

REQUIREMENTS TO AMEND THE MAIN INFLUENCE FACTORS ON THE SAFETY CULTURE AFTER FUKUSHIMA ACCIDENT

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ABSTRACT

The paper presents a general model that provides a framework for the safety culture assessment, creating the possibility to identify factors that can significantly influence the safety culture. The main safety culture influence factors (SCIF) used by model are the following: regulatory environment, organizational environment, worker characteristics, socio-political environment, national culture, organization history, business and technological characteristics. After the analysis of the deficiencies and weaknesses of SCIFc in evolution of the Fukushima accident, some issues that may become necessities and requirements to change and improve both the safety culture and safety of the nuclear installations were highlighted. For each influence factor were identified some requirements to amend. The results will emphasize the necessity of the human – technology - organization system assessment. Hence it was demonstrated that the safety culture results from the interaction of individuals with technology and with the organization.

Key words: safety culture, nuclear, accident

Introduction

The safety culture continues to be of great interest to the international nuclear community and constitute a major challenge with regard to the integration of the lessons learned and improvements into a better approach to safety. As a result of the efforts to understand the safety culture concept, many definitions have been issued. For example in (1) the concept is defined as “the set of beliefs, norms, attitudes, roles, social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious”. The International Nuclear Safety Advisory Group (INSAG) defines it as the “assembly of characteristics and attitudes in organizations and individuals which establishes that, with overriding priority, nuclear plant safety issues receive the attention warranted by their significance” (2). Hence, the safety culture is important because it influences the contributors in behaviors, attitudes and values, which are elements needed to realize the nuclear facilities performance.

The consequences of the Fukushima accident (11 March 2011) had great impact both within Japan boundaries and outside. To mitigate this accident and limit its consequences not only technical problems were relieved but safety culture issues were highlighted also as key elements in this accident. As a result of analysis of the Fukushima accident reports ((3), (4), (5), (6), (7) and (8)), human and organizational factors, organizational culture and safety culture were highlighted as the key areas of impact on nuclear

safety. It could be concluded that there is an indubitable need for development, implementation and evaluation of them.

Woody Epstein, in a presentation at Hiroshima University, said he is sure that nuclear power generation has, and always will have risks. Nothing is 100% safe (9). The experts say that the Japan's Fukushima accident could have been avoided, but there was a belief that such a severe accident "cannot happen here". This attitude had a significant influence on safety culture.

The role of safety culture in the nuclear field

The nuclear safety is a set of technical and organizational measures considered to ensure the prevention and mitigation of consequences of any abnormal or accident situations that may impact on the personnel, population and environment (10). All organizations engaged in important activities in nuclear installation operation have the responsibility to give the highest priority to activities related to nuclear safety.

The importance and necessity of safety culture are specially described in the fundamental principles of safety 3 (Leadership and security management) and 8 (Prevention of accidents) (11). For a nuclear installation, the safety culture should include the following strategies:

- Individual and collective commitment to safety from leadership part, management and personnel at all levels;
- Accountability of organizations and individuals for safety at all levels;
- Measures to encourage a questioning and learning attitude and to discourage the complacency with regard to safety.

In Japan, a safety culture statement had been proposed. This was defined as a confluence of behavior norms, attitudes and traditions. The statement apparently signaled a commitment for an organizational culture directed to a strong safety. After the Fukushima disaster it was accentuated the fact that in Japan was a big difference between the statement and its application (6).

According to (12) the accident showed quite a number of problems in Tokyo Electric Power company (TEPCO) such as: insufficient capability in organizational crisis management; problematic hierarchical organization structure in emergency responses; insufficient education and training assuming severe accident situations; and apparently no great enthusiasm for identifying the accident causes.

In light of the nuclear accident at Fukushima Daiichi some observers have pointed out that certain unique national factors have impacted, both positive and negative, the safety culture prevailing in the Japan nuclear industry (13). This applies not only to Japan. All nations have strengths and weaknesses. Few methodologies for assessing the safety culture have included national factors (for example: SCART). Each Member State shall ask what factors in a context of national culture can facilitate or hinder the development of a strong safety culture.

Main factors with influence in the safety culture

According to (14), the main factors that could significantly influence the safety culture are the following: regulatory environment, organizational environment, worker characteristics, socio-political environment, national culture, organizational history, business environment and work/technology characteristics.

■ Regulatory environment

The regulatory body' role is to protect public health and safety related to nuclear energy. It oversees reactor safety and security, reactor licensing and renewal, licensing of radioactive materials, radionuclide safety, and spent fuel management including storage, security, recycling, and disposal. An independent regulatory requires three things (15):

- (1) structural independence (a regulatory body with adequate regulatory powers and defined relationships with other governmental bodies and non-governmental bodies that assure no undue influence;
- (2) operational independence (adequate technical and financial resources);
- (3) cultural independence (establishing and fostering a strong, independent safety culture among agency management and employees).

■ **National Culture**

In developing an improved safety culture, attention needs to be paid to the national culture. In some countries there may even be significant differences among regional cultures (14). The characteristics of a national culture can amplify or attenuate the factors associated with a good safety culture. A simple example of the potential of the national culture to influence safety culture in a positive or negative way is provided by a national culture which readily accepts large differences in status and power, and provides limited access to persons with authority. In such a culture there may be strict compliance with regulations and commands. National culture is a factor that can shape the culture of nuclear safety. In some cases, the safety culture of the organizations that have nuclear plants seems to exceed the national culture, but in other cases, national culture appears to influence the safety culture. We may conclude that the safety culture assessments should take into account the influence of national culture characteristics (16).

■ **Organizational Culture**

Safety culture and human and organizational factors were identified as important elements that could affect consideration of external events, design, severe accident management, including operator training, proper functioning of national organizations and preparing for emergencies (17). Despite a general agreement on the importance of organizational factors there is no consensus on relationships and their definitions. A general classification of relevant variables organizational factors leading to nuclear safety is provided in **Figure 1**.

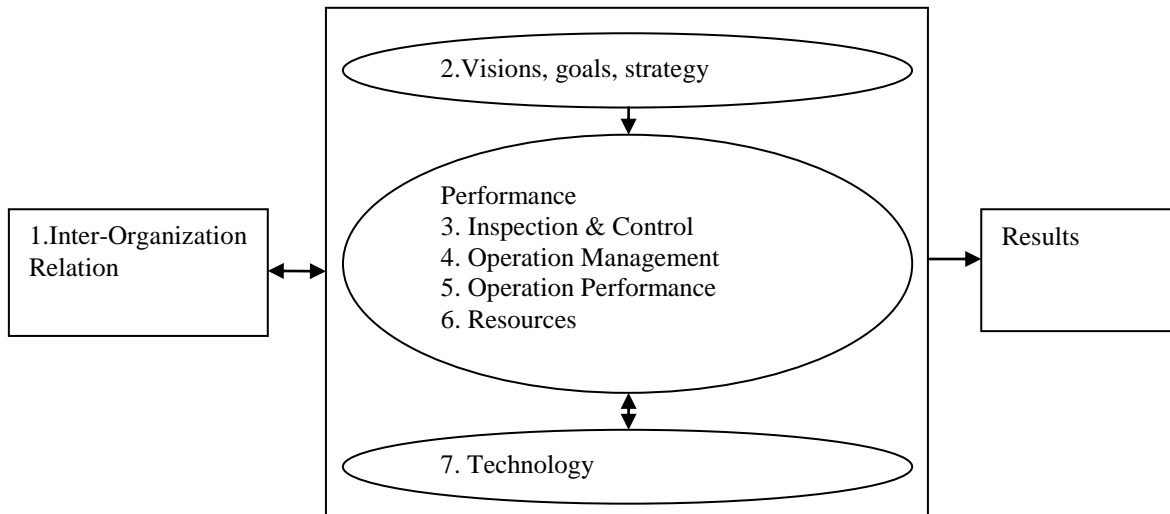


Figure 1 Organizational factors and nuclear safety: a classification of relevance variables (17)

■ Worker Characteristics

For appreciable professional results, an operator does not suffice only the competence. Something else is needed for reaching the performance, as reflected in the formula:

$$PERFORMANCE = COMPETENCE + ATTITUDE$$

Attitude (Professional) is an employee's intention to work, to be useful to work, to exploit its entire professional competence. *Competence* is the ability of an individual to do properly a task. A competency is a set of defined behaviors that provide a structured guide enabling the identification, evaluation and development of the behaviors in individual employees (18).

The main individual characteristics are the anthropometric features, the psychic, the skills and the knowledge. The human behavior represents what a human does and says. It is a noticeable act which can be seen and heard. It is measurable.

■ Organization History

History is part of the underground organization providing a substantial support in the emergence of what was to survive and that is visible and palpable for developing the nuclear field. In this light, norms, values, basic assumptions underlying reality are developed. The experience is a main element to understand the organization history. Visible aspects of culture refer to things made by man, people's actions, and language.

■ Technology characteristics

Generally, it is acknowledged that the specific and unique aspects of the nuclear technology must be admitted and considered as key aspects of the nuclear safety culture. It is defined as a complex tool that performs a function or a process. Individual characteristics of the machine are the technical specifications of the equipment, the reliability and the economic parameters.

Results

■ Requirements to change the influence factors on safety culture

TEPCO (*Tokyo Electric Power Co*) has been prepared for different accident scenarios which imply faults of equipments and human errors. However, the arrangements were not enough to prevent the accident due to a tsunami beyond design base. Any confusions developed on the subject of the core cooling systems and actions to change to alternating methods were not scheduled and managed.

Also, the operation and maintenance personnel have not had the necessary procedures, equipment and training to ventilate first containment vessel in the event conditions.

As a result of analysis of the Fukushima accident reports, safety culture was highlighted as a key area, with major impact on nuclear safety. The need for understanding, development, implementation and evaluation of safety culture has been stressed. **Table 1** presents the changes needed for safety culture influence factors. These changes could lead to a more solid safety culture.

Table 1 *Requirements to amend the main influence factors on the safety culture*

| Influence factor | Need to amend |
|-----------------------------|---|
| National Culture | <ul style="list-style-type: none"> - Relationship between the national culture and NPP operation and its influence on safety culture - Consideration of the safety culture in the national context - The investigation and analysis of positive or negative national cultural aspects in all efforts related to safety culture |
| Regulatory environment | <ul style="list-style-type: none"> - Importance of the regulator independence - The safety culture of the regulator for effective supervision of safety of nuclear installations. -The ability to make decisions independently and safely enforce them require competent and sufficient human resources, adequate legal authority and adequate financial resources. - Learning from accidents (the regulators must learn from accidents and not distance themselves to take into account the differences). - Keep up with the latest knowledge and technologies, and continuously undergo reform activities under the supervision of competent bodies |
| Organizational environment | <ul style="list-style-type: none"> - The responsible for developing and implementing the nuclear safety program, - Establishment of policy guidelines and supporting documents (such as training materials and communications) - The planning for more rigorous and clearer responsibilities; - Establishing clear the people, offices and organizations that deal with the distribution of information and decisions that have been established; - The improvement of protective measures both on site and off site; - The appropriate training and exercises both expected events and unexpected events; - The development and evaluation of safety culture. |
| Worker characteristics | <ul style="list-style-type: none"> - Learning from accidents (the operators must learn from accidents and not distance themselves to take into account the differences). -The acquirement of the competent experts in behavioral and social sciences, specializations in nuclear technology and operation, human factors,organizational and safety culture assessment. - Participation in at least one emergency preparedness response organization drilled each year in the simulator. |
| Socio-political environment | <ul style="list-style-type: none"> - The laws on nuclear issues (they must be completely reformed). - The roles for operators and all government agencies involved in emergency activities (they should be clearly defined). - Monitoring and regular updates must be implemented in order to maintain the highest standards and the highest technological level of the international community in the nuclear field. - Criteria to determine whether the reactors should go out of service. |
| Businesses environment | <ul style="list-style-type: none"> - The cooperation between suppliers, users, government regulators and public should be enhanced. |
| Features Work / Technology | <ul style="list-style-type: none"> - The implementation of defense in depth (DiD) measures at nuclear facilities. - The power plants with modern reactors (are safer and can be operated more safely than the ones that caused major accidents). -Models even safer, such as Gen III+ and Gen IV, equipped with several passive cooling systems that can cool the fuel in days without electricity supply and high pressure water injection, among other improvements. |
| Organization History | <ul style="list-style-type: none"> - Investigation of the activities and products made by the company, the used and abandoned researched technologies (in order to understand the skills and the vision of developments); -Analysis of the employees and their behaviour (work experience, education, occupation function type), strategies and how they succeeded: the evolution of competitive position, specialization / diversification, internationalization, relations with suppliers, distribution networks. |

■ **Relationship between the main influence factors**

After analyzing the deficiencies and weaknesses identified in mitigation of the Fukushima accident in a systemic approach to safety culture, some issues were highlighted. They may become necessities so they can change, maintain and improve the safety culture. The results presented in **Table 1** emphasized again the Individual – Technology - Organization system assessment. Further, in **Figure 2**, the relationships between ITO system and the main influence factors in safety culture assessment are presented.

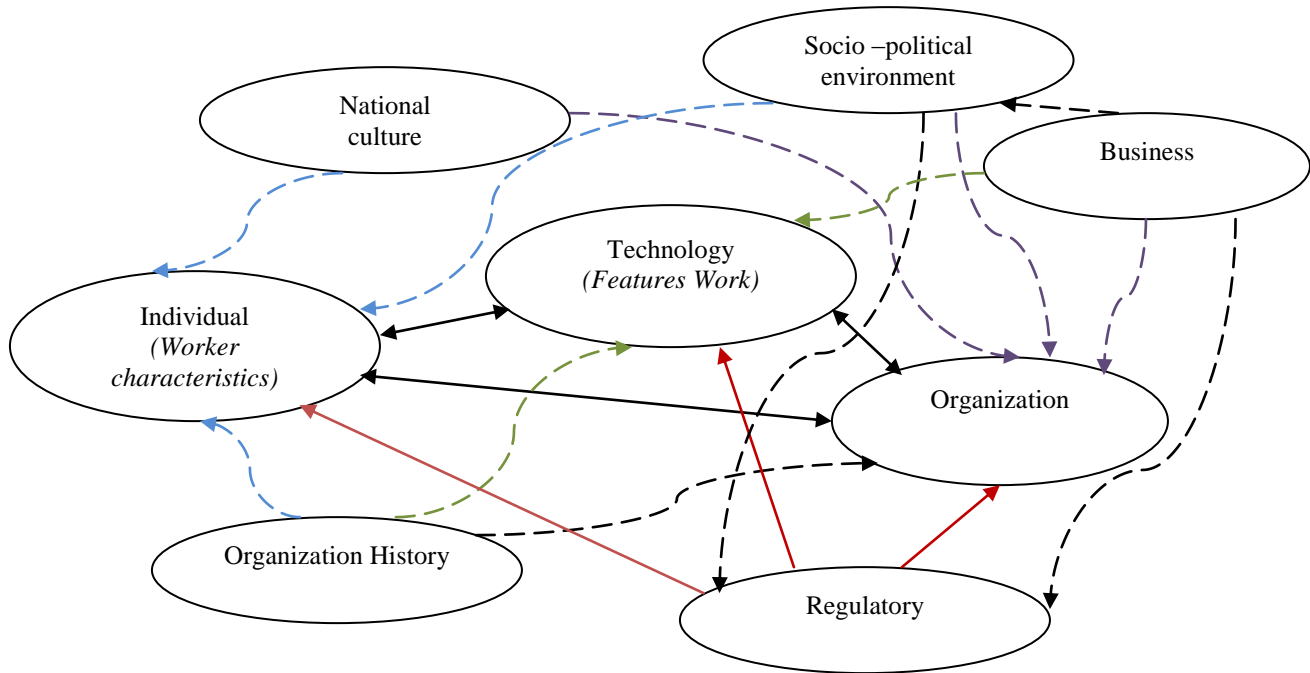


Figure 2 *The relationship between the main influence factors in the safety culture*

The regulatory environment has a direct influence in ITO system. National culture, organization history, socio-political environment and business could indirectly influence the ITO system. They can amplify or attenuate the influence mechanisms on the regulators, individuals, technology and organization. This result should lead to the need to analyze the mechanisms by which the factors are influencing both ITO system and safety culture.

Conclusions

(C1) Starting from the basic principles of nuclear safety, 3 and 8, the results of studies and reports regarding to nuclear safety culture have been useful in identification of the requirements for development, maintenance and improvement of nuclear safety. Many studies and reports on the Fukushima accident have highlighted the safety culture as a key element in the nuclear field. It is important to know the factors that influence the safety culture and to use them to anticipate new developments in the nuclear field.

(C2) The main factors which influenced the safety culture in Fukushima accident are the following:

- National Culture
- Regulatory environment
- Organizational environment
- Personal characteristics
- Technical characteristics
- Socio-political environment

For each factor analyzed, the necessary changes were identified, so that the positive influence would lead to a stronger safety culture.

(C3) The main conclusion of this paper refers to the complexity of the safety culture field. It is demonstrated that safety culture is a multidisciplinary field with accent on the data and principles of the behaviour, social and cultural sciences, engineering and organizational culture. The development, maintenance and improvement of a strong nuclear safety culture is an ongoing process that requires a sustainable commitment from all the parties involved.

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I.2 NUCLEAR REACTORS AND GEN. IV