event reporting and investigation

- A new event investigation guideline is under preparation at the HAEA. There are some new features in our regulatory approach to this sensitive inspection area.

- HAEA will not directly participate in the International Nuclear Event Scale rating of operational events. It will issue the Hungarian version of INES manual and prescribes to follow its instructions in rating of events.

- At the same time HAEA elaborates it's own event rating scale with more emphasis on INES-0 level, on human errors and management issues in operational events. This new regulation is going to be introduced in 2003–2004.

SAFETY CULTURE IN NUCLEAR INSTALLATIONS – THE ROLE OF THE REGULATOR.

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ABSTRACT: Safety culture is an amalgamation of values, standards, morals and norms of acceptable behavior by the licensees, Radiation workers and the Regulator.
The role played by a Regulator in establishing safety culture in a nuclear installation is that related to Authorization, review, assessment, inspection and enforcement. The regulator is to follow the development of a facility or activity from initial selection of the site through design, construction, commissioning, radioactive waste management through to decommissioning and closure. He is to ensure safety measures are followed through out the operation of the facility by laying down in the license conditions of controlling construction of nuclear installations and ensuring competence of the operators.

INTRODUCTION:

The long-term management of safety, calls for approaches that go beyond simple adherence to established design standards and operating procedures, but requires the development of a comprehensive " safety culture" at all levels of an organization with visible and consistent leadership from senior management [1]. Safety culture is the assembly of characteristics and an attitude in organizations and individuals, which establishes as an overriding priority nuclear installations safety, receives the attention warranted by their significance. This is also an amalgamation of values, standards, morals and norms of acceptable behavior, by the licensees, Radiation workers and the Regulators.

Regulatory inspections and enforcement are essential tools for monitoring nuclear safety at installations. The safety culture in this case is of three stages. Compliance- based regulation, performance based regulation and process based regulation. The licensee is required to comply with safety objectives and the regulator to observe trends in safety, and to provide prescriptive standards and requirements for operators to follow and to penalize non-compliance.

1. LICENCING.

The construction and operation of nuclear installations all over the world are subject to a number of laws and regulations. This requires that a construction license be obtained before an operating license. The regulator must lay down in the license the method of controlling whether the nuclear installation is being constructed according to the legal requirements and the condition of the license [2]. The facility is not to be licensed if it does not meet basic requirements like, putting in place a person responsible for radiation safety, qualified personnel to operate the facility, appropriate signs, symbols, alarms, safety assessment report detailing foreseeable incidents and their consequences.

The operating license must impose the condition that nuclear installation may not be operated unless the general regulations concerning operation of the facility and conduct of the personnel have been established. In Kenya, the licensing of nuclear installations is carried out by the Radiation protection Board that is established under the Radiation Protection Act Cap 243 Laws of Kenya [3]. The licensees are responsible for setting up and implementing the technical and organizational measures that are necessary for ensuring the protection of the radiation workers and the public.

2. INSPECTIONS.

Inspections both announced and unannounced are to be done on continuous basis to ensure that the internal safety checks of nuclear installations are functioning satisfactorily. The regulator should be empowered to suspend the operation if conditions for granting a license are not met. In Kenya, the regulator who is the Radiation Protection Board is empowered by the Radiation Protection Act to carry out inspections of nuclear installations. Section 7(3) of the Act states that, " The approved nuclear installations shall be inspected by or on behalf of the Radiation Protection Board once a year in order to ensure that proper radiation protection procedures are followed when using the building facilities together with use of appropriate warning signs."[3].

Compliance monitoring provides the assurance that radiation safety requirements are being met and the opportunity to enforce corrective action. This can take the form of on site inspections or regulatory mechanisms that require the user to notify the regulator in specified situations e.g. equipment malfunctions and actual or suspected overexposures. [7]. One of the most positive components of compliance monitoring is on the site inspection that is often the principal means for direct personal contact between the users and the regulators. An adequate inspection programme can be based on the use of 'Checklists' that are formulated from predominantly prescriptive regulations. An attitude of openness and co-operation should be fostered between the regulated legal persons and the regulators, which includes facilitating access by inspectors to premises and to information. [6].

3. RADIOACTIVE WASTE MANAGEMENT.

The regulator is to be empowered to enhance legal requirements related to all aspects of radioactive waste generated from a nuclear installation. Prior to the granting of an authorization for activities that generate radioactive waste or for radioactive waste management facilities, the regulator shall ensure that interdependencies among all steps in the generation and management of radioactive waste are appropriately taken into account. [4]. He shall also ensure that appropriate consideration is given to making provision for the necessary capacity and storage of the anticipated radioactive waste. He should also ensure that the processed waste and waste packages are compatible with the anticipated nature and duration of storage, with account taken of the strategy for the regular surveillance of waste and the need for retrievability of waste from storage for further processing or disposal. The regulator is to specify the value of dose constraints although the licensee may additionally specify them in their internal rules. [6].

4. ENFORCEMENT.

A strong and effective enforcement programme is a key component of the regulatory infrastructure for assuring the success of regulatory objectives. The regulatory authority must have sufficient authority to impose sanctions that will deter deliberate or careless deviation from the regulatory standards.

The main functions of the regulator are carried out within and are dependent upon the national legal framework. The regulatory process continues through out the life cycle of a facility or the duration of an activity. Enforcement actions are designed by the regulator to respond to non - compliance with specified conditions and requirements. The action is to be commensurate with the seriousness of the non-compliance. Thus there should be different enforcement actions, from written warnings to penalties and ultimately withdraw of an authorization [5]. In all cases the operator shall be required to remedy the non-compliance, to perform a thorough investigation in accordance with an agreed time scale, and to take necessary measures to prevent recurrence. The regulator is then to ensure that the operator has effectively implemented any remedial actions.

Enforcement can only be accomplished by instilling the enforcement ethic within the regulator. He should have thorough knowledge of the legislation and regulatory framework of the country and be familiar with the relevant international standards. The establishment of a published enforcement policy will put the licensees on notice about the possible sanctions and penalties for failure to comply with regulatory requirements. [7]. A published policy also benefits the regulator by providing guidance and justification for enforcing the standards and requiring prompt and effective corrective actions.

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Managing for Safety and Safety Culture within the UK Nuclear Industry. A Regulator's Perspective

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Abstract. This paper outlines the basis of the legal system for the regulation of health & safety at work within the United Kingdon (UK), and in particular, the regulation of the nuclear industry. The framework, formulated by the regulator, which has been published as a practical guide for directors, managers, health and safety professionals and employee representatives for the successful management of health & safety is explained. This guidance, however,concentrates, to a large extent, on management systems and only addresses in part the types of issues, such as behaviours, values, attitudes and beliefs which contribute to the safety culture of an organization. The regulator of the UK nuclear industry has considered research, and other work, carried out by several organizations in this area, notably the Advisory Committee on the Safety of Nuclear Installations (ACSNI) and the International Atomic Energy Agency (IAEA), and produced its own framework for managing for safety at nuclear installations. As a regulator, the Health and Safety Executive (HSE), and its inspectorate responsible for regulation of the nuclear industry, HM Nuclear Installations Inspectorate (HMNII), are not the appropriate organization to assess the safety culture of an organization, but positively encourage organizations to both carry out this assessment themselves and to monitor their performance. To this end, HSE has developed, and made available, the Health and Safety Climate Tool which is aimed at providing organizations with information which can be used as part of a continuous improvement process.

Regulation of health and safety in the UK nuclear industry

In the United Kingdom the primary legislation governing the health, safety and welfare of both workers and the public, from activities at work, is the Health and Safety at Work Act 1974. For the vast majority of work activities, the regulation of the requirements of this Act, and the associated secondary legislation, is the responsibility of the Health and Safety Executive (HSE) which is a non-Departmental Government body. Regulation of the nuclear industry is the responsibility of HSE's Nuclear Safety Directorate (NSD) whose operating arm is HM Nuclear Installations Inspectorate (HMNII). The legal framework within which HMNII regulates is provided by the Health and Safety at Work Act 1974, the associated relevant statutory provisions of the Nuclear Installations Act 1965, and other relevant Regulations. Under this legislation, no site may be used for the purpose of installing or operating any commercial nuclear installation unless a nuclear site licence has been granted by the Health and Safety Executive. HMNII is that part of the HSE responsible for administering this licensing function. The Acts lay down only general requirements for the safety of nuclear installations. Specific requirements are a matter for HMNII to formulate and apply. These take different forms, for example, conditions, binding in law, which may be attached to the site licence. Additionally, guidance is set out in the *Safety Assessment Principles for Nuclear Plants*[1] which HMNII has developed for its own internal use to assess the adequacy of licensees' safety cases.

Managing for health and safety and safety culture.

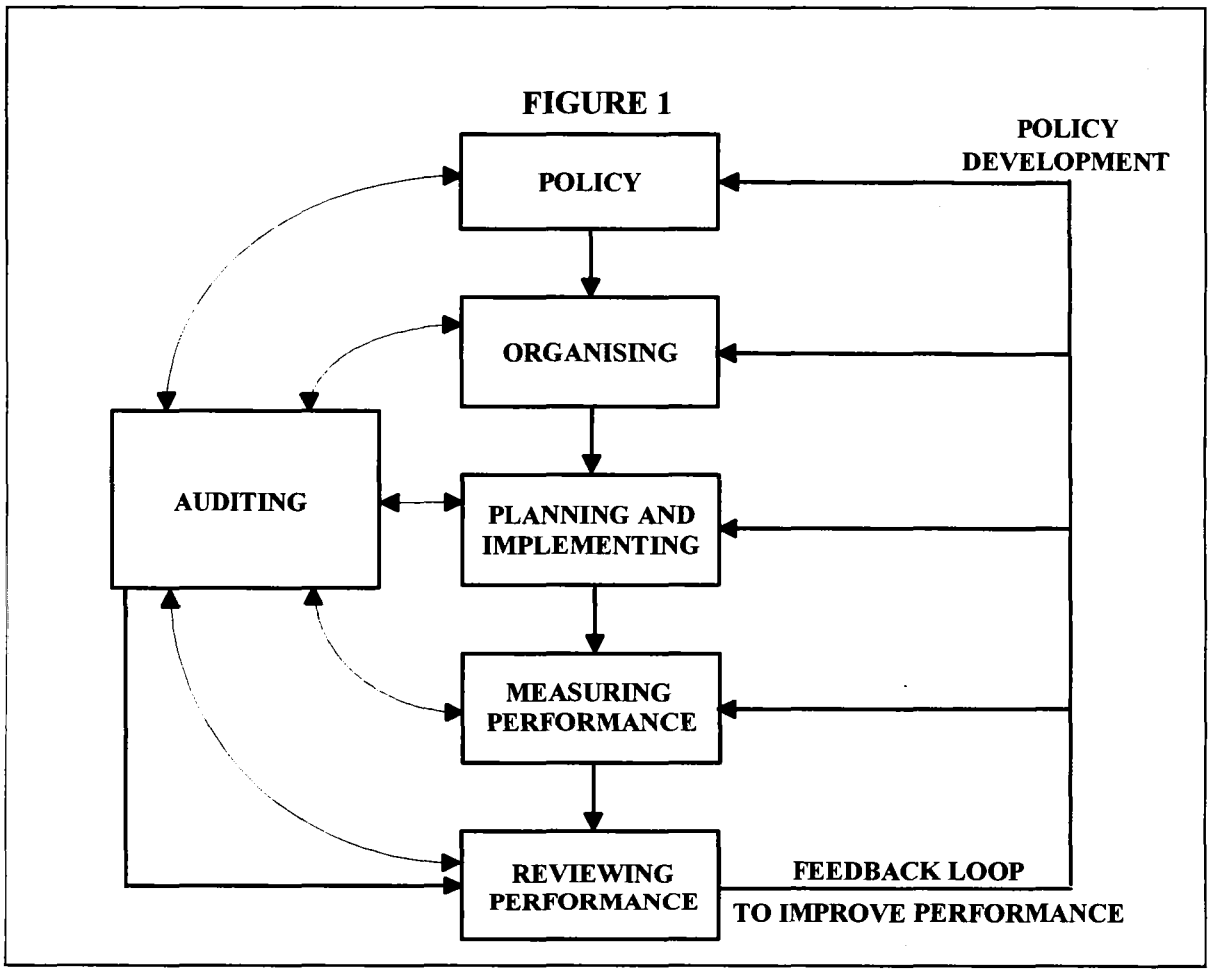
It is now widely accepted that an organization needs to have in place an effective management process if the risks to health, safety and the environment from its activities are to be controlled effectively. In 1991 the UK regulator, HSE published a Guidance Document HS(G)65

Successful Health and Safety Management[2] and the second edition was published in December 1997. This describes good practice in managing health and safety based on the model shown in Figure 1. Together with the requirements of the relevant statutory provisions, the framework described in HSG 65 provides the basis for the approach which HSE inspectors take when auditing an organization's arrangements for managing health and safety. HSG 65 is referenced in HSE's guide to the Control of Major Accident Hazard Regulations 1999 (COMAH) which implement the Seveso II Directive in Great Britain.

The performance of an organization's arrangements for managing health and safety is ultimately and critically dependent upon people. Any group of people develops shared attitudes, beliefs and ways of behaving. These form a culture that is more than the sum of its parts. In a safe organization, the pattern of shared assumptions puts safety high in its priorities. New events and decisions are then handled in the light of that priority, by whatever individual they affect. Thus the commitment to, and the style and proficiency of, an organization's safety programmes matters as much as the formal definition of those programmes. This commitment and style are the product of individual and group values, attitudes, competencies, and patterns of behaviour, and it is suggested that this is used as a working definition of "safety culture". Without this culture, an otherwise effective safety department is no guarantee of a low accident rate. If the problem of reducing hazard is regarded as the responsibility of others, then that attitude may be positively dangerous. For the organization to be safe, every part of it must be concerned with safety. Many organizations have learnt that there are limits to what can be achieved in health and safety solely by addressing hardware/technological solutions. Similarly, the introduction of safe systems of work and operating rules and procedures are of little use if people do not work in accordance with them. Increasingly organizations are coming to recognise that they must address the specific part which human factors has to play if high standards of health and safety and a positive safety culture are to be achieved and maintained.

Managing for safety in the nuclear industry.

In the nuclear industry, the social, political and financial implications of failing to manage safety effectively are considerable and add a further dimension to the importance of health and safety. At nuclear licensed sites the regulatory control system and the way licensses tend to organize corporate and site responsibilities differ from the methods used in general industry.



Several publications have addressed the particular needs of the nuclear industry and described management processes and activities considered to make up an effective management of safety system and to promote the development and maintenance of a good safety culture. These include *Organising for Safety*[3] (Advisory Committee on the Safety of Nuclear Installations report), *The Safety of Nuclear Installations*[4] (IAEA NUSSAG report) and *Safety Culture*[5] (IAEA INSAG report).

The conclusion drawn from the publications mentioned above, coupled with considerable regulatory experience of operating the licensing system gained by HM Nuclear Installations Inspectorate, and the way in which the regulation of the nuclear industry has evolved, is that the management of safety systems for nuclear licensed sites is entirely consistent with the basic management steps of the model in *Successful Health and Safty Management*[2] but that special emphasis needs to be given to particular elements within these basic steps. HSE's Nuclear Safety Directorate (NSD), which incorporates HMNII, has further developed the HSG 65 model and placing a greater emphasis on planning and implementation, the assessment of risks, the control of risks and the application of operational controls, has produced the publication *Managing for Safety at Nuclear Installations*[6].

It is acknowledged that one of the major influences in shaping people's safety related behaviour is the prevailing health and safety culture of the organization in which they work. There have been many definitions of the term "safety culture" and it remains the subject of numerous academic papers. One of the definitions of health and safety culture which has received widespread acceptance is that from the UK's Advisory Committee on the Safety of Nuclear Installations in their third report "Organising for Safety"[2] .

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

The term health and safety climate is often used to describe the tangible outputs of an organization's health and safety culture as perceived by individuals or work groups at a particular point in time, i.e. "the way things are around here". For example how people view the importance their organization gives to health and safety relative to quality or production, or how committed they believe their superiors or peers are to health and safety. The health and safety climate provides a practical focus for measurement and can provide some insight to the organization's health and safety culture. Many organizations have now reached a stage of maturity in their approach to the management of health and safety where they feel ready to tackle the complex area of health and safety culture/climate.

Health and safety climate tool.

As the regulator of the UK nuclear industry, HMNII is not the appropriate organization to actively measure the safety culture or climate of a regulated organization, not least of all because the organization, in line with the management model in HSG 65, should have its own system for measuring performance. HMNII does however, positively encourage licensees to assess and monitor their safety culture. HSE, following intensive research and development work, has produced a software-based tool for organizations to use to assess aspects of their health and safety climate. The tool consists of a 71 statement employee questionnaire and enables easy analysis of the data produced. The tool includes computer software and a user manual which describes how to use it. It has been designed to be used in a Windows environment. The primary purpose of the tool is to promote employee involvement in health and safety and to provide information which can be used as part of a continuous improvement process. It was made available to the public in December 1997 and to date, over 500 organizations across all employment sectors including high hazard industries have made use of it.

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Experiences in assessing Safety Culture

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Abstract. Based on several Safety Culture self-assessment applications in nuclear organisations, the paper stresses relevant aspects to be considered when programming an assessment of this type. Reasons for assessing Safety Culture, basic principles to take into account, necessary resources, the importance of proper statistical analyses, the feed-back of results, and the seting up of action plans to enhance Safety Culture are discussed.

Introduction

Safety culture rests on those who work in the organisation, built up by the way safety has been and is practised. It can have a high or low level, but it exists since the start of the organisation activities and can always be enhanced. In general, safety conditions and procedures are appropriately set in the initial stages of a nuclear project. All what is required after its implementation is to maintain and update them, with continuous monitoring efforts, at relatively low costs, to check that degradation of these conditions and procedures does not occur. This process is at the base of a safety culture assessment and enhancing programme [1].

Safety culture assessment surveys carried out in different organisation, by exploring the perceptions of the employees regarding their working conditions and managerial environment, allowed objective findings on whether the safety doctrine, that the organisation claims to apply in everyday activities, is really carried out [2] [3] [4] [5].

Reasons for assessing safety culture

The decision to implement a safety culture enhancement programme, or even an assessment of the current situation of an organisation, has many reasons such as:

- organisational changes of large impact in the management of personnel,
- recurrence of minor events, impairing the smooth operation of plant facilities,
- relaxation in quality assurance measures, leading to frequent reworking and replacement of materials or equipment,
- coexistence of different technologies in the same site, requiring special actions for blending into a common culture, the different safety conditions and procedures coupled to such technologies,
- reaction to environmental groups criticism related to safety conditions in the organisation.

Some of these aspects, or a combination of them, can provide a basis for concern regarding the possibility of degradation of the safety culture level of an organisation. This, and the experience of other companies having endured radical consequences due to safety culture degradation, prompted in some of the surveyed organisations, a decision for conducting an assessment of their safety culture.

Basic aspects

Safety culture, as in any cultural expression of human activity, depends on particular aspects related to social environment, historical background, and accepted values. Thus, it may not be meaningful to compare in absolute terms safety culture levels between two different organisations. However, it is very important to have a reference status from which an

organisation can start a process of safety culture enhancement. Through an assessment of its current safety culture level, the organisation will be able to find out where weaknesses exist, set up a plan to correct them and, in due time, check the new level of safety culture reached, to confirm if the measures taken have been effective. In this way, there is no comparison with other organisation's safety culture levels; the only possible comparison is between situations of the same organisation in two points in time, by using same assessment processes.

To successfully implement a safety culture assessment, some basic principles need to be observed:

- Since the start up of an organisation activities, the assessment of safety culture should be the concern of the senior management, because it represents a tool for the management of the organisation safety.
- As there is always the risk of unsatisfactory results, mainly in the case of an initial assessment, it is very important that senior management be involved in the decision to proceed with the assessment, so that they will stand behind any findings that may appear.
- The assessment can focus on a specific part of the organisation, for instance, on the operational area. It has to be understood that safety culture permeates the whole organisation (i.e. Operations rely on procurement of materials and equipment, which could be performed by the area of Administration, on manpower qualification and training which could be provided by Personnel, on third-party services to be contracted by the Commercial area, etc). Thus, when making partial assessments, it is necessary to have a good understanding of where area boundaries lie. Also, because employees in the particular area being assessed may feel discriminated against, when such an exercise is performed, special care has to be taken to provide them with a clear explanation of the objectives of the assessment in their particular area.
- A self-assessment has the advantage of creating a process within the organisation allowing for continuity of application, as well as for creating a complete internal infrastructure of expertise for its implementation and follow up. Also, with respect to safety issues that were observed in some cases, one of the senior management main concerns was to assure a thorough analysis of results before publishing them. In this respect, it was more suitable to have a self-assessment of the safety culture of the organisation than to do it through external consultants or audits.
- The self assessment body should be a unit representing all company's divisions, in order to produce results accepted by all employees due to its overall representation and unbiased composition.
- It has to be borne in mind that, especially if a self-assessment is being done for the first time, results need to have credibility both internally and externally. It is therefore important to have an independent organisation, with reputed expertise in the field, to audit and endorse the applied methodology and the quality of the assessment performed. Surveys performed in different organisations selected the IAEA for this support, by taking into account its experience in dealing with internationally accepted assessment methodologies and statistical analysis techniques.

Internal and external resources

An assessment of safety culture requires resources of the organisation in terms of manpower, employees' time, publications, meeting places, computer programmes for statistical analysis of results, and external resources either in terms of experts, if the assessment is done by outsiders, or in terms of auditing support, if the assessment is self-performed.

As already mentioned, in the case of a self-assessment, a team has to be established with members of different professional backgrounds related to the different disciplines involved in a safety culture assessment (in one case, the team was made up of nuclear safety engineers, nuclear physicists, operators training specialists, psychologists, sociologists, personnel management specialists, mathematicians and statistics technicians). This team has to undergo a special training on the concepts of safety culture, on methodologies to assess safety culture and on interviewing techniques. Some of its members would need training on the specifics of statistical handling of data for this type of research. To perform the assessment this team should be given the authority to reach all areas of the organisation and work as a task force acting under a manager specially appointed by the top management.
In order to have an employees' universe large enough to extract meaningful conclusions, the organisation could consider different approaches to obtain their responses:

- survey by using questionnaires; this has proved to be one of the preferred methods of data gathering because of its easy way to get a large number of replies. In this case, employees can fill the questionnaires after working hours or, as in some of the cases considered, during working hours which assured a rather large universe (in surveys performed using this approach, the range of responses was between 73 and 82% of the whole population under study). This approach involved senior management approval, due to its cost implications (about one-hour working time for each employee).
- individual interviews by selecting a sample of the total population, requiring a special selection process to identify groups to represent the whole organisation.

Tools for statistically analysing the results should be made available to the assessment team, like computer programmes for analysing profiles, means, standard deviations, significant deviations, etc.

Communication with the whole of the employees population to explain the importance and scope of the assessment, and its results, is another example of other activities the assessment team will need to perform. This will be translated in information letters, questionnaires, publication of results to all employees that the organisation would need to consider in the assessment budget.

In the case of an assessment made by external organisations, many of the above resources will be included in the service contract to be signed with such organisation. However, a minimum team of the organisation employees, to act as a liaison group, will always be required. Training of this team, along the lines described for the self-assessment case, will also be necessary.

Statistical analysis
Statistical analysis can give a diagnosis of deviations of certain safety culture components, as a function of different background conditions of employees, or as related to specific units of the organisation. These deviations are the basis for future actions of safety culture improvement.
The statistical analysis is a key element to reach meaningful conclusions. It requires careful judgment on the way survey results are handled. In one occasion, the statistics of the results was based on a grouping of data that concealed the existence of weak areas. This was due to a kind of compensation between high and low marks by such grouping. A different way of grouping the results allowed to find out clear indications of weak areas, and this by using the same survey data bank

Feed-back to the organisation

Senior management is informed of the results and may decide to communicate them to all participants of the survey. As in several of the assessments performed, this action helped to respond to expectations of a number of surveyed employees who were sceptical of its results when the process was initiated.

The process of sharing of results is useful to get a feed-back from the surveyed population regarding relevant elements that could have been misunderstood or underestimated.

Action plans

Based on statistically diagnosed deviations and relevant feed-back information, action plans can be developed for application to enhance the safety level found in the survey.

The action plan should result from consensus of the managerial corps of the organisation, as it is this body who will implement it and apply the corrective measures that are proposed.

The safety culture team's role is to report on results and deviations detected, and on relevant feed-back information gathered from the surveyed population, for the managers to agree on the set of measures to be applied.

This set will constitute the organisation action plan to be submitted to the senior management for approval. This plan should be applied during a reasonable period of time (i.e. 18 months) for the measures to be implemented and turn out the desired results.

The number of measures shall not be too large as it may lead to an action plan too difficult to implement or manage.

Conclusions

A good Safety Culture in an organisation translates itself into sound safety practises that contribute to run its production smoothly, according to its strategic planning.

Safety Culture assessment is a managerial tool allowing to recognize where areas of improvement are required in terms of safety practise. Self-assessment projects applied in several organisations demonstrated the feasibility of applying such a tool and of implementing plans for enhancing Safety Culture. A great deal of the success of these applications was based on the credibility of their results, reached through the endorsement of the IAEA on applied methodologies and the quality of the assessment performed.

An efficient way for obtaining reliable results is a survey on the perceptions of the organisation working population regarding how safety practise is being performed in their everyday activities.

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Statistical analysis applied to Safety Culture self-assessment A survey example

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Abstract. Interviews and opinion surveys are instruments used to assess the safety culture in an organization as part of the Safety Culture Enhancement Programme. Specific statistical tools are used to analyse the survey results. This paper presents an example of an opinion survey with the corresponding application of the statistical analysis and the conclusions obtained. Survey validation, Frequency statistics, Kolmogorov-Smirnov non-parametric test, Student (T-test) and ANOVA means comparison tests and LSD post-hoc multiple comparison test, are discussed.

Introduction

One of the main steps on a Safety Culture Enhancement Programme is the assessment of the safety culture in the organization. A tool used to assess the safety culture of an organization is the performance of an opinion survey of important characteristics related to it. Statistical handling of survey results gives the detailed information on the strength and weakness of each safety culture characteristic in the organization. The partition of the population surveyed into background conditions such as 'Area of activity', 'Time experience', 'Education', 'Age' and 'Sex' is used in the survey analysis. Statistical analysis of the survey data on these background conditions provides clear statistical results on which actions for enhancing safety culture can be readily set up.

To demonstrate the statistical analyses, a fictitious organization with 500 employees is used. The surveyed population is 250, 50% of the total amount of employees. The survey is composed of two characteristics here called characteristic 1 and characteristic 2. Characteristic evaluation ranges from 0 to 4.

In section 2 the validation of the survey "representativeness" (its condition to represent the whole universe of the research) is presented. Section 3 shows the application of descriptive and non-parametric statistical tests on the total survey. Section 4 presents the application of means comparison and post-hoc multiple comparison tests on the background conditions. Finally, in section 5 conclusions of statistical analyses application on Safety Culture self-assessment are given.

Representativeness of the survey

The total survey is considered representative of the organization if, at least, 30% of the total amount of employees is surveyed. The representativeness of the survey for each background condition is validated comparing the survey distribution with the employees' distribution in the respective categories of the background condition. The distributions must be consistent for all categories in each background condition. If, for any background condition, the survey is considered not representative, this background condition shall not be used for the assessment of the organization safety culture.

Table I shows an example of a valid and an invalid survey for the background condition 'Sex'. It can be noted that the survey distribution compared to the organization distribution for the valid case is similar (89.20% and 11.80% in the survey and 88.60% and 11.40% in the organization, for categories 'Male' and 'Female', respectively) and strongly different for the

invalid survey (98.00% and 2.00% in the survey and 88.60% and 11.40% in the organization, respectively).

TABLE I. EXAMPLE OF A VALID AND AN INVALID SURVEY FOR BACKGROUND CONDITION 'SEX'

Sex	Total		Surveyed		Sex	Total		Surveyed	
	No.	%	No.	%		No.	%	No.	%
Male	443	88.60	223	89.20	Male	443	88.60	245	98.00
Female	57	11.40	27	11.80	Female	57	11.40	5	2.00
Total	500	100.00	250	100.00	Total	500	100.00	250	100.00

Total survey statistics

A frequency analysis with mean and standard deviation shall be carried out for each characteristic of the total survey. Standard deviation too high in any characteristic indicates a possible lack of conformity with expected normal distributions. In this case, a Kolmogorov-Smirnov test is applied to compare the survey distribution function to the normal distribution. Small significance values (less than 0.05) indicate that the survey distribution does not correspond to the normal distribution. As a result, statistical analyses on the background conditions shall be applied to those characteristics to find out if the evaluation of the characteristics by the categories of background conditions differs significantly and, if this is the case, where and how.

Table II shows the frequency analysis of the survey example. The high standard deviations for both characteristics indicates that, possibly, the survey distribution does not correspond to the expected normal distribution. In this case, the Kolmogorov-Smirnov test shall be applied.

TABLE II. FREQUENCY ANALYSIS OF SURVEY EXAMPLE

		Characteristic 1	Characteristic 2
Number	Valid	250	250
	Missing	0	0
Mean		3.31	3.00
Std. Deviation		.53	.80

Table III shows the Kolmogorov-Smirnov test applied to the survey example. The results confirm that the survey distribution differs significantly from the normal distribution in both characteristics (significance values less than .05). Specific statistical analyses shall be applied on the background conditions.

TABLE III. ONE-SAMPLE KOLMOGOROV-SMIRNOV-TEST OF THE SURVEY EXAMPLE

		Characteristic	Characteristic
Number		250	250
Normal Parameter	Mean	3.31	3.00
	Std. Deviation	.53	.80
Most Extreme Differences	Absolute	.189	.338
	Positive	.128	.270
	Negative	-.189	-.338
Kolmogorov-Smirnov Z		2.988	5.344
Significance Value		.000	.000

Background condition statistics

Specific statistical analyses are applied on each background condition to determine which categories differ significantly from the others. Significant mean differences, between categories are interpreted demonstrating which category has higher or lower perception of the safety culture than other(s).

Student means comparison, called T-test, is applied on the background conditions with only two categories. Table IV gives the result of the T-test for background condition 'Sex' of the survey example. Levene's test high significance value (greater than .05) for characteristic 1 indicates that the results assuming equal variances for both categories shall be used. For characteristic 2 (significance value smaller than .05) the results not assuming equal variances shall be used. Analysis of T-test results shows that, in characteristic 1, there is no significant difference between 'Male' and 'Female' evaluation (significance value .368). In characteristic 2, however, the results show a significant evaluation difference (significance value .023). The positive mean difference (.039) demonstrates that 'Male' gave significantly higher evaluation than 'Female' for this characteristic.

TABLE IV. T-TEST OF BACKGROUND CONDITION 'SEX' FOR THE SURVEY EXAMPLE

		Mean Difference	Levene's test Significance Value	T-test Significance Value	95% Confidence Lower	Upper
Characteristic 1	Equal variances assumed	.08	.152	.368	-9.11E-02	.25
	Equal variances not assumed			.510	-.16	.31
Characteristic 2	Equal variances assumed	.039	.000	.002	.14	.64
	Equal variances not assumed			.023	5.54E-02	.73

ANOVA means comparison is applied on the background conditions with more than two categories. Table V gives the result of the ANOVA test for background condition 'Area of activity' of the survey example. Results show that, in characteristic 1, there is no significant

difference between the categories (significance value .138). In characteristic 2, however, the results show a significant evaluation difference (significance value .031). For this characteristic, a post-hoc analysis shall be performed to verify which categories differ and how.

TABLE V. ANOVA-TEST OF BACKGROUND CONDITION 'AREA OF ACTIVITY' *FOR THE SURVEY EXAMPLE*

		Sum of Squares	df	Mean Square	F	Significance Value
Characteristic 1	Between Groups	1.556	3	.519	1.855	.138
	Within Groups	68.803	246	.280		
	Total	70.360	249			
Characteristic 2	Between Groups	5.614	3	1.871	3.001	.031
	Within Groups	153.382	246	.624		
	Total	158.996	249			

Post-hoc LSD test is then applied on the characteristic 2 of background condition 'Area of activity', for which ANOVA test has indicated significant differences on categories evaluation. Table VI gives the result of the LSD test for characteristic 2 of background condition 'Area of activity'. Results show that categories 'Operation' and 'Engineering' gave significant different evaluation from category 'Maintenance' (significance values .014 and .020, respectively). Positive means differences demonstrate that 'Operation' (mean difference .30) and 'Engineering' (mean difference .40) gave significant higher evaluation than 'Maintenance' (mean differences -.30 and -.40, respectively).

TABLE VI. LSD-TEST OF BACKGROUND CONDITION 'AREA OF ACTIVITY' FOR THE SURVEY EXAMPLE

Dependent Variable	Area of activity (1)	Area of activity (2)	Mean Difference (1-2)	Significance Value	95% Confidence Interval Lower	Upper
Characteristic 2	Operation	Engineering	-9.74E-02	.577	-.44	.25
		Maintenance	.30*	.014	6.00E-02	.54
		Administration	5.92E-02	.677	-.22	.34
	Engineering	Operation	9.74E-02	.577	-.25	.44
		Maintenance	.40*	.020	6.18E-02	.73
		Administration	.16	.398	-.21	.52
	Maintenance	Operation	-.30*	.014	-.54	-6.00E-02
		Engineering	-.40*	.020	-.73	-6.18E-02
		Administration	-.24	.080	-.51	2.88E-02
	Administration	Operation	-5.92E-02	.677	-.34	.22
		Engineering	-.16	.398	-.52	.21
		Maintenance	.24	.080	-2.88E-02	.51

* The mean difference is significant at the .05 level

Conclusion

Some statistical tests, if appropriately selected and applied, form a very robust tool for analysing any kind of opinion survey. This study gives an example of the application of statistical analyses in the safety culture self-assessment as part of the Safety Culture Enhancement Programme.

The whole path of the analysis is shown from the validation of survey representativeness up to the identification of safety culture perception differences between categories of background conditions.

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Development of Safety Culture
—*A Chinese Traditional Cultural Perspective*

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Abstract. ***Living in a social community, the culture of an enterprise is certainly under the influence of that society. Safety culture of nuclear utilities is the core of the enterprise culture. As a formal expression as defined in INSAG 3 & 4 by IAEA, it as a matter of fact originated from the summing up of the experiences of western nuclear industry, particularly after such epoch-making accidents of Three Miles Island and Chyelnoble. In view of the geographical culture theory, whether or not this conception of western industrial culture will be absorbed and assimilated by Chinese Nuclear Industry is a challenging issue. This is because, on the one hand, Nuclear Power is comparatively speaking a newly developing industry in China and, on the other hand, China has enjoyed an uninterrupted history of traditional culture over five thousand years. In other words, whether the*** **new and alien** ***values will conflict with or be constructively assimilated by our traditional mindset is a critical question to be answered in any development program of safety culture.***

Since Guangdong Nuclear Power Plant (GNPS) under CGNPC has come into commercial operation in 1994, it has made incessant efforts to develop a safety culture with Chinese characteristics. All these efforts have already paid off as demonstrated by the outstanding performance of the plant. In addition, the practices have been successfully applied and innovatively further developed in the construction and operations preparation of Ling Ao Nuclear Power Plant, the second project of CGNPC at Daya Bay. Our experience has proved that so long as we keep an open mind we can learn from the west in one regard and make innovations by applying our traditional culture in developing the safety culture in the other.

During the consultation program of safety culture training text material and the safety culture development symposium, both organized by IAEA in 2001, the author of this article has expressed some of the views on the development of safety culture from the perspective of Chinese traditional philosophy. Some of these views are commented as very constructive and wave-like under the framework of safety culture development program of the Agency. This paper is intended to highlight some of these views with the writer's latest findings. The key points include the following.

1. Revelation from the definition, the nature of safety culture
2. Culture versus substance, the part versus the whole, the basic intention of the development of safety culture
3. Integration of technology and human performance, the main contents of the culture development program
4. Education and coaching by the leaders and managers, the key to the success of safety culture development
5. Upholding both moral forces and regulations, the principal way of developing safety culture

Key Words: **nuclear, safety, culture, Chinese, tradition, characteristics**

1. Introduction

Since 1994 Guangdong Nuclear Power Station (GNPS) has been enthusiastically developing a safety culture with Chinese characteristics. For GNPS the challenge lies in the fact that nuclear power industry is still very young on the one hand, and on the other hand China

enjoys a long incessant traditional culture. The question is how to adapt the modern western safety management philosophy to our living environment without being obsessed by our own traditional understanding and practices, or rather in the processes making the best of those traditions to promote the safety culture of our industry. The practice of the recent years has shown us a very interesting and encouraging revelation, that is, our traditional culture in terms of both philosophy and methodology could be an invaluable bridge to the innovations of safety culture development.

2. Revelation by the Definition

What is culture? It is very difficult to define, especially in such terms as enable the non-philosophers like engineers and mechanics to understand as clearly as a concept of physics or a method of fixing a machine.

In view of the western philosophy, which I don't know much, I recently read in a paper a definition of culture by a British anthropologist, Mr. Edward Burnett Tylor (1832-1917). His definition runs to the effect that culture or civilization is, in a broad sense of nationalities, a complex whole of knowledge, believes, art, morality, customs and the capability and habits of any individual as a social being.
From the view of Chinese traditional philosophy, which is rather a set of how-we-should-live ideas than any kind of ratiocinated models, culture is a concept opposite Nature.
More than 2500 years ago, Confucius, the master of Chinese philosophy said,

> "When natural substance prevails over culture, you get the boorishness of the rustic. When culture prevails over natural substance, you get pedantry of the scribe. Only when culture and substance are duly blended do you get the true gentleman."

Whatever the definitions are, certain characteristics can be derived and the understanding of these characteristics is certainly important to develop safety culture.
First of all, culture is not of biological nature, and thus not the output of instincts, but the result of ***learning, understanding and living harmoniously with nature.*** This characteristic means that ***creative and innovative power of man*** is the key to the success of developing a culture.
Secondly, developing an intended culture is in essence to ***teach and coach people into " true gentlemen"***, or in our terms, the qualified staff of the utility.
In the third place, culture is not ascribed to any particular individual but to a group, a corporation, a community and a nation, and thus culture is of ***social nature.*** This characteristic leads us to the conviction that only until the concepts and values are ***recognized, accepted and practiced by the majority*** of our corporation or utility, we cannot boast of having a substantial culture in our favor.
The fourth characteristic of culture is the fact that it takes a ***gradual long process*** to grow into being. For a national culture it takes generations and generations, for a successful corporation it takes years as well, for without such a long and gradual process, it is impossible to have sufficient deposits of knowledge, believes, art, moral criteria and so on. Here ***tradition*** is naturally the hallmark of a culture and justifiably ***a bridge to its innovation***.
All in all, the definitions of culture reveal the significance of the issue, that is, developing a safety culture is ***a strategic issue of utmost importance.*** To the changes of market, enterprises may be able to alter their financial arrangement quickly but they cannot make sure of their response unless their culture which cannot change overnight is such as ready to stand out to challenges.

3. Reconstruction of the Broken Mirror

In his well-known book The Fifth Discipline, Mr. Senge advocates to restore a broken mirror as he points out the fact that business management has for long suffered from unsystematic thinking. In general terms this could mean to nuclear power industry the integration of technology with human performance. According to our ancestral thinkers, this concept could be reflected in the analogue of a carved wine cup, from which originated the Chinese character *wen (part of the phrase of culture)*: the cup will have little value without artistic engraving but lose its usefulness if the artificial cutting makes holes on its wall. According to Sun Tzu, the renowned Chinese strategist of more that 2500 years ago, a general can never win a campaign without a whole picture in mind of the ultimate goals, the forces of both sides, the battlefield geography, the weather conditions and, finally the tactics.

Thus, ***the intrinsic structure and wholeness*** of a culture necessitates ***system thinking*** rather than haphazard approaches. And this is why I personally prefer the definition of the safety of a nuclear power plant as simply as Plant Safety, containing not only the element of reactor safe operation but industrial safety, fire protection, health physics and environment protection as well. Saying, the drop of a tool might either injure a person or damage a fuel assembly, and the real important thing from safety culture's point of view, is to prevent the event from the very beginning no matter what consequences are anticipated.

Instead of an inconsistent way of getting together the pieces of glass, the restoration of the broken mirror shall be ***a well melting and merging process within its own frame and as a whole.*** This concept is particularly important when different cultures meet one another. Such a meeting sometimes is constructive and sometimes deleterious depending on what a selection of approaches is made. For instance, the western culture is characterized with a strong linear pattern of logic reasoning and action, while the Chinese traditional culture centers upon the moral cultivation of an individual's character, which is believed to be the essential power source for action, in such a homocentric manner as to reach his folk at hand and the cosmic being in the end. This could be illustrated by what Confucius said about governing people.

> *"Govern the people by regulations, keep order among them by chastisements, and they will flee from you, and lose all self-respect. Govern them by moral force, keep order among them by ritual and they will keep their self-respect and come to you of their own accord."*

Which patterns of thinking and action as mentioned above is better than the other is not a good question, just as we cannot ask which culture is better than the other. To my mind, the important thing is to make a reasonable choice that blends the foreign cultural strength with our own merits.

4. Ways of Developing Safety Culture

In the process of integrating technology and human performance our experience has demonstrated that the most difficult part as well as the most essential one is to cultivating the integrity of the staff and changing their mindset and behavior in respect of plant safety. According to our traditional assumptions of human being, we believe that majority of our staff desire to do a good job, and that the motivation of the people is based upon their needs, checked and regulated by the rules, but essentially motivated by moral force cherished in their heart. In view of this assumption the development of corporation's culture calls for all the efforts to ***stimulate the staff's needs, simplify regulations and reinforce their moral force.***

The process of developing culture, as said before, is a long, gradual and continuous process. As for a corporation, it is not so simple as for the top management to make a policy statement and repeat it at various meetings. It needs ***systematic down-to-earth actions starting from the***

daily performance of every individual staff. Just as Lao Tzu, another leading philosopher of our nation, said,

> *"For the tree big as a man's embrace began as a tiny sprout, the tower nine storeys high began with a heap of earth. The journey of a thousand leagues began with what was under the feet."*

Thus the initial concrete step of developing the safety culture is to help the staff not only to know but also to ***feel the importance of their daily work to the overall safety*** of the utility. I remember that in Mr. Philip Crosby's book *Quality is Free,* a hundred luxurious Benz cars standing better than a figure for the equivalent loss due to poor quality performance is a typical example to let people feel the importance of quality. As a result, the people will no longer act as on-lookers but as participants, for before that they believed that safety was only the reactor operators' concern, and even the operators said to themselves that safety was the business of on-shift STA (Safety Technical Advisor).

To help people understand the ***mechanism of human errors and the nonlinear system accidents through case studies*** is an efficient way to assist the staff in understanding and feeling their roles in the whole safety structure of the utility. An analogue could be made between the complicated systems of a nuclear power plant and the biological and physical complex of human body. Every part has its role to play in constituting the whole function of the body, and antibiotics are not sufficient to recover but a healthy living style is fundamental for standing health.

The difficult part of developing culture is how to help the staff to ***be fond of or love his job.*** It is only until he feels interested and happy in his job, which occupies the major part of his daily life, that he will not devotes himself to the job, thus leaving a higher chance of making errors which might initiate or join the sequence of an incident. Therefore, ***human resources management and the construction of a friendly working environment*** play a profound role in the development of safety culture.

Among all the elements of moral force cultivation the most important is integrity of the individuals. This integrity hereby means honest to safety as well as to one's conscience, for by Chinese traditional values integrity is the primary value without which nothing can be achieved with grace and stand long. That is why our ancestral philosophers emphasized more on what we term today as self-assessment. Confucius said,

> *"A true gentleman makes self-assessment three times a day", and*
> *"Without cultivating self one cannot support a family let alone govern a state".*

5. Moralization, the Example by the Managers

The managers of the corporation are certainly decisive in the process of culture development. Their personal integrity, commitments to the values, and actions to materialize their concepts etc., all makes ***a beacon to the staff*** to follow. Just as Confucius said,

> *" He who rules by moral force is like the pole-star, which remains in its place while all the lesser stars do homage to it."*

The moral force of the managers, according to the Master, manifests in *attending strictly to business, punctually observing his promises, being economical in expenditure, showing affection to his subordinates in general, and using the resources only at proper times of the year.*

All this makes up the essential virtue of a manager and could be manifested as in an old saying,

> *"When missing the target, not blame your bow but yourself."*

But nowadays we seldom have such a manager who first of all looks at himself in face of a problem rather than criticizes his subordinates. Sometimes, if not so much often, we face such

an embarrassing scene that just yesterday the manager solemnly stated that all the staff were encouraged to report any events because the events were "learning opportunities and good resources", but today upon such a reporting he immediately jumps to reprimand in fury.
I am fully in support of the modern west management allegation that managers should be ***designers and coaches*** as well. Not only are they supposed to direct and control but also they are expected to carefully plan and personally show or guide how the job should be done and, of course, when the job has been successfully accomplished, they would withdraw to the background leaving their staff to feel proud. I remember that Mr. Senge cited in his book *The Fifth Discipline,* from Lao Tzu the criteria of future leaders and managers:

"Of the highest the people nearly know that such a one exists;
The next they draw near to and praise.
The next they shrink from, intimidated; but revile.
Truly, ' It is by not believing people that you turn them into liars,'
But from the Sage it is so hard at any price to get a single word
That when his task is accomplished, his work done,
Throughout the country every one says ' It happened of its own accord.' "

Unfortunately, however, nowadays it seems still always the managers that show in spotlights. It is not an exaggeration to say that ***leaders create culture*** and start it from themselves.

6. Conclusion

In the first few years of our safety culture development program there was a heated argument among our staff. As it were, the aggressive party believed that "safety culture" was another modern west panacea for nuclear safety, and the conservative said that it was just kind of western painting of nude, which was not in line with our traditional aesthetic tastes. (Such arguments have been discussed in the first edition of the textbook, *Safety Culture,* edited by the writer.) But today, people's mindset has changed already. We have come to a more constructive and insightful understanding, and believe that our tradition could do us good as a bridge spanning the differences of the cultures and connecting to the innovations of own characteristic.

About the Author

Zhou Weihong has been worked in occupational safety management in GNPS and LNPS since 1992. He has acted as industrial safety section head, branch head of health physics and the member of the plant and the site safety committees. Currently, he is the branch head of health physics of LNPS and the office director of Daya Bay Site Safety Committee. He is also qualified safety peer inspector of WANO and OSART of IAEA (Operation safety assessment and review team of International Atomic Energy Association.).In regard of safety culture development, he has long been the facilitator and the writer of a number of training material and the instructor.

Safety Culture Management and Quantitative Indicator Evaluation

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Abstract: This report discuses a relationship between safety culture and evaluation of quantitative indicators. It shows how a systematic use of generally shared operational safety indicators may contribute to formation and reinforcement of safety culture characteristics in routine plant operation.
The report also briefly describes the system of operational safety indicators used at the Dukovany plant. It is a PC database application enabling an effective work with the indicators and providing all users with an efficient tool for making synoptic overviews of indicator values in their links and hierarchical structure. Using color coding, the system allows quick indicator evaluation against predefined limits considering indicator value trends. The system, which has resulted from several-year development, was completely established at the plant during the years 2001 and 2002.

1. Introduction

IAEA has defined Safety Culture in [1] as the "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 follows from the definition that the safety culture is a very complex concept based mainly on intangible sociological aspects (individual behavior and attitudes, working environment, personnel relationship), that cannot be directly measured or quantified.
Performing employee surveys and observing their behavior and attitudes to organization practices can facilitate a qualitative evaluation of safety culture at the plant. However, to be able to monitor and manage the level of safety culture in an organization, a continuous quantitative evaluation of safety culture is necessary. Although the safety culture cannot be directly quantified, there is a number of quantitative performance indicators that, from their nature, imply the actual level of safety culture in the organization and can be used for its indication. The values of these indicators reflect some particular symptoms of safety culture characteristics. Such indicators may include those evaluating plant equipment performance, personnel radiation exposure and overall radiological situation as well as plant administrative processes and work practices. Also quantification of qualitative surveys belongs to these indicators. Many plants currently face the task of finding a set of suitable indicators to help quantifying the level of individual aspects of safety culture.
This report, however, does not address the specific safety-culture-related indicators. It rather discuses an influence of a broad use and evaluation of operational safety indicators to the safety culture formation and improvement. It also provides an example of a computer application that may significantly promote such a development.

2. Monitoring of operational safety performance contributes to safety culture improvement

For the plant staff to perceive safety improvement as the top-priority task and permanently adjust their behavior and approaches accordingly, they need to see that plant top management systematically monitors and evaluates plant safety performance and culture. Operational safety indicators provide managers and plant staff with a tool for evaluation of performance status and trends in their areas of activity or interest. Regular use of these indicators reinforces and cultivates such safety culture elements like systematic approach to safety, self-assessment, questioning attitude, motivation to improvements, review of quality of administrative and work processes, understanding of connectivity in organization and time, respect for colleague's work, etc.
Should the operational safety performance indicators have the positive effect to safety culture improvement, the indicator values and trends must be transparently, intelligibly and truthfully communicated to all plant staff. The indicator results should be presented in a synoptic, comprehensible form allowing a quick overview of the actual safety performance and trends in a specific area of interest. As such, the performance indicators form an important means of communication within the plant. In addition to actual indicator values, however, safety measures and decisions based upon the indicator trends have to be taken and communicated in order to provide an

efficient feedback and to complete the effect of performance monitoring on safety culture improvement.

3. Computer based Indicator Display (INDI)

In its publication [6], the IAEA submitted a comprehensive concept of operational safety performance indicators. In this concept, the indicators are organized in a hierarchical structure based on specific performance indicators at the bottom line. From this baseline, the indicators are sorted into groups and aggregated into strategic and overall indicators forming the upper hierarchy levels. In order to facilitate evaluation, monitoring and displaying of the structured indicators, a computer database processing system may be effectively applied.

Considering the aforementioned concept, the computer database application called INDI (Indicator Display) [7] was developed at the Dukovany NPP over the past three years. The application is based on a performance indicator value database extended by build-in functions that enable indicator evaluation and display at all hierarchy levels as well as generation of operational safety performance reports and charts. The application is accessible from all plant computer network workstations and allows simultaneous work of several users logged in the network.

The main features of the application include:

- Distributed system of data entry
- Structured hierarchy of indicators
- Indicator evaluation using acceptance criteria (goals and limits)
- Aggregation of evaluations into the hierarchical structure
- Colour coding of evaluated indicators
- Synoptic display of indicator values and their trends
- Easy generation of charts and tables
-

4. Examples of INDI functions

4.1. Indicator specification

Each specific indicator in the system database is determined by its descriptive data (name, concept, definition, data source and note) and parameters (unit, type, evaluation criteria, numeric format, range, basic reporting period and unit pertience). The indicator specification also includes an indicator guarantee (responsible department) and list of data providers. The specification section (see Fig. 1) assures that individual indicators will be correctly understood and interpreted.

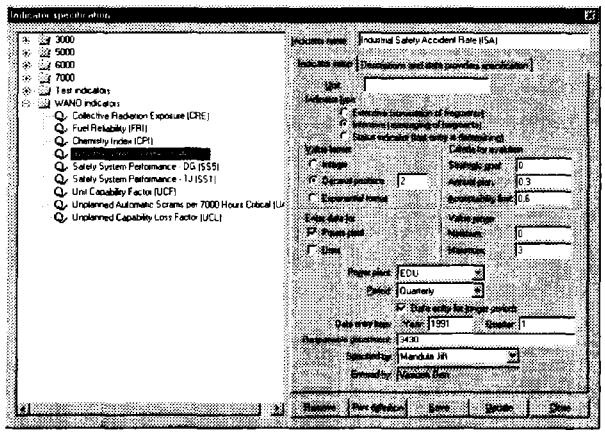

FIG. 1. Indicator specification

4.2. Report generation

FIG. 2. Chart generation The system provides a report generation option allowing generation of periodical reports using predefined templates. The user-defined report template can include charts, tables and text. The chart templates are prepared using the standard MS-Graph functions; the tables are based on the MS-Excel format. To generate a periodical report, a user selects only the report template and reporting period. Generated reports (see Fig. 2) can be exported to MS-Word. The report generation

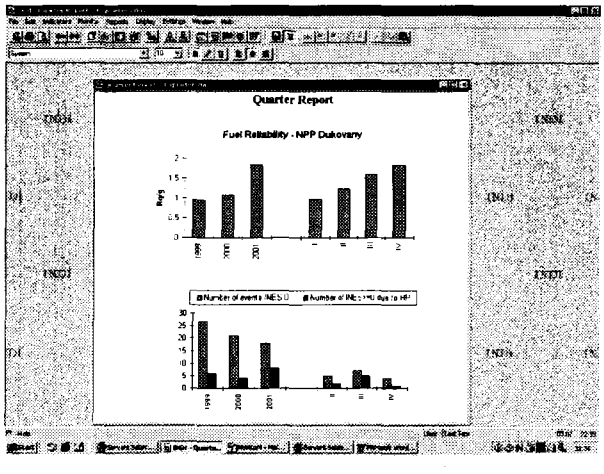

FIG. 2. Chart generation

function is routinely used at the plant for reparation of weekly, monthly, quarterly and annual performance reports.

4.3. Performance Monitor

This function provides a synoptic display of the entire indicator structure (see Fig. 3). The selected structure tree is displayed in both vertical and horizontal format. It provides information about actual status and trends of performance in the selected areas of interest. Color codes are used to show the actual "position" of indicator value in respect of the evaluation criteria. The performance monitor is used as an efficient tool for performing routine reviews of operational safety performance at the plant.

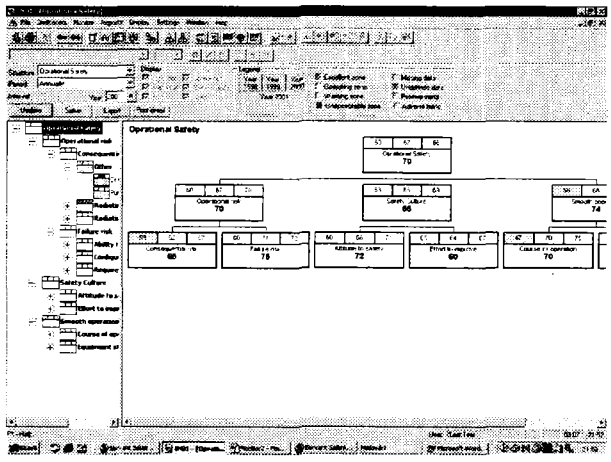

FIG. 3. Performance monitor

4.4. Specific indicator display

The INDI Performance Monitor includes also a specific indicator display (see Fig. 4). It provides possibility to monitor and analyze indicator trends. The relevant criteria (goal, annual plan, limit) used for indicator evaluation are displayed in both numeric and graphic form. Together with the specific indicator details also the indicator structure is displayed on the screen. The display offers the user a comprehensive information about the indicator including its definition and specifications, which are here also available.

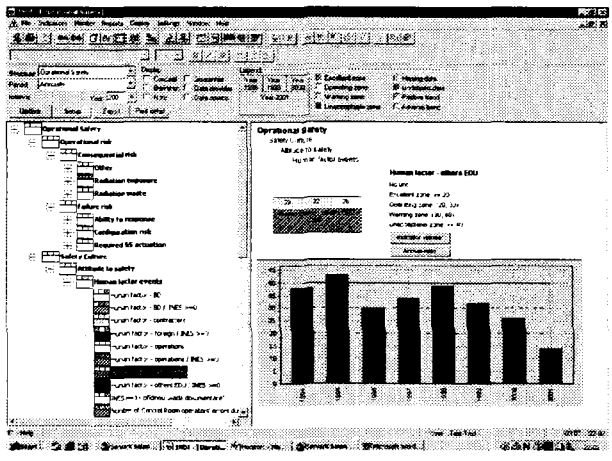

FIG. 4. Specific indicator display

5. Conclusion

The user-friendly computer based Indicator Display (INDI) system developed at the Dukovany plant represents an important tool also in the plant Safety Culture Management. The application has been widely accepted by Dukovany plant personnel, and has been also positively acknowledged at some peer plants. It has significantly enhanced the performance indicator processing culture and improved efficiency of indicator evaluation and trend monitoring at the Dukovany plant. The INDI provides a clear feedback to all plant personnel showing them, how their own attitudes and practices are reflected in a measurable performance, which increases their involvement and accountability. It also provides a qualitatively new means of communication within the plant staff and between the plant staff and management.

Successful development and introduction of the performance indicator display system, however demanding and important, has been only one pace on the way the plant should pass through. The system will be continuously revised and amended to optimize the specific indicator selection and their relationship. User training will also continue to effectively use all possibilities the system offers to improvement of both operational safety and safety culture at the plant.

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Safety culture in a major nuclear fuel cycle facility

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Abstract. Human factor plays an important role in development of safety culture in any nuclear fuel cycle facility. This is more relevant in major nuclear facility such as a reactor or a reprocessing plant. In Indian reprocessing plants, an effective worker's training, education and certification program is in place to sensitize the worker's response to safety and safe work procedures. The methodology followed to self evaluation of safety culture and the benefits in a reprocessing plant is briefly discussed. Various indicators of safety performance and visible signs of a good safety management are also qualitatively analyzed.

1. Introduction

The principles of radiological protection evolved by the ICRP are well known and generally accepted and practiced in nuclear fuel cycle facilities, worldwide. Such facilities, as per the requirement, are well designed and equipped from the safety considerations. The accidents at the TMI-2 plant in 1979 and several years later, in 1986, the accident at Chernobyl, brought into focus the human factor in radiation safety. It is now well understood that the long-term management of safety calls for approaches that go beyond the engineered safety and adherence to the safe procedures. Continued improvement in the safety performance of a facility requires the development of a "safety culture" at all levels of an organization [1].

2. Safety Culture

The Safety Culture as defined by the International Nuclear Safety Advisory Group (INSAG), is: "that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance" [2]. The safety culture is an amalgamation of values, standards, morals and norms of acceptable behaviour. It has to be inherent in the thoughts and actions of all the individuals at every level of an organization, from the top management to the lowest level workman. It needs to be established in all the nuclear fuel cycle facilities and other facilities, which handle radioisotopes and equipment, which emit radiation.

3. Indian commitment to safety

India is committed to give priority to safety and continue to maintain and further improve the overall safety record in its nuclear fuel cycle facilities. For example, the first Indian reprocessing plant at Bhabha Atomic Research Centre, Trombay, began its operations in 1964 and has processed spent uranium metal fuel from research reactors. The plant has met the plutonium demands of several programs including the fuel requirement of Fast Breeder Test Reactor, at Kalpakkam, in the eastern coast of southern India. The plant has provided invaluable experience in decontamination and decommissioning aspects of reprocessing plant. The safety record of the plant is very good; the average exposures are maintained at about one-tenth of the annual effective dose of 20 mSv, without any significant internal exposures to the workers.

4. Safety considerations

A reprocessing plant handles, annually, several million Curies of fission product activity and highly toxic actinides in highly dispersible form. Due to very nature of the operations and in-spite of the engineered safety features (such as containment, shielding and ventilation), the potential for significant external and internal exposures is quite high if not handled properly. A well-designed and plant specific radiation protection program, established in the plant, over the years, ensures the radiological safety in the plant. A separate Radiation Hazards Control (RHC) Unit attached to the facility, which works on round-the-clock basis, carries out the radiation monitoring and exposure control activities. A technically competent regulatory body controls the discharges from the reprocessing plant. The regulatory procedures evolved over the years help to enhance safety culture.

5. Training, education and licensing procedures

The plant management is responsible for the safe operation of the plant and safety of the personnel. This calls for deployment of well trained and highly disciplined work force in the plant. Efforts are continually made for establishment and upgrading of the safety and reliability of various systems in the plant. In addition to the basic requirement of a degree or diploma at the entry level, the workers have to undergo a year's comprehensive training before their regular employment. To meet the regulatory requirement of licensing, procedures are available to meet the requirements for qualifying the workers to various levels – level II being the highest level in a reprocessing plant, i.e., position of a Plant Superintendent / Shift Charge Engineer, level III of a Junior Shift Engineer, level IV of a Control Room Assistant and Level V of technicians. Experience of 4 to 8 years at a given level is one of the eligibility criteria for elevation to a higher level. Similar system is applicable to health physics personnel. Minimum staff requirements, educational qualification and experience of the staff members are specified for the plant operation in round-clock-shift.

In addition to the necessary regulatory certification process, which the personnel have to undergo, in major facilities such as reactors and fuel reprocessing plants, the work force, including the management staff, is provided with financial incentive to achieve certain level of competency in terms of education and training. The scheme called Qualification Incentive Scheme (QIS), is a comprehensive scheme, consisting of classroom lectures, written examination, clearing checklists, walk-through examination and finally personal interview by a team of experts. Every three years, the personnel are re-qualified. The scheme is popular and quite effective.

6. Inculcation of the safety culture

In general, a good safety record reflects an effective safety culture that exists in the plant. Some of the attributes of a good plant management committed for the continued development of safety culture are:

- Clear lines of authority for decisions on protection and safety. The radiation protection manual for the plant specifies the lines of authority for the decisions connected with the safety.
- The manual also clearly identifies and defines responsibility of each individual.
- Each individual is suitably qualified and trained in the plant operations and radiation protection. Certified operators are employed in all important areas of the plant.

- In establishing of the operating procedures safety is given highest priority. The procedures are discussed and approved by the local safety unit, which is responsible for providing safety surveillance in the plant.
- Problems affecting protection and safety are promptly identified and corrected in a manner commensurate with their importance. ALARA is the buzzword.
- Safety is not just a technical issue. Maintaining high level of awareness of behavioral and attitudinal issues of the work is important. The RHC unit provides all the necessary support to the management in maintaining high standards of safety.
- The plant management should strive for continuous improvement in the safety performance. Safety status is reviewed in multi-tier safety review committees, which meet at regular intervals.

7. Self evaluation of safety culture

Process of self-evaluation / assessment is a way of providing some formal structure to the development of safety culture. The existing activities in a plant and the safety related plant parameters should be critically compared with that of pre-determined set of expectations. The expectations are arrived at by taking into consideration regulatory requirements and are generally lower than the Technical Specifications for the plant. The actual performance targets for effluent releases, man-sievert expenditure, etc should always be maintained lower than the Technical Specification values. The targets should be periodically reviewed to ensure that they continue to promote improvement.

For example, the management in a typical reprocessing plant can assess the safety culture in the plant by:

a. Comparison of the trend in personnel exposures of the last say 5 years. Any increasing trend, which is not explained, should be of safety concern and should be investigated.
b. Number of spillage / enhanced air activity levels taken place in the recent past. These occurrences during the operation of the plant should be investigated without delay. Causes identified and rectification measures taken and lesson learned should help to reduce recurrences of such incidents in future.
c. Waste generated in the plant is an indicator of the working status of the plant. Amount of waste produced per ton of the spent fuel reprocessed is an important indicator for comparison with similar plants. The radioactive waste transfer / disposal are authorized by the relevant regulatory body.
d. Industrial /radiological incidents/ unusual occurrences in the plant help to assess the safety performance of the plant. Such event are reported in the specified format and investigated by the appropriate regulatory committee(s). Workers also participate during the initial stages of the investigation carried out by the local safety committee.

The process of self-evaluation of the safety culture can be complemented by audits, such as compliance checking, interactive review of the work procedures, arranging operational feedback sessions, etc.

In some of the nuclear fuel cycle facilities in India, a concept of Quality Circle [4] has enabled to achieve worker's participation in identifying problem areas, to utilize their full potential in creating safe working environment and ultimate reduction in man-sievert. The Circle is a group of employees who voluntarily come forward to assist the management.

8. Benefits of self evaluation

The benefits of self-evaluation of the safety culture are:

- Promotion of safety performance through direct involvement of the personnel in critical examination and improvement of their own work.
- Ensures that the line of management is effective in monitoring operational safety performance and takes timely corrective actions to improve performance.
- The staff involvement results in a better understanding of the safety culture in relation to both, their own jobs and the organisation as a whole, and
- Promotes good communication within the organisation.

9. Visible signs of good safety management

- Publicizing safety objectives and monitoring progress towards meeting the objectives.
- Creation of safety related post, such as safety engineer, with appropriate level of authority.
- Safety performance is recognized through, awards, appreciation letters, etc.
- Interest is shown in safety issues through dialogue, debate and brainstorming sessions, operational feedback sessions, etc.
- Workers are encouraged to take interest in safety issues, identify safety problems, suggestions to improve procedures, etc. For example, in nuclear facilities, March 4 is generally celebrated as National Safety Day, where workers are encouraged to take part in quiz contest, safety related poster competition and exhibition of the safety related equipment. The management appreciates good work openly.
- Periodic training and refresher courses for the workers.

10. *Conclusion*

A good safety culture is the key to continued progress in safety management. The safety culture should be inherent in the thoughts and actions of individuals at all levels of an organization. In nuclear fuel cycle facilities, such as reprocessing plant, this is very relevant due to the potential radiation hazards associated with the facility. Effective functioning of the local and regulatory safety committees provide the necessary inputs, by way of investigation and recommendations, required for the overall safety culture development in a plant.

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Different regulatory strategies in regulation of nuclear power projects An Indian experience

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Abstract. Regulatory strategy needed for management of safety and safety culture involves careful planning and use of engineering concepts keeping in mind feasibility to implement certain safety requirements. It also requires adequate attention on working environment and mental conditions of designers, operating & maintenance staff and regulators. Different strategies followed during safety review and regulatory inspection of nuclear power projects for improving status of safety management and safety cultures have given certain results. The present paper brings out certain experience gained during regulation of Indian Nuclear Power Projects by Atomic Energy Regulatory Board of India in the area of management of safety and safety culture.

1. Introduction

The International Nuclear Safety Advisory Group (INSAG), in its publication on 'Safety Culture' in IAEA Safety Series No. 75-INSAG-4 [1], defines safety culture as: *"Safety Culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance"*. To achieve the mission for ensuring adequacy of safety management and safety culture at nuclear power projects/plants (NPP) at various stages of design, construction, commissioning, operation and decommissioning, an effective regulation is needed, which is a highly specialised task and require a lot of efforts.

2. Scope

Nuclear power plants being regulated in India are of different types viz. boiling water reactors (BWR), pressurized heavy water reactors (PHWR) and pressurized water reactors of VVER-1000 type (VVER-1000). At present 14 NPP units are under operation (e.g. 2 × 160 Mwe BWR, 4 × 200 MWe PHWR, 8 × 220 MWe PHWR) and 8 units under construction (e.g. 4 × 220 MWe PHWR, 2 × 540 PHWR and 2 × 1000 MWe VVER-1000). Design of a proto type Fast Breeder Reactor (PFBR) of 500 MWe capacity is under review.

Atomic Enegry Regulatory Board (AERB) of India, which was consituted by the Government of India in 1983, has grown up to a mature level. AERB has been regulating these NPPs effectively and independently by adopting different strategies to improve quality of work and working environment. Significant improvement in management of safety and safety culture as well as a downward trend in safety related incidents have been achieved by performing intensive safety review and regulatory inspections during last 15 years.

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3. Objectives

While regulating an NPP, one of the objectives set by AERB is to improve management of safety and safety culture at all stages by way of working out certain strategies as given below:

(1) Provide good regulatory documents to the regulator, designer, operator and the public.

(2) Granting of authorization to NPP for specific activities after detailed safety review in line with AERB regulatory safety codes & guides.

(3) Conduct planned and reactive inspections and enforcement actions.

(4) Exchange feedback experience gained during safety review and regulatroy inspections to improve safety review/inspection strategies.

(5) Continuous updating of knowledge to keep on improving technical competence of AERB staff.

(6) Publish important findings and keep public informed about improtant safety issues.

4. Strategies

To achieve above objectives for meeting dynamic requirements of effective regulation following strategies were adopted by AERB, which include: internal re-orgianization; development of regulatory docuements; improvements in techniques for safety review; and regulatory inspection of NPP.

4.1 Re-organisation of regulatory activities related to NPP

AERB, since its constitution, has re-organized its internal structures time to time to suit dynamic requirements for effective regulation of NPPs through various Technical Divisions and associated Safety Review Committees and Advisory Committees. These Technical Divsions have optimum trained and qualified staff and facilities for carrying out safety review, regulatory inspections and development of regulatory documents.

4.2 Development of regulatory documents

AERB has taken up speedy preparation of several Codes of Practices and Safety Guides in the area of design, operation and quality assurance. Certain published regulatory documents are being revised incoporating feedback experience gained during safety review, regulatory inspections and published international documents such as revised IAEA Safety Standards.

4.3 Enhancement in technical competence and related abilities of regulators

AERB has been training its staff through training courses conducted by AERB, IAEA and other national/international bodies and use of internal library resources for self-studies. Every computer terminal of AERB has been connected to Internet to provide access to rich information available on the net.

4.4 Availability of guidelines for safety reviewer and regulatory inspectors

AERB staff have been equipped with necessary national and international standards, codes, guides, manuals and other reference tools required for safety review/assessment and regulatory inspection activities. Based on these standards and safety guides, necessary

manuals and checklists are prepared as per requirements and followed during safety review process and regulatory inspections.

4.5 Safety review strategy

AERB Safety Manual on 'Governing the Authorization Procedure for Nuclear Power Plant/Projects' [4], is being followed for granting stagewise authorization to an NPP for carrying out construction and commissioning activities. Detailed requirements regarding submission of necessary documents along with application, for Authorization for each stage of construction, commissioning and operation, within stipulated time frame for review are given in the manual. It prescribes format for safety analysis reports, design basis reports and the applications. The safety review follows 3-tier review process. Levels of authorization are defined to decide levels of review. The three levels of reviews and clearances are: review by Project Design Safety Committee (PDSC); review by Advisory Committee for Project Safety Review (ACPSR); and review by AERB Board. Nuclear Projects Safety Division (NPSD), a Technical Division of AERB, monitors the safety review process through a programme evaluation and review technique (PERT) chart (in line with that followed by an NPP) to ensure timely completion of safety review. Compliance of implementation of safety requirements in design and commissioning documents is checked by a working group chaired by Head of the NPSD.

4.6 Regulatory Inspection and enforcement strategies

Regulatory inspections are conducted in parallel to safety review for checking compliance of regulatory requirements by the NPPs. Applicable AERB Safety Guide and associated Manuals are followed for regulatory inspections [3]. As per need a field check-list is prepared on the basis of outcome of safety review and other technical documents. Depending upon the stage of the NPP and schedule of certain special tests, inspection programmes are planned and implemented. These inspections include planned team inspections as well as reactive inspections. These are either announced or unannounced. In case of commissioning, resident inspectors are posted at NPP site itself for continuous monitoring of NPP activitiy for management of safety and safety culture. Special attention is paid on quality assurance (QA) programme of the utility during all activities and protection of commissioned equipment. Inspection programme is updated incorporating feedback experience from inspections as well as safety review.

5. Effects of strategies on improvement in management of safety and safety culture

Even though safety culture can not be mandated, AERB has been able to get this mentioned in its safety documents [3]. Various strategies followed during safety review and regulatory inspections yielded certain results time to time. Some of them are brought out here:

5.1 Frequent re-organisation of regulatory functions

Dynamic organisation of AERB has established better structure for carrying out regulatory work, through Technical Divisions by optimum use of expetise and resources, and providing good opportunity to every individual to have exposure to different types of works and enhance their knowledge. This helps in ensuring adequate backup staff for safety review and regulatory inspection activities for all types of NPPs. Thus regulatory works do not suffer in case of unavailability of an individual and every body has capability of effectively monitoring of NPP for management of safety and safety culture. Documentation system ensures retrievability of required information in time from an established data bank for each NPP. Also, regulatory staff get more job satisfaction as psychological load is minimum and they

feel more comfortable in carrying out safety review and regulatory inspections of any type of NPP. Communication gap regarding technical information between different persons is minimised and same quality of regulatory work is almost assured.

5.2 Safety review

The three tier safety review process has been effective in resolving safety related issues in time at different level of management. Defined levels of Authorizations help in controlling NPP activities as per importance of safety requirements at its various stages. To ensure implementation of recommendations of various safety committees and AERB, following method has been adopted:

5.2.1 Categorisation of safety issues

Safety issues emanating from safety review of an NPP are categorised into following categories:

(1) **Category-A**: to be resolved before Phase-A commissioning (i.e cold or hot run of the systems without fuel loading in the core);

(2) **Category-B:** to be resolved before fuel loading in the core;

(3) **Category-C:** to be resolved before initial criticality and low power physics experiments;

(4) **Category-D:** to be resolved before raising initial power of the reactor from 0.1% full power to 100%full power; and

(5) **Category-E:** requring research and development and of long term nature.

Close follow-up for implementation of recommendations of safety committees as per the above categories is done by way of having interaction among regulatory staff, designers and operators. Necessary safety analysis and safety review are carried out quicly to resolve outstanding safety issues. However, trend to request change in category of a safety issue, by the utility to get more time, is observed and a regulator needs to take a stand at appropriate level.

5.2.2 Assistance to utility in resolving safety issues

During safety review, experts of various safety committees give certain advices how to improve the systems to meet certain safety requirements. These guidelines are not a part of recommendations of AERB but for helping designers to share experts' experience. This approach has given very good results.

5.3 Regulatory inspections

Regulatory inspections are carried out with alertness and keeping its objectives in mind. Planned inspections are generally carried out with announcement at short period to assess more realistic status of management of safety and safety culture of an NPP. However, announced inspection results in temporary corrections in certain areas. Unanounced inspections are generally carried out in case of an unusual occurrence to ensure that evidences are not lost. This gives an opportunity to assess the incident to find out the real root cause to compare with the reported one.

5.3.1 Regulatory inspection and enforcement techniques

During an inspection, a dynamic field-checklist is prepared and modified/augmented at NPP site as per requirements. Discussion with an NPP staff is held in a strategic manner. Absence of boss while discussing with the NPP personnel gives true picture of most of the deficiencies at NPP which exist for want of resources. Positive attitude and friendly approach brought a lot of improvement in managing safety and safety culture. Site personnel become more open if design support is assured based on inspection. Similarly, during inspection of maintenance areas, true history of failures at NPP is revealed if availability of more spares and tools is assured because of inspection. Based on insepctions and enforcement actions, AERB creates an interface between NPP site and design organization. This helps in solving design-related problems and improving safety. Repeated direct observations with small time gap help detection of unsafe situation or violation at times. In case of serious violations, strong enforcement actions improve safety culture. Initiation of enforcement actions based on categorization of inspection findings, as given below, has improved the safety culture:

(1) **Category-I:** Direct Violation of Technical Specifications or Mandatory Safety Requirements;

(2) **Category-II:** Serious problems discovered which require urgent safety review;

(3) **Category-III:** Design related and generic deficiencies;

(4) **Category-IV:** Inadequacy in procedures and their compliance or deficiencies in equipment/quality assurance related deficiencies; and

(5) **Category-V:** General observations which are of minor nature but NPP have to correct themselves.

Follow-up of previous insepction in the next inspection as per the above categories reduces the pending safety issues.

5.3.2 Areas of improvements at NPP

Role of top management positions: Top management positions having personnel of sharp brain and foresightedness with positive approach give better output in terms of maintaining good safety culture among NPP staff and effective safety management. They play catalytic role in understanding the difficulties or problems arising in variuos systems and process and working out on-the spot solutions to avoid further degradation in the system. Following a management approach rather than beaurocratic approach gives good results in preventing safety related incidents or in mitigating consequences of an incident, should it occur. This creates an environment of openness among the operating and maintenance staff.

Role of middle management positions: In-plant Operation Review Committee (IORC) plays an important role in solving the problem at NPP and recommend corrective measures at times. The Committee consists of members mainly from middle management positions. Immediate publishing of the root cause, of any problem and violations during NPP operation or maintenance, gives good operational feedback to all and similar problems are avoided in other NPPs. In view of this, keeping Member-Secretary of IORC independent of operation and maintenance group improves quality of record on deliberations of IORC. Middle management positions having hard working personnel and good communication become an important advisor to top management and an effetive guide to the working level staff.

Role of working level staff: It is known fact that working level staff expect timely appreciation of their good works, else, they may lose interest in improving their performance in the area of safety management. Motivating of the staff, without wasting time and through

reward on the basis of their work and not due to good relation with bosses, increases competitiveness as well as friendly environment and eliminates feeling of comparison. Effective utilization of their skill, knowledge, hard working capability gives them job satisfaction and enhance interest in improvement of safety management and safety culture.

Differentiation between operators and maintainers: Giving importance to operator over maintainer creates a jealousy attitude and quality of maintenance work may suffer. This may result in safety related incidents. Thus avoidance of a comparative approach results in good coordination, friendship and better safety management.

Communication gap between designer and operator: During NPP operation certain design related improvements are required. However, due to a communication gap between designer and operator, sometimes design-related dificiencies remain unattended and operator has no choice and forced to violate safety requirements or some times misinterprate the write-up of the procedure. Thus interaction between designer and operator improves a safety culture a lot.

Coordination between regulator and utility: Relation between regulator and utility is very important in improving safety management and safety culture. Utility expects help from regulator and not a beaurocratic enforcement. Thus while conducting safety review and regulatory inspection an exchange of design/operational feedback really help very much to designers and operators to overcome certain difficulties. Beaurocratic approach is necessary only for enforcment actions where serious violations are observed. Most of the time a good communication between regulator and utility solves several problems and better management of safety and safety culture is expected.

Safety awards: AERB gives safety awards in certain areas of industrial safety. These awards gives motivation to other projects to improve industrial safety. However, this award is given to the NPP who really has shown improvement and not merely only on comparative basis.

Strong database and information management: Providing of local area computer network has improved quality of documentation, better management of operational and design data, quick analysis of any problem and availablity of required consultation at times. In parallel, provision of access to internet updates the knowledge level of operator, maintainers and designers with full utilization of feedback from worldwide NPPs and other institutions available on web sites.

6. Conclusion

Management of safety and safety cultures at an NPP are dependent upon many factors which include: availability of resources and expertise; healthy mental and environmental conditions of staff; and appreciating approach of top managements in the areas of design, construction, operation and regulation.

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Assessment of Safety Culture at INPP

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Abstract. Safety Culture covers all main directions of plant activities and the plant departments involved through integration into the INPP Quality Assurance System.

Safety Culture is represented by three components [1]. The first is the clear INPP Safety and Quality Assurance Policy. Based on the Policy INPP is safely operated and managers' actions firstly aim at safety assurance.

The second component is based on personal responsibility for safety and attitude of each employee of the plant.

The third component is based on commitment to safety and competence of managers and employees of the plant. This component links the first two to ensure efficient management of safety at the plant. The above mentioned components including the elements which may significantly affect Safety Culture are also presented in the attachment. The concept of such model implies understanding of effect of different factors on the level of Safety Culture in the organization.

In order to continuously correct safety problems, self-assessment of the Safety Culture level is performed at regular intervals.

INTRODUCTION

This section provides a brief description of the history of Safety Culture program development and improvement at INPP. According to the Law on Nuclear Energy of the Republic of Lithuania, Article 27, the following requirement is set forth: the enterprise granted with the license on NPP operation shall guarantee to VATESI the high level of safety culture in the organization. Such a requirement is described in the Terms and Conditions of VATESI issued license No 12/99 for Unit 1 operation, clause 17: Ignalina NPP shall annually submit a report to VATESI presenting analysis of implementation of Safety Culture improvement measures.
The General Requirements to the Quality Assurance System at Nuclear Power Plants and Other Nuclear Facilities, VD-KS-02-99 describe the requirements to plant employees on vocational training including understanding of the policy, objectives and Safety Culture principles [2]. The above mentioned requirements apply to all activities having either direct or indirect influence on nuclear plant safety.

METHOD

Current plant practice

Establishment of Safety and Quality Assurance Department

At the beginning of 1995 the Safety and Quality Assurance Department subordinated directly to the Director General of INPP was established at INPP. The Director General delegated to

that department the responsibility for monitoring and evaluation of safety of the plant. The department is responsible for elaboration and adoption of the quality assurance program and development of safety culture at INPP.

Management Structure Improvement

In 1995 the INPP management structure was brought to conformity with the Law of the Republic of Lithuania on state enterprises and municipality enterprises that resulted in establishment of three directorates and three services. The established INPP organization structure appeared to be quite effective since authorities and responsibilities of the heads of the Directorates and Services were well distributed and described and it could be easily managed. More detailed description of development of the organization structure and responsibility of the administration is given in Chapter 9.2 of SAR-2 Task 9.

INPP Safety and Quality Assurance Policy

In May 1995 the Director General of INPP declared the Safety and Quality Assurance Policy of INPP [29]. The following is stated in the declaration:

- Having clear understanding that the INPP management under the leadership of the Director General bears full and formal responsibility for the plant safety, we are declaring:

- The aim of INPP is to become the safest plant with RBMK type reactor and economically competitive among all power units.

- Only in case if the Director General of INPP can give positive answer to each of the above mentioned provisions, the plant will operate with the required quality level. Only in case if every employee can give positive answer to each of the above mentioned provisions, they will perform their job with the required quality level.

The INPP management is willing to ensure irreproachable performance of all works linked with safety and strives for the improvements.
The declaration was circulated among the plant personnel. During safety culture audits understanding and perception of the Safety Policy at INPP was reviewed.
In order to provide the plant personnel with the working guide for performance of the routine activity, 5000 booklets "High Safety Culture in the Nuclear Energy" were issued. The booklet contains appeal of the General Director of INPP to the INPP employees to seek the high Safety Culture. This booklet refers to the daily activity arrangement and behavior of each plant employee. Every employee of the plant received such booklet.

Training of INPP top and middle managers in modern management techniques

In order to implement new management styles complying with the Safety Culture principles, a number of seminars regarding modern management styles was arranged for top and middle managers of INPP and conducted by the Swedish Institute of Management (IFL). In total 15 seminars were conducted within the period of 1995-1997.

INPP Safety Committee

At the beginning of 1996 the Safety Committee was established at INPP. It has been an advisory group for the General Director to make safety related decisions. The Committee consists of 9 members; the specialists have been selected so that to provide the highest level of expertise [7].

The Safety Committee is responsible for conducting review and assessment of acceptability of safety related proposals submitted by the INPP directorates and services, including:

- Safety and quality assurance policy;
- Safety related modifications and solutions prior to their submission to VATESI;
- Safety cases; changes in Operations Regulations;
- Preparation for licensing of Unit 2;
- Proposals on safety related organization changes;
- Reports on safety related events;
- Issues related to decommissioning of INPP Units;
- Other issues related to tasks and functions of t he Safety Committee according to the Regulations on the Safety Committee.

Minutes of meetings of the Committee are submitted to General Director and VATESI. The final responsibility for making decisions regarding implementation of Safety Committee recommendations lies on General Director.

Safety and Efficiency Indicators

In the long term the main Safety Culture indicators are plant safety indicators which were declared as activity objectives at INPP at the beginning of 1996. Annually the plant management sets new activity objectives to achieve a higher level of safety. The following indicators were accepted for evaluation of safety and efficiency of the plant:

- Gross Production;
- Unit Capability Factor;
- Capacity Factor;
- Unplanned Capability Loss Factor;
- Unplanned Automatic Scrams;
- Collective dose;
- Individual dose;
- Industrial Safety Accident Rate;
- Volume of Low Level Solid Radiation Exposure;
- Safety System Performance;
- Fuel Reliability;
- Chemistry Index;
- Releases through the Stack;

- Safety Significant Events (level 1 and higher).

These indicators are subject to regular analytical reviews in order to learn lessons and define necessary corrective measures and track their timely implementation.

Plan of Measures on Safety Culture Improvement

In May 1997 an international seminar on development of Safety Culture of NPPs with RBMK type reactors was arranged at INPP with the assistance of IAEA, ES-konsult and SYDKRAFT Konsult consulting experts. Representatives from six countries and ten organizations from Lithuania took part in the seminar. Representatives from the Lithuanian Government and members of the Seimas were also invited. The participants of the seminar got familiar with experience of Safety Culture development at NPPs in Sweden, the USA, Switzerland, Russia and the Ukraine. Based on the seminar results IAEA report No RBMK-SC-051 was prepared.
In June 1997 a Plan of Measures on Safety Culture Development, was prepared and approved by the Director General. The Plan included recommendations from the Safety Analysis Report for Unit 1 and described specific measures of safety culture development at INPP.
The Measures primarily aimed to achieve the following goals:

- The Safety Policy shall obtain support of the plant management;
- Safety Culture shall become the key element of the plant activity management;
- To change attitude of the plant employees to their work, to form new mentality and inner critical position of the plant personnel which would ensure safe performance of works;
- To conduct Safety Culture audits resulting in the subsequent corrective actions and improvements;
- To use operating experience in order to define areas for their improvement;
- To provide the plant personnel with information on all works performed at INPP in order to ensure understanding of the common tasks and plant operation perspectives by each employee of INPP;
- Training of INPP personnel using the examples of good and bad practice.

Creation of Openness of Communications

One of the most important elements for high Safety Culture is an atmosphere of openness which ensures free communication of safety related information by the plant personnel. Especially it applies to admitting and communicating mistakes by the personnel.
In order to achieve these goals a Director General appeal on the Policy of openness was prepared in August 1997 and a procedure was developed which enabled the personnel to report safety problems to their managers and directly to the Director General.
During Safety Culture seminars INPP employees and managers were additionally explained that punishment for the error enables it to be hidden and its possible reoccurrence in future while informing on the error considers to be an act of plant safety improvement. A booklet was developed wherein the General Director advised the plant personnel on the Policy of openness towards errors and safety problems. This booklet was purposed to create the atmosphere of openness and trust. The Appeal contains the following theses:

- If after having reported the error the employee is punished, no reports will follow;
- If error reports are considered as positive actions and a person is rewarded for that, employees will report the errors;

- From time to time everyone makes errors but seldom do they want to cause damage or injury;
- The root cause is not a human error;
- Staff errors are symptoms not reasons;
- The problems which have been reported shall be considered and assessed at the management level and corresponding corrective actions shall be carried out;
- Punishment is not a corrective action.

Independent Safety Audits, Internal Audits

Ignalina NPP is open to international missions on assessment of operating safety. ASSET missions (1989 and 1993) and OSART missions (1995 and 1997) were held at INPP
In 1996-1997 Safety Culture audits were conducted in the plant departments: Reactor Department, Control Room, Electrical Department, Instrumentation & Calibration Department [3], [10]. The audit plan included the following questions:

- Personnel understanding of INPP Safety and Quality Assurance Policy;
- Personnel responsibility for safety;
- Use of operating experience;
- Management and personnel relations;
- Incentive and punishment of personnel;
- Training of personnel.

During the audits plant-general deficiencies relating to Safety Culture were identified:

- Managers do not discuss Policy issues with the personnel;
- Most of the operating personnel could not mention the most important thesis of the INPP Safety and Quality Assurance Policy;
- Not all job descriptions of the personnel define responsibility for safety;
- Managers do not encourage the personnel for proposals to improve safety;
- In the plant departments there is no procedure on how the personnel get familiar with the plant and industrial operating experience;
- In the plant departments there is no procedure and accounting system for proposals to improve safety received from the personnel;
- Most of the maintenance workers do not get familiar with reports on violation of work requirements at INPP;
- Employees do not receive enough information in connection with their activities (insufficient amount of technical literature, reference books, specialized magazines);
- The devices and instruments used on repair sites in the plant departments are old;

- The relations "subordinate-manager" are not open enough, employees not always report problems occurred at work to their managers;
- Audit results are not always discussed between managers and employees;
- Training programs and the scope of personnel knowledge do not contain questions on Safety Culture and INPP Safety & Quality Assurance Policy.

Audit reports were submitted to the General Director, Technical Director, department heads and INPP Safety Committee.
The heads of the audited departments together with the personnel reviewed the audit results and developed corrective measures to eliminate the detected findings. The issues identified during the audits were discussed with the personnel at the Safety Culture seminars. As a result, recommendations to improve the existing practice were submitted by the personnel.
Booklets containing clarifications on the basic provisions of the Safety and Quality Assurance Policy were spread among INPP personnel. The contents of these booklets had been reviewed and discussed with the personnel at the Safety Culture seminars.
The annual plan of internal audits conducted under the Quality Assurance Program includes issues on Safety Culture.

Safety Culture seminars for INPP Personnel

Training seminars have been conducted since June 1997. The programme of the seminars covered the information on the Safety Culture elements described in 75-INSAG-4, information on the quality assurance program, description of good and bad examples of Safety Culture based on INPP operation experience, issues of personnel incentive and punishment.
During these seminars the causes of Chernobyl NPP accident relating to Safety Culture [9] were reviewed, the problems in the Safety Culture area and their possible solutions were discussed. The reason of shutdown of seven Units at Ontario Hydro which were caused by the Safety Culture related problems occurred in this company were also reviewed.
The participants of the seminar received the reports on events at INPP and other nuclear power plants relating to deficiencies in Safety Culture. Based on the discussion results, the participants proposed work and safety improvements. A report on the results of each seminar was prepared [4].
The seminars rendered significant assistance to establish understanding of necessity and advantage of the quality assurance programme, foundation of the Safety Committee, implementation of Safety Culture at INPP.
The employees of the plant participating in the seminars consider them to be successful and necessary for exchange of experience and open discussions. This is witnessed by a big number of proposals submitted with regard to the safety improvements.
One of the most important results of the seminars both for the management and personnel was creation of the collective approach – team work on the basis of trust, openness, cooperation and mutual assistance.
In order to conduct the seminars, monthly schedules and a training plan were developed and a training manual was used. In total more than 150 seminars were conducted.
In 1998 training tools were prepared giving basic information on general principles of Safety Culture. A schedule for training of the top and middle managers of the plant, operating personnel including Control Room operators and engineering staff of the plant was drawn up. Within the period of 1997–2002 more than 2000 employees were trained under this programme. The Safety Culture manual for INPP [8], has been included into the plant personnel training programme.

Information posters on the self-control method of STARK had been issued which were placed in the personnel working area. Prior to issuing the posters, long discussion regarding the their contents had been conducted. There are indications given how to monitor oneself during performance of works related to safety.

Personnel Proposals

Within the period of 1997 – 1998 proposals on improvement of safety and work performance were submitted by the personnel of departments. These proposals were considered at a meeting with Technical Director. As a result, measures to implement these proposals were developed, [5]. These measures apply to almost all activities at INPP.
A procedure on processing of proposals for improvements, code ПТОэд-0312-1, was developed and implemented. The plant employees can submit their proposals to the heads of departments in accordance with this procedure. Each plant department is provided with proposal journals. Special forms for proposal submission directly to the General Director were also developed.
While analyzing operation events, the events relating to Safety Culture deficiencies and use of the STARK method during work performance shall be investigated without fail. A description of the STARK method is given in Attachment 1. At Safety Culture seminars employees of the plant submit proposals which could be used for work performance. Such improvements can be proposed also by means of "yellow sheets" which are submitted to INPP Director General and "proposal journals" available in the plant departments.

Self-Assessment of Safety Culture

The IAEA Workshop "Self-Assessment of Safety Culture"

Implementation of recommendation 9.2.1-4 of Safety Analysis Report INPP Unit 1. The IAEA Workshop "Self-Assessment of Safety Culture" was held at INPP in August 1998 [14]. Experience of other nuclear power plants in self-assessment of safety culture was presented by the IAEA experts. The self-assessment method proposed by IAEA was applied by the INPP project team to develop management procedure QA-2-022, "Safety Culture" [6], and to develop own self-assessment method which would be based on interview sheets-questionnaires.
In 1999 under the SIP-2 programme and together with consultants of the Swedish companies ES-Konsult and SYCON [40], the method to assess Safety Culture was complemented with features describing Safety Culture and special forms for assessment were prepared. By filling out the form, positive trends of improvement or deterioration of the Safety Culture features can be identified. The assessment results enable the plant management to detect problems at an early stage and draw up measures to eliminate these problems.
Self-assessment of Safety Culture consists of 5 steps:

- Determine problem areas (causes impacting the safety level reduction);
- Select importance priority for each problem area;
- Determine the connection between problem areas ad Safety Culture indicators;
- Determine Safety Culture weak elements;
- Determine corrective actions priority regarding the improvement of Safety Culture.

Results of Safety Culture Self-Assessment

Within the period from December 2000 to February 2001 an attitude survey of 1500 plant employees was carried out. 33 questions (11 World - class characteristics).
The participants were represented by employees of 10 plant departments mostly Technical Directorate and S&QA Department.
Option grades :

1. Strongly disagree;
2. Slightly disagree;
3. Undecided;
4. Slightly agree;
5. Strongly agree

Statistical handling of survey data of total 300 Questionnaire

Criteria:

- very good 85%< X
- good 75%< X < 85%
- satisfactory 65%< X < 75%
- regular 50%< X < 65%
- non satisfactory X < 50%

The questionnaires were filled anonymously and were purposed for three categories of INPP employees: heads of departments and their deputies, engineers and workers.
Preparatory work was performed prior to the plant personnel attitude survey:

- The attitude survey objective and sequence of assessment performance were explained to the heads of the departments;
- Specialists of ten plant departments were involved in attitude survey arrangement and performance of filled questionnaire analysis.

In March 2001 the tentative assessment results were submitted to the heads of INPP Directorates and Services at the meeting with the General Director. The management and representatives of VATESI participated as well.
Table I below presents the results of the attitude survey held in 1998 and 2000. The following was used as criteria: features of Safety Culture applied by the BNFL company and presented to INPP in 1998 at IAEA Workshop.

TABLE I. THE RESULTS OF SAFETY CULTURE SELF-ASSESSMENT IN 1998 AND 2000

#	Safety Culture characteristics	BNFL 1998, %	INPP 1998, %	INPP 2000, %	Rating
1.	Visible leadership and commitment to safety of top management	80	69	83	good
2.	Safe role of line management as regards safety	100	79	81	good
3.	Strategic business importance of safety	92	91	80	good
4.	Supportive organizational culture	80	84	78	good
5.	Involvement of all employees	69	74	62	satisfactory
6.	Organizational learning	80	80	78	good
7.	Safety assessment	74	84	82	good

8.	Mutual trust and confidence between management and workshop	85	76	82	good
9.	Openness of communications	80	62	64	Improvements are needed
10.	Absence of safety vs. production conflict	72	62	65	Improvements are needed
11.	Demonstration of care for all those affected by the business	100	82	55	Improvements are needed

INPP presented the results of Safety Culture Self-Assessment in 2000 May 2001 for the Directors of nuclear power plants WANO Moscow Centre [41].
The assessment results will be used for identification of the problems impacting the Safety Culture level deterioration and for determination of the corrective measures purposed to Safety Culture improvement. The self-assessment results may be of great importance with regard to timely response to the problems occurred in connection with making decisions on early decommissioning of INPP Units.
Safety Culture is planned to be assessed in 2002 by using computer software and the Internet as tool. To present the software has been prepared for testing.

RESULTS

Corrective actions following Safety Culture Self-Assessment

13.Employee involvement in improving safety is encouraged by managers - 35%

In order to improve the 13th Element relating to the 5th of the Safety Culture characteristic the following corrective actions are suggested to implement [42]:

- The plant management aims and objectives with regard to social protection of INPP personnel in connection with the planned closure of Unit 1 should be specified in the Safety and Quality Assurance Policy.

- Personnel encouragement and punishment practice shall be carried out under the formally issued Policy. A procedure on encouragement of INPP employees shall be developed.

- A procedure on the use of safety indices and Safety Culture indicators shall be developed and continuous practice of applying Safety Culture indicators at INPP shall be implemented.

32.Plant management care about social protection of the employees in connection with Unit 1 decommissioning - 36%

In order to improve the 32nd Element relating to the 11th of the Safety Culture characteristic the following corrective actions are suggested to implement [42]:

- To assist the Ignalina NPP in selecting and appointing a team to address Human Resources (HR) and Industrial Relations (IR) issues, and in arranging appropriate organizational and communication links

- To train the appointed Team in HR/IR/ strategy issues to be addressed in period approaching closure and assist with developing strategies appropriate for INPP.

- To train the appointed Team in Formal Change Management Process and assist with developing processes and documents, and implementing processes at INPP

- To train the appointed Team in processes for retaining key skills for U1 and U2 to closure and assist with developing processes appropriate for INPP

To train the appointed team in information exchange and public relations, to assist and consult on arranging work with the staff representatives, the Regulator and public.

Conclusions

Key safety culture and organizational issues were determined. The list of safety issues suggests a scope for safety culture and organizational evaluation of plants during decommissioning [43].

A number of organizational aspects the Ignalina NPP Top Management to address in developing a long-term strategy were identified:

- Setting the appropriate priority for decommissioning oversight;

- Developing an organizational strategy for decommissioning;

- Obtaining and developing necessary staff expertise for oversight of decommissioning;

- Determining and developing framework for oversight of decommissioning.

INPP had three foci for addressing human factors and organizational issues of decommissioning:

- Oversight and safety assurance during the period prior to and after shutdown of Unit 1 of the INPP
- Identifying and addressing the issues that were likely to arise regarding oversight of all stages of decommissioning and
- Identifying and responding to the safety issues that were likely to arise as a consequence of all stages of the decommissioning process.

ACKNOWLEDGEMENTS

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Nuclear safety – culture or obsession?

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Abstract. Although nuclear activities are among the safest, having an enviable record in this respect, public perception is quite different. It is argued here that, regardless of the fact that environmental groups and the media in general look unfavourably towards the nuclear sector, the emphasis the sector places on safety matters is a liability rather than a asset. In short, public acceptance of a risky enterprise increases with the safety concerns shown by an entrepreneur up to a certain point. Beyond this threshold the enterprise is found too risky to be accepted, and it looks like the nuclear establishment has already crossed it. Ideas for further relationship with the public are then shown.

1. Introduction

It can be argued that the word "nuclear" is more frequently associated with "safety" than with "energy". Although the common man does not usually refer to nuclear safety, every time he reads about or talks about nuclear energy, concerns about safety are implicit. This should be good news, were it not for the fact that the common man perceives all nuclear activities as inherently unsafe. This skewed perception was long attributed to the association between nuclear activities and the Hiroshima bombing. The idea that the world population could be wiped out in a flash was almost too much to bear, and any activity dealing with uranium or plutonium or radiation was likely to be seen as unacceptable. However, the fact that scores of wars have killed millions since 1945 and not one single atom bomb was dropped has certainly shown the public that a nuclear weapon is more nuclear than weapon. And hundreds of nuclear reactors have been operating for more than half a century, and not one of them came close to exploding like an atom bomb.

Despite the nuclear sector's enviable safety record (even the Chornobyl accident cannot be counted among the worst man-made disasters), news reports on nuclear matters are systematically negative and almost always full of mistaken data. They usually deal with "radioactive leaks", "radioactive doses", "exposure", "radiation contamination" (whatever that may be) and the like, and are not complete without words like "risk", "danger", "cancer" and "death". Inevitably, even minor nuclear or radiological accidents never fail to attract massive media coverage – and are never forgotten. An explanation for that is attempted here.

2. How much safety is too much safety?

A sizeable portion of man's activities throughout the centuries have centred on personal safety, starting with housing. Although it is not ethical to confer a monetary value to human life, the fact is that the rising cost of occupational accidents – in terms of loss of production, legal imbroglios and class action – was one of the main stimuli of the recent emphasis on personal safety. One way or the other, the culture of safety is, broadly speaking, something so deeply ingrained in everyone's mind that whenever a new product or technique is launched preoccupations with safety aspects very rarely are among the first priorities of potential users. It is implicitly assumed that whoever is capable of developing a product or technique should not be as incompetent or irresponsible to create anything unsafe.

In the old days, when this idea was not completely consolidated, acceptance of new ideas was far from immediate. One good example of the stepwise acceptance of a hazardous product is provided by the aeroplane. At first a very risky occupation, being almost solely the pastime of daredevils and stuntmen, flying nowadays provides a convenient, enjoyable and safe travel experience. Although it does not share with other means of transportation the possibility of mid-course stopping, flying is found safer by any yardstick. Even first-time flyers now enter jet planes with full confidence that nothing wrong will happen.

One interesting aspect of this public confidence in air travel is that it was not fuelled by any particular effort by airlines or aeroplane makers to stress safety. True, cabin crews are required by international law to demonstrate safety procedures just before takeoff, but very few passengers really bother to pay attention. But fear of flying is real, as the post-Sept. 11 syndrome showed. A zealous entrepreneur could well address this problem by stressing safety. His aeroplanes would be spotlessly clean and passengers would be shown maintenance reports indicating that parts are routinely replaced much earlier than technically required. While waiting for takeoff, passengers would watch a video explaining how recent air crashes occurred, being reassured that they would never happen to this company's planes. Finally, in order to allay any remaining fears, each passenger would be supplied, just in case, with a parachute.

It is not difficult to forecast the future of such a company (and even of all aviation industry, if such a company is ever launched): confronted with such an emphasis on safety, potential clients would certainly be completely terrified, because they had never been aware of the real danger behind air travel. The zealous entrepreneur crossed the threshold separating "enough safety" from "too much safety". Man has always lived with risks, and did his best to minimise them, especially when new technologies were introduced. The riskier the undertaking, the stronger the concern with safety, in order to deal with legal requirements, but mainly to ensure public acceptance. But there seems to be a limit to that, and a probable representation of the public acceptance of something risky is given in Figure 1. Given the direct relationship between risk and preoccupation with safety, if this preoccupation crosses a certain threshold the risk is judged too high to be acceptable. It looks like the nuclear sector has already crossed this threshold.

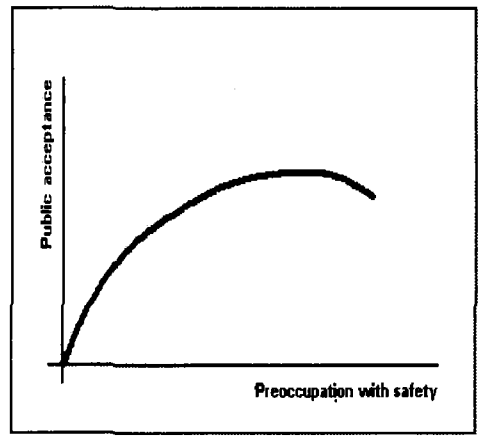

FIG. 1. How public acceptance of something inherently risky changes with safety concerns.

3. The case of nuclear safety

The concept that guides nuclear activities apparently states that they should be made entirely risk-free. This inevitably led to two alternatives: either these activities should be phased out or, in case some of them still had to be performed, no amount of effort and cash should be spared in order to guarantee that their risk was set as close to zero as reasonably achievable. Therefore, after having assured the world that all radiation doses, however small, could be harmful (through a strange concept known as linear non-threshold dose response, or LNT), after having created countless national and international associations devoted solely to the cause of radiation protection, after having swayed health authorities into passing legislation to control clinical X-ray exposure, after having convinced everybody that a tiny deviation of the planned dose in radiotherapy would kill the patient by rendering the applied dose either ineffective or deadly, these specialists told common man that they were so concerned with safety that neither him nor his progeny would ever be affected by nuclear activities, despite all risks associated with them.

Indeed, no economic sector is seen to be so obsessed with safety as the nuclear sector. This obsession is evident in the smallest details. Books on nuclear engineering, besides the usual engineering topics, will always add at least one chapter on the biological effects of radiations. Even the so-called popular

science books incorporated these trends: no book on radioactivity, nuclear energy, nuclear reactors or similar topics leaves aside Three Mile Island or Chornobyl. Which other engineering field would be so concerned with the effects of their activities on human lives? Which other human endeavour must stress that it is only promoting the peaceful use of anything? Which other economic activity (with exception of those having safety as their product) spends so much human and financial resources on one topic only, safety? Finally, which other sector, despite so many pledges, is still not trusted by the common man? Adepts of conspiracy theories credit this skewed perception of radiation, radioactivity and nuclear matters to oil and hydroelectric companies that would have plenty to lose by the proliferation of nuclear power plants. Others recall that radiation is an invisible threat, that can fatally affect people without their being aware of. What is the nuclear establishment's reaction to all that? It simply places more emphasis on safety.

Nuclear reactors, for instance, are surrounded by all types of biological barriers, in case anything wrong, however unlikely, happens. The reactor building is capable of withstanding the impact of a fighter jet loaded with conventional bombs. Redundancy systems are activated in case the standard systems fail. Environmental assessment in the area is carried out annually from the moment the reactor is planned. Moreover, no nuclear reactor is built before an emergency plan, necessarily involving the quick evacuation from a wide area, is designed and discussed with the community, the local government, the police authorities, the armed forces and so on. Of course, all these precautions are entirely justified. But other installations, like oil refineries or chemical plants, are also dangerous. However, the same precautions are not taken by their proponents, thus leaving the nuclear companies in the same position as the "zealous aviation entrepreneur".

Probably an even greater threat than the nuclear reactor itself is presented by the wastes it generates, although they are produced in very small amounts. All existing proposals to deal with radioactive waste are quite similar and start by choosing a suitable geologic formation (after countless studies and public hearings) as a final repository. In one of them, the waste is diluted and embedded in glass blocks. Each block is then encased in a steel drum full of concrete. Once this drum survives gruelling tests (broiling at 1000°C for one day, ramming by a 150 km/s locomotive), it is pronounced safe for burial.

Well, man has lived with toxic waste from immemorial times. Toxic chemicals are produced and disposed of in increasing amounts. Some are so dangerous that even minute quantities are capable of killing thousands. However, stricter regulations and a plethora of safety measures managed to reduce their risk to a minimum. But none of these regulations and measures compare with the almost sacred awe towards nuclear waste. It can be argued that the world will not become less safe if nuclear waste is treated like all hazardous waste, but it will be rendered unfeasible if all hazardous waste is treated like nuclear waste.

This is an area in which the common man's viewpoint should be heeded. He knows that highly-poisonous wastes are carefully sealed in steel drums that are later buried in engineered repositories, and he is satisfied with that. When confronted with the way nuclear waste is treated, can he be condemned if he thinks that, judging from the extreme precautionary measures taken, nuclear waste is so utterly dangerous that not only kills but also leads to eternal damnation, so that all nuclear activities should be immediately stopped? The irony is that all these precautions stem from the nuclear sector's safety culture. The philosophy behind radioactive waste management is that it should be disposed of in such a way as never to present any threat to future generations. This is clearly ideal, but negates future generations' ability to deal with environmental problems, besides being a highly questionable goal. Once again the "zealous entrepreneur" comes to mind.

4. Suggestions

It is commonly said that Caesar's wife must not only be virtuous, but above all look virtuous. However, if Caesar's wife roamed the streets of Rome proclaiming her virtue to the sound of drums and trumpets, the citizens would have all the right to be suspicious. So this is the nuclear establishment's present conundrum: it must assure the world that its activities are not unbearably risky without emphasizing safety, even though the potential risks have been raised by the nuclear sector itself. How is it to proceed?

In the first place, safety details can be presented in such a way as not to call attention to safety. Everybody knows what an electric switch is for, but it is in essence a safety device: connecting and disconnecting two wires would do the same job, but with a switch the risk of an electric shock is all but eliminated. By the same token, a nuclear reactor's containment building must withstand the collision of an aeroplane not only for safety reasons, but also to safeguard a one-billion-dollar machine. And X-rays exposures must be controlled not only due to radiological risk, but also to reduce costs and obtain better images.

Secondly, information, albeit accurate, must be conveyed in the simplest terms. If possible, a condition should be stated as either safe or unsafe, acceptable or unacceptable, and so on. Brazilians remember quite well when the government imported milk in 1987 and that this milk was branded as radioactive (some called it "Chornobyl milk"). Instead of commissioning one single laboratory to analyse the milk and issue a simple verdict on it (safe or unsafe), officials allowed the release of several different figures for the presence of radioactive materials in milk samples. Confronted with strange names like becquerel per gram, microsievert, permissible doses and, above all, with the conflicting results the laboratories periodically released, the population simply stopped consuming milk, thus risking malnutrition.

Thirdly, unnecessary connections between radiation or radioactivity and risks should be avoided. For example, well-meaning researchers have shown that tobacco contains natural radioisotopes (which is not surprising), but ended up by spreading the idea that smoking is harmful not because of nicotine or tar, but due to the inhalation of radioactive materials. And why stress all the time that a nuclear reactor will never explode like an atom bomb?

Finally, truth must prevail. Nuclear risks must be analysed, presented and dealt with accordingly, i.e., all safety procedures and their costs should be well justified. What is the point of telling a community that hundreds of millions of dollars are being spent to prevent an accident which is highly unlikely to happen anyway? And what will be the position of the nuclear establishment if something wrong does happen? Unfulfilled promises are by far the worst publicity.

5. Conclusion

The nuclear establishment disseminates the idea that it is a victim of the media, environmental groups and others that have put the public against it. Perhaps it is true. But it can easily be argued that after calling the attention for so many years to the safety aspects of nuclear activities and waging a campaign for the control of radiation doses that bordered the paranoia, the nuclear establishment has nothing to complain about: the 400-plus nuclear reactors that produce about one-fifth of the world's electricity, the nuclear fuel reprocessing plants still operating and the current use of radioactive isotopes are clear indications that if the public is not exactly enthusiastic about nuclear activities, at the very least it tolerates them. There is a universal tendency to take with a pinch of salt all concerns with

safety, especially if they look exaggerated. It is quite probable that the common man thinks that nuclear and radiation specialists have gone too far in their quest for safety.

In all, the nuclear sector, since it deals with palpable risks, must have a well-developed safety culture, which is certainly the main reason behind its fantastic safety record. However, this concern with safety seems to have crossed, at least on some occasions, the threshold that separates care from obsession. At a time when the world is beginning to feel that their energy needs will not be met by fossil fuels or hydroelectricity without significant environmental damage, nuclear energy appears as the obvious choice to bridge the gap to a time when more convenient energy forms are available. Food irradiation with gamma rays may be the answer to the pressing needs of agribusiness. Newer medical techniques using radioisotopes will extend the lives of millions, helping in the diagnosis and cure of many of today's fatal ailments. All this can only be possible if the common man perceives nuclear activities as risky but manageable (which they truly are). This perception, for its turn, can only be possible if the nuclear establishment exploits the advantages of its safety culture without looking obsessive towards it.

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The Safety Culture Change Process Performed in Polish Research Reactor MARIA

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Abstract. The Safety Culture Change Process Performed in research reactor MARIA is described in this paper. The essential issues fulfilled in realization of the Safety Culture Enhancement Programme are related to the attitude and behaviour of top management, co-operating groups, operational personnel, relations between the operating organization and the supervising and advising organizations. Realization of this programme is based on changing the employees understanding of safety, changing their attitudes and behaviours by means of adequate training, requalification process and performing the broad self-assessment programme. Also a high level Quality Assurance Programme helps in development of the Safety Culture.

The culture change process

The Safety Culture as a part of material culture is conditioned and developed in historical process and the level of culture is the function of industrialisation level, social-political relations, economical development and so on. The feeling of culture and its understanding is highly dependent on ethnic and national group, so also the culture change process must be dependent on these specific circumstances. The attempt on standardization of mechanisms by which we will try to change the culture seems to be unusful.

The culture change process should be conformed to national culture.

The most important factor in creation and development of Safety Culture is that it influencing the people awareness and its modification which allows to increase the Safety Culture understanding and creation of the processes which help the people to achieve this goal.

By the conventional training, system of motivation it is possible to create some attitudes, to respect the procedures, to respect the principle of behaviour i.e. the factors increasing the nuclear plant safety but they are only derivative issues of Safety Culture.

The process of development and improvement of Safety Culture contains the following issues, which we've considered as the most important and our efforts are focused on it achieve:

- Visible commitment of the management of the Reactor Operation Department to the improvement of Safety Culture.
- Involvement of the co-operating groups (project office, safety analyses and reactor measurement service, maintenance group) to increase their safety improvement.
- Improvement of co-operation with supervising and advising organizations such as: Regulatory Body, Safety Committee, Inspector of Nuclear Safety and Health Physics, Inspector of Quality Assurance.
- Involvement of operational personnel to improve the safety.
- Adequate training as an important factor improving safety.
- Introduction of the broad self-assessment process.
- Improvement of teamwork.

These issues are realized in the first stage of programme of improvement Safety Culture. In the second stage the elaboration of the system of performance indicators for assessment of Safety Culture is foreseen.

Safety Culture Enhancement Programme

II.1. Commitment of the top management of the Reactor Operation Department to the improvement of the Safety Culture

The top management must show the personnel why the improvement of Safety Culture is very important, what negative consequences can be created as the results of low level of Safety Culture. As often as possible should to be underlined the high significance of Safety Culture in the time of training, exams, organization of work and so on. Senior manager is a member of examination commission for requalification of personnel, which gives him an opportunity to verification the meaning of the Safety Culture concept and to record these questions which weren't properly understood. After they are being discusses in the time of training sessions.

II.2. Involvement of the co-operating groups (project office, safety analyses and reactor measurement service, maintenance group) to increase their safety improvement

The good practice performed in Reactor MARIA Operation Department is to invite the personnel of these groups to training meetings where the safety related problems are discussed. Such common meetings help the people to aware the importance of well performed work and it influence on safety. It's very important to aware what can be the consequences of badly done even the small work.

II.3. Involvement of operational personnel to improvement of Safety Culture

Engagement of operational personnel to improvement of Safety Culture is very important and without it the process of Safety Culture change is unrealistic. For this item we convoque many efforts and time.

Realization of it is carried out by following means:

a) Promotion of openness attitudes what help to avoid the cases of hiding the errors and events. Errors related to safety are considered as an opportunity to improve the safety through experience feed back. All detected defects and organizational errors have to be reported, after their analysing the lessons learned must be drawn. To obtain this goal it is necessary to aware the people that even small error if it has been analysed can by the source of knowledge which can be useful in development of safety. The error hidden by one person can be repeated by the second person. The important item of this question is of course the adequate system of reward and sanctions. The sanctions provoque to hiding the errors.
b) Taking into account the themes of training to be requested by employees. This gives us an opportunity to clarify the questions bothering the employees. Each training is ended by discussion which gives the opportunity to compare different points of view on Safety Culture and to choose the optimal solutions.
c) Performing the requalification process.
   All licensed personnel: shift supervisors, reactor operators, health physicists, I&C operators, mechanics, electricians have to pass the requalification exams. Requalifications is performed in every three years for shift supervisors, and in every two years for the rest of personnel. The exams are oral, because this gives the excellent opportunity to verify the understanding by employees the safety problems and the relations between their work and the reactor safety. Only the oral exams give this possibility. For experienced personnel this kind of exam is more reasonable then the test exam.

II.4. Open and partnership co-operation with supervisory organizations

The role of Regulatory Body and others supervisory organizations is important to improve Safety Culture but the co-operation between these organization have to be correct.

There are three external bodies supervisoring the reactor MARIA:

- Regulatory Body (Level of National Atomic Agency);
- Inspector of Nuclear Safety and Health Physics (Level of Institute of Atomic Energy);
- Inspector of Quality Assurance (Level of Institute of Atomic Energy).

We promote the open and partnership co-operation with this bodies, they are invited to discuss all problems related to safety, all new projects and modernization plans are negotiated with them. The inspections are always announced and their programme is determined. The big projects are discussed by Nuclear Safety Committee which is composed of specialists of different fields. Nuclear Safety Committee is the highest level endorsing board appointed by IAE Director.

II.5. Adequate training as an important factor improving safety.

Training is performing in such a way that it enables to increase not only the knowledge but also to change the personnel understanding of safety, attitudes and behaviours. To realize this goal it's very important to have the high level trainers who can not only transfer the knowledge but also are the agents promoting Safety Culture. The trainers have to be an authority on nuclear safety. To underline the importance of safety quite often the members of Nuclear Safety Committee are the trainers.

Very important item is also an adequate composition of training programme. The themes of training are chosen in such way that they enable to increase an understanding of the Safety Culture.

Frequent themes of training are:

- accidents which happened in nuclear reactors and analysing the reasons of these accidents, particularly if the human error was involved;
- unplanned shut-down in our reactor with detailed analyses;
- disturbances and defects in our reactor;
- presentation of new projects and modifications.

II.6. Broad self-evaluation process.

The managers of services analyse disturbances and unplanning shut-down occurred and present this in the time of training. Lessons learned serve to undertake the actions which resolve the problems before they will appear. Errors are also an opportunity to improve safety. The Officer of Quality Assurance verifies the reports of performed verifications, tests, calibrations of measurement devices and their accordance with the schedule contained in Quality Assurance Programme. He verifies the registration in the cards of disturbances, the safety documentation, updates of procedures and so on.

Essential item of self-evaluation are quarterly reports on reactor operation. These reports constitute a proof of operation of the reactor in accordance with Safety Analyses Report and Quality Assurance Programme. The reports are accepted by Inspector of Nuclear Safety and Health Physics and after they are approved by Director of IAE and sent to Regulatory Body.

II.7. Improvement of teamwork

Correct preparation of tasks is one of many important factors influencing the Safety Culture. Each task is based on standard procedure or if it is unusual task or project it must be realised according to an individual Quality Assurance Plan. In these documents the detailed organization plan is presented and the responsibility for each employee is clearly defined.

It is the first, essential step which have to be fulfilled if we want to achieve satisfactory teamwork, particularly when a task is complex. The second step it is to make an appointment of all employees involved in execution of the task before the task has been performed. In the time of this appointment the task and the way of it realisation is presented, all unclear issues are discussed and first of all these related to safety. This gives a guarantee that all employees properly understand their role in execution of the work. These two steps are essential in achieving the high level of teamwork and in consequence high level of Safety Culture in performing the task.

The additional mean in improvement of teamwork it will be the training on understanding of group behaviour, interpersonal relations and the means of resolving the conflicts inside the group. This training should especially be addressed to managers.

Continuous improvement of Safety Culture

Always can be better then it is now, this is the motto which we repeat the employees. The continuous improvement of Safety Culture can be realised only when both the management and the employees will be genuinely interested in this. We do the efforts that the suggestions of improvements, both these related to equipment as these related to procedures would be initiated by employees. This gives the guarantee for the better engagement of employees in safety improvement process. The man who sees that his initiative is appreciated and realized will be more committed in performing his tasks.

Important aspect, applied in our reactor motivating the employees to creative attitude to Safety Culture is appropriate system of rewards (bonus, foreign mission for training and technical visit). Also the paths of promotion, depened on employee attitude and his commitment to improvement of Safety Culture.

A change of attitude: from rescue to prevention

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Abstract. The qualitative and quantitative leap recorded by economical companies after the Romanian Revolution occured in 1989, has positively influenced the functioning of the workplaces and working environment by incresing the employees' occupational safety, well being, health and results of their activities. In fact it has determined a new approach of safety culture. This has resulted in a change of attitude: from rescue to prevention.

1. Introduction

Safety culture is a term used to identify an overall approach to manage safety within an organisation. Safety culture consists of shared belief, practices and attitudes, which are deemed to characterize the organisation. Culture is the atmosphere, the invisible force which shapes our behavior.

The first thing to recognize about safety culture is that it cannot be quantitatively measured. Instead, it is more appropriate to survey attitudes and observe employee and management behaviors and the quality of the work process on the other hand.

Reviewing the way safety culture is achieved, we can conclude that it results from:

- management and employee attitude
- policies and procedures
- supervisory responsibility and accountability
- safety planning and goals
- actions in response to unsafe behavior
- employee training and motivation
- employee involvement

Safety as well as the work performance are functions of behavior. Behavior is a function of attitude. Therefore the right attitude is the cornerstone of a safety culture. Thus, safety culture should starts during the hiring process. To hire the right people, people with the right attitude should be an important requirement of corporate management.

2. Safety culture in a high centralized economy

Safety culture should be adopted by management. But divisional and corporate management is held responsible and accountable for both production and safety.

In a country with a high centralized economy, as Romania was before 1989, the major objective of the economic policy was the production increasing with a high productivity in any conditions. The principle "safety is topmost priority" was substituted by the assumption that danger does not really exist or, if so, only for beginners but not for experienced people. As result of this assumption, our rules had provided the employee training as a part of hiring process, but often the employees training appeared to be inadequate. As per the companies programs, knowledge refreshment was provided, but the productivity items did not permit to

spend an unproductive time. The mechanism of cost reducing and effective productivity increasing by reducing the number of accidents was not known as a viable one. Cost – cutting mania was sweeping through companies. Spending time and money on health and safety was not the agreed solution. Under planned economy conditions, in the companies, managers had often told workers that no additional costs would be incurred in maintaining a safe workplace. A variety of symptoms identified the absence of, or breakdown in safety culture. This situation may not be defined as a safety issue.

Beginning with the first work days, safety norms did not become salient in the minds of the people involved. But other issues were salient, such as efficiency. Improper selection of equipment or material, poor maintenance of facilities or equipment added to unsafe behavior resulting in a near-miss, injury or fatality.

Different situations activate different goals, norms and identities. These lead to situational ethics where norms are violated because they do not appear relevant to the situation at hand. Safety was not seen as an integral part of the workplace. More, when a fatal accident occurred it was hidden for good and all. The leadership ears should not learn of it. Employees were afraid to report accidents or injuries. Management "hided" behind the chain of command. Top-management was unaware of the real condition of the company and employees.

Lack of consistency in worker attitudes about what issues are important and unwillingness to face difficult problems or correct them are two important symptoms of safety culture problems.

Reviewing any of the components of a safety culture mentioned above, a conclusion is clear: the absence of safety culture is quite visible in the former Romanian economy. The rescue was the only action performed in an accident situation. Rescue was the only feature of safety and health activity. This concern may characterize the workers attitude in former Romanian companies.

3. Developing a safety culture in the new political era.

The changes occurring in Romania after the Revolution of December 1989, called for fundamental and structural modification of life quality. The new economic look, the new relationship with the external strong companies have led to a really safety culture.

There is no consistent and visible prescriptive formula for developing a strong safety culture. The choice of practices for developing an improved safety culture takes into account the existing weakness. To create a safety culture is a process involving many elements or sequence:

- individual awareness of the importance of safety got through communication, safety posters, warning signs
- knowledge and competence conferred by education and training
- commitment requiring demonstration of the high priority of safety
- recognition through observation to understand the objective of work and to know the methodology for completing the task
- corrective action and change through investigation of accident and near-misses and behavioral changes
- accountability through safety goal and activities

- results and benefits through reduced costs and increased productivity

These steps are now under development in most companies. When all these steps have been successfully taken, then we can truly affirm that safety culture exists in the company.

It can be appreciated that changing an existing culture has been a difficult process, because change may result in a temporarily increase of uncertainty. This change is product of a long learning process, during which an organization has to develop accepted ways of dealing with its problems.

Each important company has created an appropriate corporate management. The safety culture has formed as the management component. Divisional and corporate management actually has became responsible and accountable for both production and safety as "one of the same". The safety culture has begun to embrace all aspects of the organisation's way of doing business. Safety becomes the "way of life" for all employees at every level of the company.

Important changes become visible. When implementing a change in an employee's behavior should clearly identify the behavior to be changed and explain the basis of that behavior and the benefits of change.
When implementing a change in management system it is necessary to re-train employees relative to any new equipment, materials or procedures. The results of the changes will be monitored and the productivity enhancements can be quantify, a feedback on progress must be provided on a regular basis.

To hold employees accountable, they must be trained on a regular basis. The three elements: knowledge, skill, attitude must be in balance for successful training. Training is on-going, it never ends. The training sessions are more effective by using actual equipment and getting the employees involved, not looking in from the outside.

There are many results and benefits already proved from a safety culture for both the company and employees:

- direct and indirect costs of accidents as well as overall operating costs are reduced
- productivity improves when accident are prevented
- profit margins increase when accident costs go down
- job security, job satisfaction

Safety banners can be seen more often in our companies such as "Preventive Maintenance First", "Safety Before Profits", "Safety is Everyone's Responsibilities", "Safety First", "Think Safety". They express the essence of safety management and they give the message that accident prevention is primarily the responsibility of individual workers.

The actions to be performed are guided by corporate management for:
-avoiding hazards through design conception and completion of the installation
- assessment of the risks which cannot be avoided
- preparing specific norms
- employees training
- ensuring a competent control over the system operation.

Since accident prevention has been defined by management as an individual worker responsibility, it is often a subject of employee involvement programs. It is recognized that a safer workplace has been created in majority of our companies. It can be argued that the primary thing that has usually changed is that the reporting of injuries has been reduced.

Good maintenance, inspection and training programs act as a preventive measure reducing the probability or severity of an accident.

The analysis of accidents at work determines prevention measures, which are implemented. Prevention is an important function of corporate management in safety culture. Now, it is recognized that the cost – benefit analysis of preventive measures shows an undeniable benefit of the prevention actions if they are well designed and performed.

4. Nuclear safety culture – a high performance work system

The concept of safety culture or a safe conscious work environment takes a different view in high reliability organizations such as in the nuclear field. The idea is to couple safe behavior with safe work process. This means creating an environment where everyone is actively involved in safe work process and incorporate the concept of "defense in depth" into the work process.

Safety culture is seen as an important factor for an effective regime in nuclear power plants. The IAEA defines safety culture as the "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". For this domain, more than anywhere else, safety culture requires all duties important to safety to be carried out correctly, with alertness, due to thorough and full knowledge, sound judgement and a proper sense of accountability. All those engaged in matters related to nuclear safety are likely to insist that what is described is entirely characteristic of their own approach.

I have to let you know that, fortunately, in our company - the owner and operator of the nuclear power plant, safety culture was created in the new era, when the social – politic framework has already been changed. The management duty has been easier than changing an existing conception.

The special training carried out by all people involved in nuclear power project have given the concept of safety a greater meaning than just compliance with safety regulations. It emphasizes the reduction of risk and uncertainty that hinders safety and reliability. The basic underlying assumption is that when employees are working safely, they are considering the risk of their actions, are aware of their environment, and are prepared with contingencies.

Some concepts and action are found in our nuclear plant as elements of safety culture:

- unqualified commitment to safety as a behavioral pattern and pervasive way of life by top management
- for all employees, safe life patterns and work habits are as normal as breathing they must be practiced off the job as well as on the job
- availability of quality, standardized equipment with which to accomplish the assigned tasks
- clear, easily understood operating procedures, followed without deviation
- inclusive system of communication for collecting, analyzing, and exchanging incident data related to safety
- re-training without penalty or stigma when safety is involved
- system for tracking incident and accident data, analysis of trends, and feedback of results
- peer acceptance that accidents are preventable, regardless of operations
- peer acceptance that safety is a matter of lifestyle – a matter of culture.

The Cernavoda Nuclear Power Plant has been operated safely through a period of five years. No event affecting nuclear safety has occurred. No event was rated higher than the first level on the INES scale. These aspects give a valuable indication of that safety culture is successfully developing and confirm the effectiveness of specific management action in relation to safety, achieved by a continuous process of growth and maturity.

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