TOPICAL SESSION 3

BUILDING CULTURE FOR SAFETY

Papers submitted

PAPERS SUBMITTED FOR TOPICAL SESSIONS ON BUILDING CULTURE FOR SAFETY

T. REIMAN - Safety Culture in New Build Projects

A. M. BOMBEN – The FORO Project on Safety Culture in Organizations, Facilities and Activities with Sources of Ionizing Radiation

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SAFETY CULTURE IN NEW BUILD PROJECTS Hanhikivi 1 NPP construction project

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Abstract

When developing safety culture it is necessary to go beyond individual attitudes about safety to the level of shared thinking, beliefs and values about safety. New build projects present a very specific challenge to building a shared culture in a multi-organizational, multinational endeavor with both technological and social complexity. Fennovoima is a new Finnish nuclear power company that will build and operate a nuclear power plant in Pyhäjoki, Northern Finland. The paper presents the Hanhikivi 1 NPP project and Fennovoima's safety culture program. The paper concludes by presenting several key themes that are important to safety culture especially in new build projects but also in the nuclear field in general.

1. INTRODUCTION

The safety culture concept was born in the aftermath of the Chernobyl accident in 1986 [1]. It strives to catch the influence of social and organizational phenomena to safety. It reminds us that accidents often have their roots in organizational and managerial shortcomings, and could thus be prevented by better safety management systems, organizational development and safety leadership. It also illustrates the importance of reflecting how we view safety, how we value it in comparison to other goals that we have, and what things we consider important in achieving safety. The concept highlights the fact that it matters how people in organizations perceive and conceptualize safety [2]. Safety culture can be defined as the shared values, beliefs and assumptions relating to (nuclear) safety [2]. There has been a lot of attention to safety culture in operational power plants, but a healthy safety culture is also critical during the construction stage [3, 4]. This paper presents how Fennovoima, a new power company applying for a construction license, has implemented a safety culture program. The paper also abstracts a few lessons learned about the importance and challenges of safety culture in the pre-operational stage of a nuclear power plant.

2. HANHIKIVI 1 CONSTRUCTION PROJECT

Fennovoima is a Finnish nuclear power company that has been established in 2007. Fennovoima will build a new nuclear power plant to a greenfield site in Pyhäjoki in Northern Finland. Fennovoima will also operate the plant when it has

been commissioned. The exact location of the plant is called Hanhikivi and hence the name of the plant will be Hanhikivi 1. The project uses the acronym FH1.

The plant will be Rosatom's AES-2006 pressurized water reactor. Fennovoima has made a turn-key contract with RAOS Project Oy, subsidiary of JSC Rusatom Energy International, which is part of the Russian Rosatom Group.

The electric power of the plant is approximately 1200 MW and thermal power approximately 3200 MW. The planned commercial operation is at least 60 years. The main contractors include Atomenergomash, Atomproekt, Gidropress and Titan-2. Atomenergomash, Atomproekt and Gidropress are subsidiaries of Rosatom.

Fennovoima has two owners: Finnish Voimaosakeyhtiö SF and Rosatom's subsidiary RAOS Voima Oy. Voimaosakeyhtiö SF owns 66 percent of Fennovoima and RAOS Voima Oy 34 percent. Voimaosakeyhtiö is owned by Finnish regional and local energy companies as well as companies in industry and trade. According to the agreed schedule, the electricity production of the power plant will begin in 2024. [www.fennovoima.com]

Fennovoima submitted the Construction License Application to STUK (The Radiation and Nuclear Safety Authority of Finland) during summer 2015. However the application will be supplemented with technical documentation during 2016. At the same time Fennovoima is developing its own organization and recruiting a lot of new personnel. At the moment there are approximately 250 people at Fennovoima, a significant increase compared to previous year's workforce.

At the construction site in Pyhäjoki, extensive construction work of infrastructure and auxiliary buildings is already undergoing. The plan is to have the construction license in 2018.

3. FENNOVOIMA'S SAFETY CULTURE PROGRAM

To ensure high level of safety culture throughout the life cycle of the power plant, Fennovoima has committed to a systematic development of its safety culture. Fennovoima employs a Safety Culture Manager (the Author), who is in charge of the Nuclear Safety Culture Program (NSCP). It defines the key principles of nuclear safety culture as well as the tools and methods used to facilitate and monitor it. The NSCP is divided into four targets (see Fig 1). The periodical Nuclear Safety Culture Program Implementation Plan describes the detailed implementation of this program including schedule and resourcing.



FIG. 1. The relationship between the NSCP targets 1-4.

"Nuclear safety" is defined as the condition and ability of the nuclear installation and its servicing personnel to prevent the uncontrolled development of a fission chain reaction or an inadmissible intentional or non-intentional release of radioactive substances or ionising radiation into the environment. Nuclear safety also includes the condition and ability of the nuclear installation to mitigate the consequences of accidents.

Nuclear safety is a sociotechnical issue, where the "condition and ability" refer to technology and people, as well as their interaction. As a long-term issue, many activities affect nuclear safety not directly but gradually by either creating better conditions and ability, or creating latent weaknesses in the sociotechnical system.

"Nuclear safety culture" is defined as the shared values, beliefs and assumptions relating to nuclear safety. Nuclear safety culture forms as the organization develops ways of responding to issues it considers relevant for nuclear safety and ways of ignoring those issues it considers irrelevant. NSCP intends to guide and monitor the development of nuclear safety culture in Fennovoima as well as the entire supply chain involved in the FH1 project.

Next, the four targets are elaborated and examples of recent activities are given to shed light on how the program has been implemented in practice.

3.1. Establishing shared values and structures

The first target aims at establishment of shared nuclear safety culture goals and expectations first for the FH1 program and then for the operation phase. It further aims at developing the structural features of the organization in a manner that they would adhere to and support the achievement of the safety culture goals, as well as high level of nuclear safety. Fennovoima has devoted time and resources for establishing shared values and ways of working concerning nuclear safety. Fennovoima has also established its expectations for high level nuclear safety culture in the EPC contract. The EPC Supplier (RAOS Project Oy) has responded to these requirements with their own Safety Culture Program.

Fennovoima has, together with the Supplier, defined a safety culture policy statement and four principles of strong nuclear safety culture for the Hanhikivi 1 Project. The principles are Commitment, Awareness, Transparency, and Continuous Improvement. A joint safety culture policy statement has been issued in collaboration with the Supplier. This policy statement describes the top management commitment to the priority of nuclear safety and sets the expectations to all parties participating in the project to adhere to the four safety culture principles.

Fennovoima's nuclear safety policy and nuclear safety manual also incorporate the main points about safety culture. Supplementary material such as booklets and printouts will be created regularly during the project.

Fennovoima has established several channels for reporting and handling safety and quality issues. There is for example a possibility to report safety concerns to the Safety Culture Manager (see below 3.3).

Fennovoima has nominated several personnel from different departments to act as safety culture ambassadors. So far fourteen ambassadors have been nominated. The Safety Culture Manager leads and supervises the ambassador work. Ambassadors are the contact points in all safety culture matters: they provide information to personnel about how safety culture manifests in their jobs, and help the Safety Culture Unit in arranging various promotional events. The ambassadors act as a people's voice, communicating concerns, positive findings and other safety related news to the safety culture unit. Safety culture ambassadors act as a positive driver of safety culture development. The ambassadors will receive tailored training in safety culture improvement and self-assessment during the following year.

3.2. Facilitating and promoting safety culture

The second target aims at facilitating and promoting the development of a healthy nuclear safety culture in Fennovoima as well as all other organizations performing safety critical work and/or having access to the construction site.

The safety culture training is the main tool to communicate the nuclear safety culture expectations to all in Fennovoima organization as well as all other individuals and organizations performing safety critical work and/or having access to the construction site. In Fennovoima the safety culture training is mandatory to all employees and in-house consultants. Fennovoima requires that all employees of Suppliers and subsuppliers performing safety critical activities receive safety culture training. In addition, everyone entering the construction site participates to a site training that includes a section on safety culture.

Fennovoima organizes regular cross-organizational safety leadership seminars to engage the top management. The seminars highlight good organizational practices and interactive meeting skills. The seminars intend to build bridges and create consensus, openness and willingness to contribute among contracting parties.

A Safety Culture Day was held for the Fennovoima Management Team (FMT) on October 2015. The day included safety culture training given by the safety culture manager, presentation of a brief survey of Fennovoima's safety culture, and group work on the management commitments to the principles of good safety culture. FMT selected a number of commitments that were afterwards elaborated.

A special event called Safety Culture Afternoon to all personnel was held on December 2015. In the event the new safety culture principles were launched (see Section 3.1), the top management presented their safety culture commitments and the personnel worked together on defining further commitments. A cartoonist was hired to illustrate each of the principles with a picture. These were made into posters and posted on the corridors and meeting room walls immediately after the Safety Culture Afternoon. They were also implemented as a screen saver into every computer at Fennovoima.

During December 2015 – January 2016 all units at Fennovoima completed a safety culture assignment based on the Safety Culture Afternoon. It required the units to discuss their practices and Fennovoima's safety culture in relation to the four safety culture principles and answer the following questions: a) what is currently working well, b) what needs improvement and c) what is our commitment, aka what can the unit in question do to live up to the safety culture principles. As of February 2016, 27 units have returned the completed slide. The next step is to summarize the units' commitments and create organizational level commitments; concrete actions and practices that everyone shall adhere to.

3.3. Monitoring of safety culture

The third target aims at monitoring the level of safety culture and identifying its strengths and weaknesses. This monitoring focuses on Fennovoima as well as on all other organizations performing safety critical work and/or having access to the construction site.

Both internal and external audits are used to verify the existence of the organizational nuclear safety culture practices. Safety culture has been a regular topic of the supplier audits conducted by Fennovoima. During the next years, focused auditing of safety culture will be started against the contract requirements and the requirements set in the regulatory guides by STUK. Fennovoima has made a

graded approach for safety culture auditing with three levels: 1) auditing the safety culture program contents, 2) auditing the implementation of the safety culture program and 3) full scale safety culture evaluation.

As mentioned in 3.1., Safety concerns can be reported by email, the Integrated Data Management System, or a physical mail box. The Safety Culture Unit handles all concerns, makes a preliminary analysis of their significance, and delegates them to subject matter experts based on the content of the concern in question. The Safety Culture Unit pays attention to the type, quantity and content of the concerns and their potential underlying factors. The main content of the concerns are reported regularly to the top management along with suggestions for development actions. Concerns that are evaluated as critical in significance are reported immediately to the top management and immediate corrective actions are taken.

Safety culture self-assessment is carried out bi-annually as part of the Management Review. Safety Culture Manager writes an annual follow-up report that summarizes that year's activities and evaluates the current strengths and weaknesses of the culture. Safety culture ambassadors are key resources in the regular self-assessment of safety culture.

3.4. Review of the program

The fourth target aims at continuously improving the safety culture program itself. It includes acute measures taken to correct identified deficiencies in safety culture as well as regular review of the goals and methods of the program against the current level of safety culture. The program review also takes into account findings on the safety culture of the Supplier and the supply chain.

The program can also be modified in a faster pace if there are acute signs of degrading safety culture or other problems in any area of activity. These signals come mainly from the carrying out of the activities described in Target 3, Monitoring of safety culture.

4. LESSONS LEARNED ABOUT SAFETY CULTURE

This section deals with three main lessons about safety culture in the preoperational phase: systemic view on nuclear safety, communication of special characteristics of nuclear construction, and cultural dialogue. Underlying all these three lessons is the need to better understand the unique nature of safety culture in project settings, and the unique requirements that projects set for nuclear safety. These lessons are a personal reflection of my work as the Safety Culture Manager at Fennovoima from November 2014 to this date. They also reflect my history as a scientist at the VTT Technical Research Centre of Finland, my previous employer.

4.1. Importance of a systemic view on nuclear safety

It is important to clearly separate (safety) culture from the other elements of the workplace, such as social structures, organizational structures, and technology, but also from the individual behaviors [cf. 5, 6, 2]. Culture refers to a shared socially constructed abstract systems of meaning, norms, beliefs and values that has an effect on behaviour but cannot be reduced into behaviors.

The abstract nature of culture makes it very difficult to define concrete and measurable development actions. Often those targets that are concrete and easily measurable focus on too narrow aspect of safety culture, and on a too short time perspective (e.g. counting the number of improvement suggestions, no. of management walk-arounds, non-conformities etc). Developing safety culture means developing the organizational preconditions, ways of working, structures, competence and tools, not only behavior. These preconditions should allow good quality work but also support a nuanced view of nuclear safety itself. It is not self-evident how different decisions will affect nuclear safety in the long run. Understanding the complexity of nuclear safety and the many sociotechnical factors affecting it is a critical element of good safety culture in all stages of a power plant's life cycle. All this implies a need for a systemic model of culture. The following simplified model, based on Reiman and Rollenhagen [2] guides the safety culture work at Fennovoima (see Fig. 2).



FIG. 2. Elements of safety culture from the deep core to its outer manifestations.

Safety culture is by its very nature intangible and as such difficult to observe, measure or manage. The tangible "artefacts" of culture can be observed, but the development of safety culture should not focus on these tangible issues only. Especially in the pre-operational phases where many important artefacts are in the making (design basis, documentation and the actual construction of systems, structures and components), it is important to try to influence the underlying guiding principles, values and assumptions as well as the "safety management system" of the company.

An added challenge is created by the nature of projects as multicultural in many sense. Schein [7, p.5] argues that due to e.g. globalization "understanding culture at any level now requires some understanding of all of the levels". He also proposes that as the world becomes more interdependent and global, "it will be differences in the deep assumptions about authority that will be most problematic" [Ibid., p. 104]. Thus, in terms of nuclear safety in projects it is important to identify which cultural differences are highly significant for nuclear safety and which are less significant.

4.2. Communicating the special characteristics of nuclear construction

Clear communication of nuclear safety and safety culture expectations is important since many organizations and individuals involved in the project may have no insight on how safety culture relates to nuclear power plants, or how nuclear safety depends on the construction activities. Organizations that operate in the construction sector often associate safety only with occupational safety issues, not with nuclear safety. Thus, it is important to differentiate nuclear safety from occupational safety.

Further, it may be unclear to the workers how the construction phase affects nuclear safety of an operating plant. When workers are asked to perform their work differently than previously (e.g. in conventional construction sites), explanation has to be given. For example, structures, systems and components may have different functions during emergency that exceed or differ from their quality requirements during normal operation. The strict quality requirements and use of certain methods & procedures, documentation requirements etc. may seem unimportant or even irrelevant if nuclear safety is not considered.

Accidents have a social and cultural context and a history [8]. They are not sudden events but rather a slow degradation of the sociotechnical system where an accident is only the most tangible sign of the process. Due to e.g. cultural blindspots this degradation can remain undetected and no remedial actions are taken before an accident occurs. This detection is especially challenging in the pre-operational phase. This is due to the fact that mistakes and non-optimal choices made during this phase can have consequences years, even decades later.

4.3. Cultural dialogue in the project and the supply chain

Safety culture is an organizational property. Complex construction project forms a virtual organization which can also be considered to possess a safety culture, its shared values, beliefs and assumptions about nuclear safety. In order to make this safety culture as coherent and healthy as possible, it is important to work together with all the parties on the fundamentals of culture: What does culture mean for the project, why is it important for nuclear safety, what are the shared principles we require everyone to adhere to, and what is critical for nuclear safety in the construction phase.

It is probably unrealistic to expect that all organizations share the same culture or even have similar structures or practices. However, as argued in 4.1, there should be some shared cultural features among the project participants, such as a view of the complexity and importance of nuclear safety. A certain degree of shared understanding is also needed of the proper ways of working, norms of conduct, authority relations etc.

The pre-operational phase is especially challenging from safety culture point of view because there are many actors who do not have a deep knowledge of nuclear technology or the special characteristics of the nuclear industry but are still crucial for the success of the project. The project has schedules and cost constrains that need to be taken into account. The "overriding priority of nuclear safety" [1] is much more abstract yet also a difficult concept in relation to the operation phase where the maintenance of status quo can often be considered safe – and production is automatically part of that status quo. In the project world, the time horizon is much shorter and requirements for practical achievements much more acute. Safety and production (schedules) are more visibly in conflict than in operational power plants, with safety being also more abstract and intangible. Furthermore, projects are inherently more varied and changing, challenging the traditional focus of safety culture methods on careful analysis and evaluation: action should dominate over analysis in safety culture development at complex and dynamic settings. To be more exact, action and analysis should be intertwined.

All of the above points to the importance of collaboration and working together from the start. There needs to be a willingness to understand the reasons for the behaviour of the other party. This goes for the national cultural differences but also occupational cultures, such as nuclear engineers and project managers. A cultural dialogue, however difficult and time consuming, is a must for a successful project execution in the nuclear field. There also needs to be an understanding of the requirements of the project work: not all practices, structures, beliefs are valid in the often turbulent pre-operational phases. The overriding priority of nuclear safety is fulfilled by different means before the start of the nuclear power generation.

The nature of the needed cultural dialogue is aptly described by Schein: "In an increasingly complex, interdependent, and culturally diverse world, we cannot hope to understand and work with people from different occupational, professional, and national cultures if we do not know how to ask questions and build relationships that are based on mutual respect and the recognition that others know things that we may need to know in order to get a job done" [9, pp. 1-2]. The specific challenges in achieving this openness and reciprocity in communication are again very much dependent on the existing national, organizational and occupational cultures.

5. CONCLUSIONS

Nuclear safety at any given time has its background, context and history. It is rooted in the decisions made during the life-cycle of the plant as well as in the current structures, practices and values systems. Development of safety culture is an important part of this context and history.

Safety culture is a collective mindset that characterizes a group, not a property of any one individual. When developing safety culture it is necessary to go beyond individual attitudes about safety to the level of shared thinking and the administrative structures and resources that embed ideas of what is means to be safe, and how safe we are now [8, pp. 20-21]. However, when building a new culture it is also necessary to pay attention to behaviour, even on an individual level. So called critical incidents and the management's response to those have a major influence on how the culture takes shape. It is also very much individual behaviour of key persons by which these administrative structures are created in the first place.

To conclude, developing safety culture in a new organization requires a systemic approach to nuclear safety; one that takes into account not only culture but other elements of the sociotechnical system such as social relations, power issues, tools, practices and also individual behaviour that builds and influences culture.

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THE FORO PROJECT ON SAFETY CULTURE IN ORGANIZATIONS, FACILITIES AND ACTIVITIES WITH SOURCES OF IONIZING RADIATION

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Abstract

The aim of the paper is to present the Foro of Iberoamerican Radiological and Nuclear Regulatory Authorities (FORO) Project on Safety Culture in organizations, facilities and activities with sources of ionizing radiation. To achieve and maintain a strong safety culture is a priority, in order to ensure the optimization of protection and prevention of radiological accidents. This means continuous improvement in the attitudes and behaviors about safety of the organizations, their management and workers. The FORO document on Safety Culture, in its various chapters, develops from the theoretical bases of the safety culture to the practical tools to assess the level of safety culture. Ten Basic Elements of Safety Culture were established, which are interrelated and all must be present to achieve a strong safety culture. The 10 Basic Elements provide a conceptual framework to orient the actions and efforts for promotion and development of safety culture. The document also describes indicators for the evaluation and the monitoring of the progress of safety culture, proposes ways to promote and develop a strong safety culture and provides a conceptual framework for internal safety culture in the Regulatory Authorities. Various topics such as the analysis of the impact of safety culture in the occurrence of radiological accidents and best practices to foster and develop safety culture are addressed in the appendices and annexes. The document can be a valuable tool to reach and maintain a strong safety culture for organizations and institutions in the Iberoamerican region and all over the world.

1. INTRODUCTION

Taking into account that safety culture problems have been widely recognized as one of the major contributors to many radiological events, several international and regional initiatives are being carried out to foster and develop a strong safety culture. One of these initiatives is the project sponsored by the Foro of Iberoamerican Radiological and Nuclear Regulatory Authorities (FORO) with the purpose to prepare a document to allow its member states understanding, promoting and achieving a higher level of safety culture.

In the framework of the FORO programs related to human and organizational factors, it was developed the FORO Project on Safety Culture. A group of experts from Argentina, Brazil, Chile, Cuba, Mexico, Peru, Spain and Uruguay, with the leadership of the Cuban expert and the scientific coordination of the International Atomic Energy Agency (IAEA) has been working on it. After two years of work, the project outcome is a document: "Safety Culture in organizations, facilities and activities with sources of ionizing radiation".

In the framework of the document, the safety culture in organizations, facilities and activities with sources of ionizing radiation has been defined, following the IAEA approach, as "the assembly of characteristics and attitudes in the organizations, its managers and workers which assures that, as an overriding priority, safety issues receive the attention warranted by their significance", and safety is understood "as the protection of people and environment against the associated risks of ionizing radiation and also the radiological safety and the security of radiation sources".

2. DESCRIPTION OF THE FORO PROJECT ON SAFETY CULTURE

The FORO Project on Safety Culture develops from the theoretical bases of the safety culture to the practical tools to assess the level of safety culture in medical, industrial and research activities, radioactive waste management and transport of radioactive material. The document also describes indicators of safety culture and proposes ways to promote and develop a strong safety culture. Various topics such as the analysis of the impact of safety culture in the occurrence of radiological accidents and best practices to foster and develop a safety culture are addressed in the appendices and annexes.

The FORO document on Safety Culture has been written in Spanish and is available free of charge at the FORO website. The document covers theoretical approaches and practical guidance on safety culture, adapted to the environment in which radiological activities are carried out. Some innovative elements are introduced in this document like a safety culture concept which considers that the radiological protection culture and the security culture are inextricable linked.

Safety approaches have had similar developments in almost all sectors of the industry and services with associated risks. Usually the occurrence of accidents or disasters has marked the beginning and the transition to higher stages, because they revealed expiration, failure or vulnerability of the philosophies, concepts and methods to address safety, existing at that time, leading to its renewal and to qualitatively better approaches.

In general, it can be considered that approaches to safety have gone through three phases. There is a first phase, characterized by a focus on technology to guarantee safety. Later, it was more relevant the contribution of individual human error during operation, leading to the human factors phase. Finally and after the analysis of some accidents occurred during the 80's decade, a new vision leads to the next and most recent phase of safety approaches, the organizational phase. It is in the latter where the safety culture is framed.

In the FORO document on Safety Culture there is as introduction with a description of the historical evolution of safety approaches through the three phases: Technological, Human Factors and Organizational, being the last one associated with the so called Soft Safety. The Human and Organizational factors pose the greatest impact on the occurrence of accidents, with an estimate contribution closer to 80-90% in some sectors (Fig. 1).

Several international documents and events have recognized the contribution of problems of Safety Culture in the occurrence of radiation events. In an Annex of the FORO document on Safety Culture is shown, from the perspective of safety culture, how attitudes and behaviors of managers, workers and organizations as a whole, created the conditions for the occurrence of certain radiological events. The fundamental interest is to know, learn and convey why the events occurred, from the point of view of safety culture. Examples of radiation events confirm that to achieve safety is not enough to have the technology or the most modern equipment, qualified personnel or certificate and all processes or tasks in written procedures.

Inappropriate attitudes and behaviors of personnel and organizations, with respect to safety, can make fail barriers and existing controls leading to radiological consequences for the workers themselves, public and the environment, with economic or social impact.



FIG. 1. Historical evolution of safety approaches.

Widespread and intense efforts have been undertaken to develop the theme of safety culture in nuclear and other sectors such as oil, aerospace, civil aviation and the health sector. The assimilation and the practical incorporation of the concept of safety culture in organizations carrying out activities with radiation sources have expanded considerably.

The importance, urgency and the need to promote and develop the safety culture are discussed in the FORO document. Also, there are summarized the most important theoretical aspects of the concept of culture whose understanding is essential to comprehend, address and act on safety culture.

3. BASIC ELEMENTS OF SAFETY CULTURE

The FORO document lists and describes 10 Basic Elements of Safety Culture in organizations, facilities and activities with sources of ionizing radiation. Several existing approaches and criteria in other risky sectors or activities were reviewed and analyzed. As result of this work the minimum elements to be considered in the scope of the document were established.

The 10 Basic Elements of Safety Culture, in the framework of the Project, are:

(1) Priority of safety.

- (2) Visible leadership and commitment of top management with safety.
- (3) Timely identification and proper solution of safety problems.

(4) Permanent focus on safety.

- (5) Responsibility, involvement and individual behavior in respect to safety.
- (6) Effective communication on safety.
- (7) Free reports on safety concerns.
- (8) Fair treatment for individual behaviors in respect to safety.
- (9) Continuous organizational learning about safety.
- (10) Environment of trust and partnership on safety.

These 10 Basic Elements are interrelated and they all must be present to achieve a strong safety culture in organizations working with radiation sources (Fig. 2). The 10 Basic Elements provide a conceptual framework to orient the actions and efforts for promotion and development of safety culture.



FIG. 2. The 10 Basic Elements of Safety Culture in organizations, facilities and activities with sources of ionizing radiation.

4. INDICATORS OF SAFETY CULTURE

A scheme of four-levels of safety culture has been developed for organizations working with radiation sources. These levels are: Low level, Incipient Progress Level, Advanced Progress Level and Level of Excellence. This classification in levels of safety culture has several benefits. First, it lets, after evaluation, to know where is the organization in terms of its safety culture. Secondly, it is easier to visualize the goals or desired states, define how distant is to achieve them and take relevant measures and actions. Finally, it serves to compare, through successive evaluations, the progress experienced on safety culture by the organization.

In the field of safety culture, any intent of assessment or measurement is complex for many reasons. However, it is necessary to have some kind of indicators to monitor the state of safety culture to recognize if there is progress or decline, and also because it is not possible to improve what is not measured or evaluated. Monitoring the safety culture through indicators identifies trends that are very beneficial for an early alert on potential or imminent deterioration of safety in the organization, acting like an "anticipatory effect" (Fig. 3).



FIG. 3. Indicators of Safety Culture for systematically monitoring.

In the context of the document, a set of Safety Culture Indicators is proposed, to evaluate each of the 10 Basic Elements and these indicators can be used by the organizations for systematically monitor their behaviors towards safety culture. In an appendix of the document, a total of 62 Indicators, related to the 10 Basic Elements, are described, as well as the possible qualitative or quantitative measures to be used to evaluate each indicator. Also, the recommended measures verification methods and the criteria to evaluate the extent are proposed.

As the indicators are the result of indirect measurements, the information they provide requires an interpretation of what is reflected in terms of culture, the possible beliefs, values and behaviors with regard to safety in the organization. Below are listed the proposed indicators associated with each of the 10 Basic Elements of Safety Culture in organizations, facilities and activities with sources of ionizing radiation.

It should be emphasized that the list of indicators is a guide for the organizations working with radiation sources to start using them in their daily work, in the appropriate form and on their distinctive features. This will enable the organization to become familiar with each type of indicator and simultaneously will validate its effectiveness.

4.1. Indicators for the basic element of safety culture (1) "Priority of safety"

- (1.1) Visibility of the priority of radiation protection and safety in the documentation of the Organization.
- (1.2) Prevention/Management of conflicts related to radiation protection and safety.
- (1.3) Suspended work for concerns or suspicions about the radiation protection and safety.
- (1.4) Interaction of top management of the organization with Radiation Protection Officer or the Chief of the Radiation Protection Unit.
- (1.5) Safety management.
- (1.6) Radiation protection and safety in the career and promotion of staff within the Organization.
- (1.7) Radiation protection and safety in hiring personnel.
- (1.8) Radiation protection and safety in the procurement of services.
- (1.9) Security of radiation sources incorporated and integrated into the safety priority.

4.2. Indicators for the basic element of safety culture (2) "Visible leadership and commitment of top management with safety

- (2.1) Visibility of top management commitment with the radiation protection and safety in the documentation of the Organization.
- (2.2) Training of top management on leadership in radiation protection and safety.
- (2.3) Training of top management on issues that favor safety culture.
- (2.4) Visibility leadership and top management commitment with radiation protection and safety in the Organization.
- (2.5) Allocation of material resources to radiation protection and safety in the Organization.
- (2.6) Allocation of human resources to radiation protection and safety in the Organization
- (2.7) Periodic assessment of radiation protection and safety by top management of the Organization.
- (2.8) Internal activities of promotion and development of safety culture

(2.9) Leadership and commitment of top management of the Organization with security of radiation sources.

4.3. Indicators for the basic element of safety culture (3) "Timely identification and proper solution of safety problems"

- (3.1) Identification of radiation protection and safety problems by internal mechanisms of the Organization.
- (3.2) Timely assessment of radiation protection and safety problems
- (3.3) Timely solution of radiation protection and safety problems
- (3.4) Identification, evaluation and timely resolution of security of radiation sources problems in the Organization.

4.4. Indicators for the basic element of safety culture (4) Permanent focus on safety

- (4.1) Consideration of radiation protection and safety issues during the planning and control of activities in the Organization.
- (4.2) Daily organizational mechanisms of proactive assessment on radiation protection and safety in the Organization.
- (4.3) Internal improvements in radiation protection and safety.
- (4.4) Assessing the impact on radiation protection and safety for change management.
- (4.5) Meetings or activities of top management with Regulators and Stakeholders.
- (4.6) Integration of the security of radiation sources in the permanent safety approach.

4.5. Indicators for the basic element of safety culture (5) "Responsibility, involvement and individual behavior in respect to safety"

- (5.1) Responsibility for radiation protection and safety in the Organization.
- (5.2) Involvement of staff in radiation protection and safety.
- (5.3) Top management attention to suggestions or staff recommendations on radiation protection and safety in the Organization.
- (5.4) Top management meetings with workers to analyze the behavior of radiation protection and safety in the Organization.
- (5.5) Incentives and awards for the involvement and contribution to the radiation protection and safety in the Organization.
- (5.6) Training of workers in areas that favor their safety culture.
- (5.7) Questioning attitude, rigorous and prudent approach of workers.
- (5.8) Consideration of security of radiation sources as an individual responsibility and involvement of staff in the improvement.

4.6. Indicators for the basic element of safety culture (6) "Effective communication on safety"

- (6.1) Recognition of the importance of effective communication on radiation protection and safety in the Organization.
- (6.2) Culture of effective communication on radiation protection and safety in the Organization.
- (6.3) Communication of the Organization with Stakeholders.
- (6.4) Integration of security of radiation sources in the culture of communication of the Organization.

4.7. Indicators for the basic element of safety culture (7) "Free reports on safety concerns"

- (7.1) Recognition of the importance of the free report on problems or concerns related to the radiation protection and safety in the Organization (equipment failures, human errors, near misses, unsafe acts, unsafe conditions, decisions, etc.).
- (7.2) Staff involvement in the free report on problems or concerns related to the radiation protection and safety in the Organization. (equipment failures, human errors, near misses, unsafe acts, unsafe conditions, decisions, etc.).
- (7.3) Nature of the reports that are made in the Organization on problems or concerns related to radiation protection and safety.
- (7.4) Preferably mechanism used by staff to the make a free report on problems or concerns related radiation protection and safety in the Organization.
- (7.5) Attention of the top management of the Organization to free reports made by staff about problems or concerns related to radiation protection and safety.
- (7.6) Incidents or events hidden by the staff of the Organization.
- (7.7) Incorporating aspects of security of radiation sources within the culture of reporting of the Organization.

4.8. Indicators for the basic element of safety culture (8) "Fair treatment for individual behaviors in respect to safety"

- (8.1) Recognition of the importance of fair treatment for individual behavior on safety in the Organization.
- (8.2) Investigation of events, incidents and other problems related to radiation protection and safety or security of radiation sources in the Organization.

4.9. Indicators for the basic element of safety culture (9) "Continuous organizational learning about safety"

- (9.1) Recognition of the importance of continuous organizational learning about safety in the Organization.
- (9.2) Amplitude of continuous organizational learning of the Organization.
- (9.3) Effectiveness of the improvements resulting from the lessons learned from events that affect safety.
- (9.4) Institutional transparency.
- (9.5) Treatment of external reporting.
- (9.6) Acceptance of social responsibility for the radiological damage.
- (9.7) Level of continuous organizational learning about security of radiation sources.

4.10. Indicators for the Basic Element of Safety Culture (10) "Environment of trust and partnership on safety"

- (10.1) Collaboration among the staff of the Organization in favor of radiation protection and safety.
- (10.2) Atmosphere of trust among the staff of the Organization.
- (10.3) Management/workers relationship.
- (10.4) Index of stuff turnover/movement.
- (10.5) Policies of the Organization to promote safety as a lifestyle.
- (10.6) Collaboration among the staff of the Organization for the security of radiation sources.

5. EVALUATION OF SAFETY CULTURE

The document also describes how to perform an evaluation of safety culture in an organization working with radiation sources, providing information, criteria and techniques to complete the evaluation. This process may also be applied to the Regulatory Authorities, when they evaluate their own safety culture. The evaluation of safety culture is necessary for the diagnosis of the starting level and to decide the actions for process improvement.

Five techniques are recognized to assess the safety culture. These techniques are: Document Review, Process Observation, Surveys, Interviews and Focus Groups. Each of the techniques has its particular advantages and disadvantages, emphasizing that the application of a single technique is not enough to reach conclusions on the safety culture of an organization. It is therefore necessary to apply a combination of all these techniques, because each has its own effectiveness to reveal or decode the different aspects of safety culture.

6. PROMOTION AND DEVELOPMENT OF SAFETY CULTURE

Achieving a strong safety culture implies a cultural change by modifying the existing values, beliefs and behaviors with new ones that respond to the desired state. A cultural change can occur spontaneously as a result of experiences and processes over a period of time or by the effect of abrupt events or other factors that require change. However, the process of cultural change can be accelerated by the planned actions. In the field of safety, you cannot expect events or accidents occur to produce a cultural change, it is necessary to act proactively to achieve the required level of safety culture, to avoid such events. This process is called: Promotion and Development of Safety Culture.

The promotion and development of safety culture is always a process "topdown", because the way people act is highly conditioned by the requirements set forth in the top levels of the Organization. This process should be complemented by the necessary involvement of all staff in terms of cultural change.

The promotion and development of safety culture in an organization working with radiation sources should be undertaken by the organization, in the first instance. However, there are external factors that may contribute positively promoting cultural changes. These external factors are, for example, the Government, Regulatory Authorities, Professional Societies, Education and Training Organizations and relevant Stakeholders. Therefore, it can be considered that there are two ways to promote safety culture in an organization working with radiation sources: internal action by the organization itself and the action of external agents.

7. SAFETY CULTURE IN THE REGULATORY AUTHORITY

The Regulatory Authority is one of the external factors who may have greater effect on the development and strengthening of safety culture in organizations working with radiation sources. Safety culture in the Regulatory Authority and its staff individually, their values, attitudes and behavior with respect to safety, will influence the methods of its regulatory action.

It is important that the Regulatory Authority has and reflects a strong internal safety culture to ensure the necessary impact of regulatory action and be an example to the organizations that regulate and in promoting a strong safety culture.

A chapter of the document is oriented to provide a guidance for the Regulatory Authority about its internal safety culture and 10 Basic Element of Safety Culture in Regulatory Authority are described (Fig. 4). These Basic Elements are:

- (1) Supreme commitment with safety.
- (2) Visible leadership and commitment of top management with safety.
- (3) Timely identification of safety problems and proper decision making.
- (4) Permanent focus on safety.

- (5) Regulatory actions that clearly favour safety.
- (6) Professional recognized relationship with regulated organizations.
- (7) Effective internal and external communication on safety.
- (8) Free reports and fair treatment for behaviors in respect to safety.
- (9) Continuous organizational learning about safety.
- (10) Proper individual behavior of Regulatory Authority staff.



FIG. 4. The 10 basic elements of safety culture in regulatory authorities.

A Regulatory Authority with a strong safety culture achieves better methods and regulatory strategies, greater rigor, credibility and respect, and better communication and common understanding with regulated organizations, among other features that should distinguish a regulatory body.

The document also provides information on how to develop a Program for the Promotion and Development of Safety Culture and examples of good practices to foster safety culture by the Regulatory Authorities are presented, taken from the experience of FORO member countries.

The document also provides information on how to develop a Program for the Promotion and Development of Safety Culture. Examples of good practices to foster safety culture by the Regulatory Authorities are presented, taken from the experience of FORO member countries.

8. CONCLUSIONS

The FORO Project on Safety Culture in organizations, facilities and activities with sources of ionizing radiation, which has been developed in Spanish language, was accomplished within the framework of the Foro of Iberoamerican Radiological and Nuclear Regulatory Authorities (FORO) and with the scientific coordination of IAEA.

To achieve and maintain a strong safety culture is a priority, in order to ensure the optimization of protection and prevention of radiological accidents. This means continuous improvement in the attitudes and behaviors about safety of the organizations, their management and workers.

Cultural change requires, from organizations working with sources of ionizing radiation, regulators and stakeholders, to have a clear comprehension of the meaning of safety culture and the basic elements that characterize it, as well as the forms and methods to foster, evaluate, monitor and continually improve safety culture.

The FORO project integrates, under the same safety culture, the radiation protection and safety aspects as well as the security of radiation sources, assuming that they are inextricably linked. It also provides a conceptual framework for internal safety culture in the Regulatory Authorities.

The FORO project on Safety Culture is the first stage of the process to achieve a strong safety culture in organizations working with radiation sources and should be completed later with other stages focused on the diffusion and implementation of the project in the different FORO member countries.

The diffusion actions to facilitate the technical understanding of the document and to prepare organizations and their management and workers for project implementation was initiated by placing the document in the FORO website, will be continued through discussions, seminars and courses organized locally in member countries and in regional events and it will be completed by the possible edition of the FORO project on Safety Culture in other languages.

All the diffusion actions will contribute to the practical, gradual and extensive implementation of the Safety Culture Project in the FORO member countries. The FORO Project on Safety Culture will be a useful reference for the Iberoamerican region and a valuable tool to reach and maintain a strong safety culture for organizations and institutions in other parts of the world.

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INPO SUPPLIER PROGRAM IMPROVEMENT

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Abstract

Within their own organizations, utilities have made significant improvements in human performance and safety culture, supported by a strong community of practice through INPO and WANO. In recent years, utilities have been making increasing use of suppliers for design, construction, inspection and maintenance services in support of their NPPs. Many of these suppliers do not have the benefit of being members of a community of practice when it comes to human performance and safety culture. To help the supplier community make improvements similar to what the utilities have achieved, INPO has recently expanded its Supplier Participant program to address the issue of human performance and safety culture in the supplier community. The intent of this paper will be to share the INPO's perspectives and activities in helping suppliers of services and products to NPPs enhance their human performance and safety culture.

1. INTRODUCTION

The Institution of Nuclear Power Operations (INPO) influences industry suppliers to achieve high nuclear standards, and to share construction and operating experience that helps others to enhance nuclear safety and avoid risks to personnel. By its close association with supplier executive leadership, INPO broadens their commitment to continuous improvement.

Suppliers and non-nuclear support organizations provide many vital functions for the nuclear industry, such as the following:

- design and manufacturing of nuclear fuel, replacement parts, and components
- engineering, manufacturing, construction, and installation support for plant modifications and upgrades
- staff augmentation and/or service to engineering, maintenance, operations, radiological protection, and outage support
- corporate public relations, government affairs, supply chain, legal, licensing, and environmental support

In many cases, critical expertise and technical knowledge of specific plant and component design bases are resident in these organizations. In all, these organizations comprise a vital segment of the nuclear industry and through their actions have the potential to directly impact its overall safety and reliability.

2. VISION STATEMENT

Reduce errors of supplemental and non-nuclear workers; challenge supplied goods and services that do not challenge safety or reliability; set specifications on high-quality parts; and create continuous improvement through the support of leaders, processes, and infrastructure. This initiative supports the fourth great challenge identified in the 2013 INPO industry-facing strategy.

3. PROBLEM STATEMENT

Contributors to this great challenge include the following:

The knowledge and skills of the suppliers and non-nuclear support organizations are eroding due to age demographics.

Suppliers and non-nuclear support organizations are faced with the same aging demographics challenges as is the nuclear industry, resulting in near-term erosion of knowledge and skill as more experienced workers retire. Moreover, the quality of their programs — such as initial and continuing training, corrective action and quality assurance — varies widely in the U.S. and among foreign vendors. The ever-increasing number of foreign workers, whose performance standards also vary nation-by-nation, adds to this complex risk calculus. Finally, low nuclear market demand invites vendors to supply a less-profitable nuclear industry with less costly/qualified workers. To the extent that nuclear industry best practices are adopted across the supplier and non-nuclear support organizations, the nuclear industry will be safer and less-prone to worker-related errors.

The improving standards and performance that has been achieved in our members' workforce is not resident to the same level in the supplier and nonnuclear support organizations.

Failure of supply services and parts accounts for an increasing percentage of critical component failures. Contributing to these failures are eroded quality standards among suppliers, the shift to a global supply chain that includes myriad foreign sub-suppliers that provide sub-standard parts, aging U.S. plants with increasingly fragile equipment, lack of competition within the vendor-base, low nuclear market demand that does not position the industry to receive the highest quality vendor expertise, and foreign and domestic counterfeit parts. In all, it is becoming increasingly difficult to uphold rigorous nuclear equipment standards.

Suppliers and non-nuclear support organizations in general recognize the need to and desire to improve the performance of their workforce. The processes, programs and infrastructure that our members developed and refined over the

last several decades are in initial stages of emulation at many of the large supplier organizations.

The choice to improve performance standards resides with the supplier and non-nuclear support organizations' leadership. Without a commitment to establishing and maintaining high standards, quality assurance, and continuous improvement, there is little prospect for improved vendor performance. INPO's ability to motivate supplier and non-nuclear support senior management to lead improvement in these areas is vital to achieving improved execution uniformity and quality for the nuclear industry.

Market demand does not position the nuclear industry well (at least in some utilities) for suppliers and vendors to provide the best expertise to running nuclear plants.

The global supply chain, including use of many sub-suppliers, is increasingly used for supplying replacement parts to our members. The U.S. manufacturing capacity has steadily reduced over the last several decades. Failure of replacement parts is an increasing contributor to critical component failures of our members.

4. SOLUTION STATEMENT

- Supplemental and non-nuclear worker errors reduced.
- Supplied goods and services do not challenge safety or reliability.
- High-quality parts available when required and meet specifications.
- Leaders ensure programs, processes and infrastructure create continuous improvement.

5. SUCCESS CRITERIA AND SCOPE

- (a) Clear performance principles developed and communicated.
 - Develop and communicate principles for excellence in supplier performance, and assist suppliers and utilities to implement use of standards.
 - (ii) Issue and reinforce Principles for Excellence in Nuclear Supplier Performance with suppliers. (INPO 14-005)
 - (iii) Add standards/guidance for how plants and suppliers should interface with each other.
 - (iv) Provide more detailed guidance for select supplier areas, such as supply chain, transmission and distribution, reactor services, etc.
- (b) Increased and more effective supplier executive engagement in supporting INPO member utility performance.

- (i) Establish and maintain routine communications and touch points with appropriate level supplier participant executives.
- (ii) Through stations' via improved support (day in the life of supplier), through other standard setting organizations (Electric Power Research Institute, Nuclear Energy Institute, others), directly with individual suppliers (assistance trips, etc.).
- (iii) Involve suppliers more on improvement initiatives, such as engineering INPO Event Reports, supplier working meetings, etc.
- (iv) Improve coordination and priorities of INPO work with suppliers.
- (v) Engage high-level executives of suppliers (president, CEO, etc.).
- (vi) Revise INPO Supplier Participant Advisory Council memorandum. Modify from informing suppliers to informing and striving for excellence
- (vii) Engage CNOs to reinforce more effective relationships with suppliers, establish goals, and other reinforcing actions.
- (c) Supplier operating experience (OE) routinely submitted and used.
 - (i) Improve depth and breadth of collection and sharing of supplierrelated OE.
- (d) Supplier performance understood and monitored.
 - (i) Develop and implement metrics to measure and track supplier performance.
 - (ii) Sharpen evaluation of supplier performance (more clearly point out supplier performance issues).
 - (iii) Clarify and implement reporting requirements for supplier events (focus will be report through the stations' processes, suppliers inform the reports).
 - (iv) Implement improved supplier performance metrics (against the principles and/or direct reflection of supplier results).

6. INPO14-005 AND SELF-ASSESSMENT REVIEW

INPO 14-005, *Excellence in Nuclear Supplier Performance*, was issued in October 2014. This principles document describes the essential principles and attributes that support achieving excellence in the services and products provided by nuclear suppliers. This document is applicable to suppliers who support the nuclear industry in areas such as nuclear facility design, procurement, fabrication, construction, inspection, and operations support. Nuclear suppliers include those contractors and subcontractors who provide materials, equipment, and/or services to nuclear power plants and other nuclear facilities and are subject to the unique requirements of the nuclear industry.

The principles outline expectations and standards for achieving excellence in nuclear supplier performance. Principles are in the following areas:

- Nuclear safety culture
- Materials, equipment, configuration control, and quality assurance
- Human performance
- Training and qualifications
- Continuous improvement
- Operating experience and lessons learned
- Procurement and contracting of materials and services

Supplier Participants completed their first self-assessment in August 2015, against the principles document. The major gaps in performance where identified as: nuclear safety culture, continuous improvement and operating experience and lessons learned. The team has several work teams working to provide recommendations to the Supplier community on how to close their gaps. The groups are as follows:

- Nuclear Safety Culture
- Continuous improvement
- Operating experience and lessons learned
- Operating experience and lessons learned (focus on legal challenges facing suppliers in regards to reporting OE)

7. LOOKING FORWARD: 2016 PRINCIPLES

Supplier participant's 2016 top priorities are as follows:

- Continue to work to close identified gaps in Nuclear Safety Culture, continuous improvement and OE/lessons learned.
- Broaden sharing of supplier-related information and OE among suppliers.
- Develop performance indicator(s) to measure and track supplier and nonnuclear support performance.

ADDRESSING THE CHALLENGES OF SHARING LESSONS LEARNED AMONGST SUPPLIERS IN A FRAGMENTED AND COMPETITIVE MARKETPLACE

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Abstract

Historically, COG member utilities largely drew from in-house supporting functions or the original plant designers, allowing active sharing of operational and human performance experience amongst a small number of relevant parties. As the Canadian industry has evolved, utilities have increasingly drawn upon a greater number of independent external suppliers to provide goods and services. This diversification in supplier base within a competitive environment changes operating dynamics, as a safety culture-focused supplier must remain mindful of developing and retaining competitive advantages over other suppliers. A market-driven perspective may undermine the likelihood of sharing certain lessons learned and best practices for fear of weakening competitive position. Utility procurement procedures must ensure fair markets to be effective, but in doing so may limit opportunity for collaboration between supplier and utility compared to historic levels. Vibrant competitive markets attract a large number of suppliers, which adds to the complexity of effective sharing and absorption of industry lessons learned. The paper will explain the activities underway through the COG Supplier Participant program to remove impediments and share industry-wide operational lessons learned and best practices.

1. INTRODUCTION

Within the last 15 years, the Canadian nuclear industry has moved from purely government owned organizations to a deregulated market (albeit supported by certain electricity floor prices) that has encouraged the entry of many new suppliers. In adding fair procurement practices to acquire formerly internal scopes of work, the industry has created a culture where supplier in-house retention of information is favourable to retaining competitive advantage and maintaining or acquiring new contracts. However, utilities have seen recurring issues from separate suppliers. Over the last 14 months, a group of larger suppliers has met to explore methods to learn lessons from each other in order to improve net supplier performance as viewed by utilities. In doing so, this endeavour has brought together suppliers that have comfortably shared detailed information and suppliers that have been extremely hesitant to share information. Details on the progress in this area are described below.

2. CANADIAN NUCLEAR POWER SUPPLIER INDUSTRY CONTEXT

2.1. Ontario's creation of a deregulated market

Canadian nuclear power production presently consists of 18 operating units in the province of Ontario and one in the province of New Brunswick, and as such is dominated by activity in Ontario. In the early 2000s, Ontario moved towards a competitive electricity market by splitting its nearly 100-year old utility, Ontario Hydro, into five successor companies, and leasing about half of its nuclear units to a new organization. In doing so, it created two operating utilities; Ontario Power Generation and Bruce Power, which operate 10 and 8 nuclear power plants, respectively, and instantly shaped the need for an independent support industry to provide technical services to both utilities.

While Ontario Hydro always had a pool of external service and material suppliers, deregulation meant that in-house technical services had to be independently and equally available to support both Ontario utilities. Larger service needs are supplied through Original Equipment Manufacturers (OEMs) with detailed knowledge of original nuclear plant design and the spin-off of central functions (i.e., the research division, and the safety analysis division) from Ontario Power Generation. Over the last decade, competitive market forces have led to a maturing of the nuclear supply chain in Ontario as substantiated by:

- Presence of an increased numbers of suppliers offering comparable skills;
- Arrival of multinational suppliers through local expansion or acquisition;
- Utility's increased pursuit of external services;
- Utility's competitive pursuit of external services to reduce operating costs.

2.2. Independent nuclear organizations with ties to suppliers

A healthy industry of associations and related organizations also support the domestic nuclear industry. Amongst these are two that interact actively with large groups of key suppliers. The CANDU Owners Group (COG) has a non-profit mandate to provide programs for cooperation and mutual assistance and exchange of information to support successful operation of CANDU plants worldwide [1]. COG brings together CANDU utilities all over the world to actively share operational experience and develop joint technical solutions to address operational needs. COG also currently engages with 12 Supplier Participants (SPs) that actively participate in joint programs to support the industry. The Organization of Canadian Nuclear

Industries' (OCI) vision is to lead and strengthen the Canadian nuclear supply chain. Its mission is to offer services to its 180 leading Canadian supplier members to enable them to be successful in domestic and international nuclear industries [2]. The OCI supports its supplier members through activities such as strengthening supplier links with utilities, preparing suppliers to participate in upcoming refurbishment projects, creating international opportunities through trade missions, and advocating on behalf of the nuclear industry [3].

2.3. Competitive supplier culture

Utility procurement activities have continued to evolve and mature as additional services are offered. In reaching out to the supplier community, it attracts more suppliers, as would be expected in a competitive marketplace. For incumbents, defending market position to support baseload operations becomes more challenging. Such suppliers often have deep-rooted knowledge of plant design and operation and utilize this to their advantage when bidding to acquire new work. In many cases, this approach of retaining information (and not sharing relevant information to industry) can provide the leading edge required to retain similar work going forward. This mindset becomes ingrained, and even intensifies as new suppliers compete for work programs. The outcome is increased isolation and barriers to communication between suppliers. Thus, lessons learned by suppliers, the very essence of what needs to be shared across the industry, runs headlong into the culture that had evolved whereby companies tightly retain every competitive advantage so as to defend (and grow) market share.

As the supplier base evolves, similar mistakes may be made by suppliers, and suffered by utilities, but knowledge of such mistakes only becomes apparent to other suppliers through hearsay and without sufficient detail to learn from and avoid the causal factors going forward. This may represent a threat to safety and future performance, and comes at a time when refurbishment programs of over \$26B have recently been committed to and initiated by utilities. A move to sharing of information is rapidly needed to ensure industry success and that plants can be reinvigorated for 30 years of future safe and dependable operation.

3. COG SUPPLIER PARTICIPANT GROUP

Currently, there are 12 large suppliers registered as SPs under COG, nominally representing suppliers of engineering services and major components. Representatives from each company held an initial meeting in November 2014 and all agreed that sharing of information was needed and important. The SP group quickly focused on achieving major objectives of: (a) sharing supplier operational experience and lessons learned, and (b) engaging with utilities to resolve common issues for the benefit of the nuclear industry. The COG SP group now meets approximately every two months, to advance practices for sharing information, as

well as sharing information itself. The progress made to date towards achieving these objectives is described below.

4. SHARING SUPPLIER EXPERIENCE AND LESSONS LEARNED

Until the COG SP group started to conduct these meetings, interactions between suppliers were generally limited to instances when two companies were involved in executing a piece of work in tandem for a client. Thus, in contrast to established processes and tools for utility sharing of operational experience, there was no infrastructure nor expectations for sharing of lessons amongst suppliers. As expected, attitudes towards sharing varied from tentative willingness to strong advocacy with relevant examples. Discussion centred on the core issue of how to share information that may be linked to commercially sensitive information (of the supplier or utility) or intellectual property. Nevertheless, despite this backdrop, the SPs began the discussion on how to share supplier information.

4.1. Information shared to date

Organizational cultural attitudes towards the level of detail of information that could be shared varied depending on topic and organization. Information relating to physical and personnel safety was openly and freely shared and discussed. In addition, following a utility presentation describing their initiatives on human performance, all SPs willingly shared significant details of their own human performance programs. Indeed, all SPs confirmed that they had learned new perspectives from the information shared by other suppliers and would be looking at capturing elements of these industry best practices within their own organizations. These very encouraging examples strongly illustrate the potential and benefit of sharing amongst SPs.

However, when it came to lessons learned from underperforming technical projects that had been performed for clients, the level of initial detail provided varied between organizations. In most cases, the information was vague and details were not sufficient to allow other SPs to gain an adequate understanding of the contributors to underperformance so as to avoid the same pitfalls themselves in the future. On these specific topics, suppliers likely feel that they have future revenue and competitive advantage at stake, as related details have historically been safeguarded so as not to (a) broadcast underperformance that may be heard by other potential customers, (b) disclose commercial, customer, or intellectual proprietary knowledge, and (c) risk having competitors position themselves to take advantage of the underperformance.

4.2. Mechanisms for sharing information

With no existing templates or protocols in place amongst suppliers, the means for sharing is under development. In working as a group to solve the problem, advances in identifying what information is to be shared are equally changing attitudes towards sharing of information.

4.2.1. Templates for sharing lessons learned

Initial requests to share information were generic and open format. This approach was utilized to allow SPs to share information to the extent that they were comfortable. However, as this approach failed to set minimum expectations, it led to a variety of topical content presented in slide format with varying degrees of detail.

Currently, the SPs are working with a draft template to provide information and details in a manner that CANDU utilities use to share operational experience worldwide. Key fields include a description of the event, applicable and significant issues, and lessons learned (with respect to findings from internal root cause investigations (or other), and in context of failures in use of INPO human performance tools [4]).

The present approach is to initiate information sharing to start immediate learning and to adapt the format for how information is presented through open discussion and critique of content. These discussions will be focused on whether information is presented with detail sufficient that other SPs can apply the lessons learned amongst their own organization. In concert with these open discussions, it is expected that SPs will become increasingly comfortable with sharing information.

4.2.2. Process for sharing of supplier lessons learned

Presently, activities are focused on developing sufficiently detailed content to be shared. As a result, the information being discussed and developed by the COG SP group is solely being shared amongst SPs, largely at working meetings. Nevertheless, to be truly effective, processes will be required to routinely facilitate sharing of information:

- Between SPs on a more frequent basis (now under development);
- With utilities, to illustrate supplier's perspectives on lessons shared, from which utilities should expect to benefit on whole;
- With industry organizations and other industry suppliers;
- Within each organization (SPs, utilities, industry organizations, and other suppliers) so the lessons can be absorbed and incorporated for the benefit of improving net industry performance.

4.3. Initial best practices

The activities underway within the COG SPs are new to the Canadian nuclear industry. As this initiative represents a culture change that presently effects twelve large supplier organizations, all of which have a somewhat limited domestic client base, organizations need to be allowed time to change perspective, and resolve obstacles and permit open sharing. As with any culture change, direct benefits need to be tangibly realized in order to adopt changes in behavior. Once these examples materialize, culture change becomes more rapid. The experience with exchange of human performance program information has kick started this cultural change amongst SPs.

The effectiveness of supplier meetings is greatly enhanced by attendance of utility representatives. Customer actions drive the behaviours of suppliers, and their attendance can offer two immediate benefits: (a) utility perspective can be added to what would otherwise be supplier-oriented discussions, and (b) suppliers' competitive spirit will likely result in being more forthcoming with information by virtue of the utility observing which organizations are sharing information freely.

5. UTILITY ENGAGEMENT TO RESOLVE COMMON SUPPLIER ISSUES

Sharing information amongst suppliers is one avenue to improve industry performance. But with utility (i.e., customer) procurement actions having such a large sway over suppliers, creating a vertically integrated industry environment of sharing is required to optimize attitude toward safety and performance culture. The manner in which utilities engage with suppliers can unintentionally affect cultural attitudes within the supply chain. For this reason, the COG SP group has been reaching out to utilities for perspective and to open channels for dialogue. Developments in this area are described in the sections below.

5.1. Perspectives of interviewed utility representatives

Utilities tend to have very large organizations with a number of prime contacts that interact with suppliers (e.g., utility representatives may lead groups in engineering, projects, operations and maintenance, supply chain, and other organizational functions). A number of senior technical executives at three Canadian nuclear utilities were interviewed for feedback on generic concerns over supplier performance. Strong themes evolved from these discussions highlighting utilities reliving similar errors from multiple vendors, and the large safety risk (i.e., supplier injuries arising from ignoring safety signage) and financial impact (i.e., additional outage costs of \$30M) to utilities of supplier underperformance.

Further discussions were held with lead utility procurement representatives regarding their interest in sharing their lessons learned from utilizing suppliers amongst the supplier community. There was unanimous interest in doing so, although concerns were raised on its implementation over potential for releasing information that might be considered intellectual property of commercially sensitive information of a supplier. The concern of a utility unintentionally sharing sensitive supplier information mirrors the concern of a supplier unintentionally sharing sensitive utility information, a further establishes the need for supplier-utility interaction in the interest of broad learning from supplier operational experience.

Experience was shared without specifying supplier names, however no forum for joint (utility-vendor community) development of common solutions has arisen to date. Amongst large institutions it is difficult to identify a central point of contact that could discuss common utility concerns with suppliers. Further discussion with utilities is ongoing to pinpoint the appropriate representative and establish the most optimal means for interaction.

5.2. Supplier perspectives

An early exercise undertaken by all COG SPs, whereby they each independently listed their top three primary concerns with interacting with utilities. Essentially all suppliers identified that late award of contracts was a major concern. One supplier shared details of how this compressed a project timeline, contributed to fast tracking of work, the resulting compromise on best practices, and end result of underperformance at the utility site. Of consideration is that, much like utilities, suppliers can also be very large organizations and the determination of primary concerns is influenced by not having a central point of contact consensus.

Currently, performance issues and supplier concerns tend to be raised oneon-one between a supplier and utility, related to a large contract (or program of similar tasks). This can give the appearance of one-off or an individual supplier perspective. However, with many suppliers expressing similar concerns, and able to recount similar threats or impacts on performance, industry-wide discussions and solutions are required.

5.3. Fragmentation and complexity amongst multiple large organizations

Through these initial discussions, it appears that utilities and suppliers have very different focuses, with utilities experiencing recurring physical and financial losses as a result of supplier activities, while suppliers feeling handcuffed by how and when contracts are let within an aggressively tight competitive market.

Further effort is required to align these perspectives. This future work will:

- Have each supplier organization determine its aggregate highest level concerns when performing work, and have the supplier community conclude on consensus wide-spread and high impact issues;
- Have each utility determine its aggregate highest level concerns when receiving goods and services from suppliers;
- Identify the appropriate resources to discuss the utility and supplier perspectives on these concerns and actively agree on how to remove impediments to success from both utility and supplier perspectives;
- Establish and implement updated processes throughout all organizations.

Utilities, as paying customers to suppliers, have the ultimate say in market conditions and supplier performance requirements. However, utilities also have the largest stake in non-performance of suppliers, and it is worth incorporating supplier perspective in procurement and execution. Thus, their actions will need to encourage sharing and interaction, and potentially even discourage misuse of shared information (i.e., to attempt to gain the favour of a utility representative through defamation of a supplier that had shared its lessons).

6. PATH FORWARD

The activities and observations recounted above reflect the initial 14 months of activities under the COG SP group program. With respect to sharing information amongst suppliers, activities to be undertaken in 2016 are:

- The COG SPs will continue to meet routinely, exchange lessons learned, and hone ways to share information, expectations for materials that can be used for benefit, and also how to address any specific hindrances to sharing;
- Implementing steps to reach out to other nuclear suppliers through the OCI and other channels.

Several steps will be taken with respect to engaging utilities on discussing common supplier concerns, sharing lessons learned, and development and implement best practices. These are expected to be initiated in 2016 through:

- Including interactive sessions during a March 2016 COG Workshop entitled "Refurbishment – Supplier/Utility Interactions";
- Identification of a representative from each utility to attend COG SP meetings and serve as an active panel for exchange of perspectives, lessons learned and implementation of corrective actions.

The need for cooperative interaction between suppliers, and all industry members, is required more than ever, as the two large Ontario-based utilities embark on massive programs to refurbish up to 10 reactor units within the next decade. Both refurbishment programs have exit strategies depending on the outcome of initial activities; that is, if the refurbishment of the first reactor does not meet expectations then subsequent refurbishment plans may be cancelled outright. Thus, it is in the best interests of suppliers and utilities alike to ensure collaborative and successful execution, as all their long term operations can be materially affected by industry underperformance. Accordingly, the typical competitive market forces must succumb to the overshadowing influence cast by the upcoming refurbishment programs in order for the small domestic Canadian industry to survive as a whole. These upcoming activities will represent significant challenges with respect to personnel safety as well as future operating success of the nuclear industry within Canada.

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