

# Safety Culture Assurance in the Supply Chain of a NPP Construction Project

Teemu Reiman<sup>a</sup> and Kaupo Viitanen<sup>b</sup>

<sup>a</sup> Fennovoima Oy, Helsinki, Finland

<sup>b</sup> VTT Technical Research Centre of Finland Ltd, Espoo, Finland

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**Abstract:** 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. This paper presents how Fennovoima, a new Finnish power company applying for a construction license, has implemented a safety culture program to assure safety culture during construction.

**Keywords:** nuclear new-build, safety culture assurance, supply chain management, project network

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## 1. INTRODUCTION

In the nuclear industry, safety culture can be defined as the shared values, beliefs and assumptions relating to nuclear safety (e.g., [1], [2]). Until recently, safety culture has been associated with power plants at operational phases. This is reflective of a relative lack of new builds after the introduction of the concept in the late 1980s and early 1990s. However, safety culture as a concept is not inherently tied to operational phases, but manifests itself throughout the whole lifecycle of a nuclear power plant. In the design and construction phase, safety culture challenges include the sheer amount of companies and contracts involved, long supply chains, changing workforce, multiple languages and nationalities and multi-location activities. For the licensee, this requires ensuring and verifying that subcontractors understand the nuclear safety significance of their scope, and managing the dynamic network of companies and employees [7]. Recently, safety culture issues were identified in the Olkiluoto 3 nuclear power plant project. For instance, nuclear-specific requirements were not explicated at tendering phase of a concreting task and suppliers with little experience in the nuclear industry were chosen to carry out nuclear-specific work, which resulted in a supply chain not understanding the nuclear safety significance of their work [8]. Problems were also found in a lack of focus on safety when designing the quality control and manufacturing processes of emergency diesel generators [9] and generally with regards to clear and open communication across the suppliers [8], [9]. Similar issues were also identified as contributors to quality problems of nuclear new-builds in 1970s and 1980s [10].

In a complex and dynamic safety-critical nuclear power plant construction network, a purely formal approach to assuring safety has been argued to not be sufficient for producing a safe plant [7]. This means that in addition to formal contract management and supply chain management (including quality control and quality assurance), a cultural approach should be used as a complementary. This includes identifying and harnessing the cultural phenomena in the project network, and intervening if there are indications of deterioration of safety culture. Ultimately, a systematic approach to safety culture in the supply chain aims to ensure that all activities in the supply chain are carried out according to requirements, quality and safety targets are met, and that nuclear safety during all lifecycle phases of the nuclear power plant is maintained.

This paper presents how Fennovoima, a new Finnish power company applying for a construction license, has implemented a safety culture program to assure safety culture during design and construction. In this paper we will discuss the limits and possibilities of using various methods in the context of safety culture assurance. We will focus on the describing the main methods and provide examples of their implementation. In addition, we will provide insight into what sort of information it is possible to gain regarding the safety culture of the supply chain by different means, and how it is

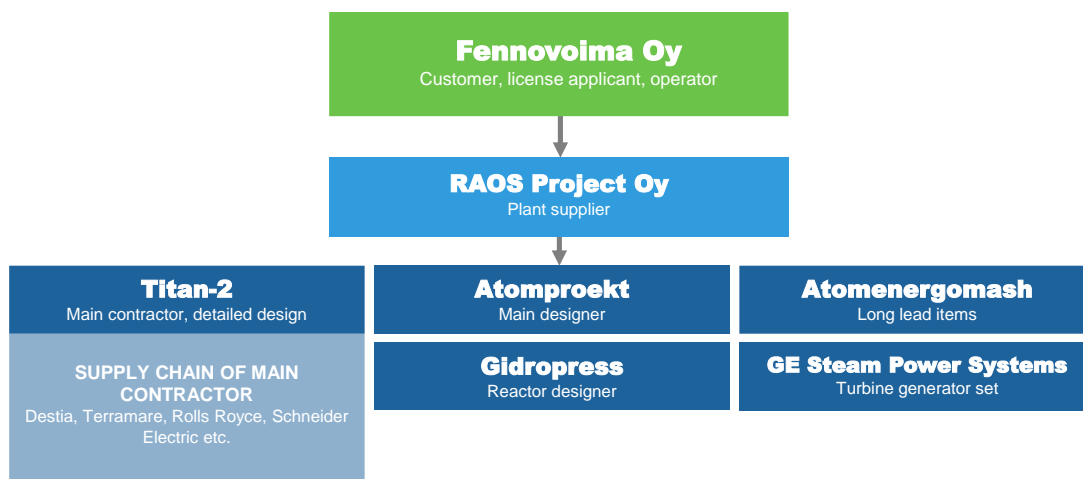
possible to influence safety culture in the supply chain. Finally, we suggest a set of good practices for safety culture assurance during nuclear power plant construction.

## 2. HANHIKIVI-1 PROJECT

Fennovoima is planning to build its first nuclear power plant (NPP) unit Hanhikivi 1 (FH1) in a greenfield site in Pyhäjoki, Northern Finland, with a generating capacity of approximately 1,200 MW. The reactor is a pressurized water reactor (PWR) VVER-1200. Fennovoima will become the operator of the finished power plant. The construction license application has been submitted and the license is expected during 2019. According to the current schedule, the plant will be operational in 2024, with life time of at least 60 years.

Fennovoima has granted an EPC (engineering, procurement, and construction) contract for a complete turn-key delivery of the NPP to the Russian company RAOS Project (subsidiary of Rosatom). RAOS Project has four main safety-critical subcontractors: general design, design of the reactor unit, construction, and delivery of systems (complex self-standing equipment and long-lead items). Figure 1 shows the main contractors, including the turbine supplier.

**Figure 1. FH1 project main participants**



According to Finnish legislation and regulatory requirements, the licensee is responsible for ensuring safety of the nuclear power plant in all of its life cycle phases [3], [4]. This means that turn-key delivery does not release the Fennovoima from its full responsibility for safety during the design and construction phase of the NPP project. In addition to being an intelligent customer, Finnish regulations require that Fennovoima shall take systematic actions to establish, foster and sustain a strong safety culture within its supply chain [3], [5], [6]. This effort is essential to ensure that all activities in the supply chain are carried out according to requirements, with quality and safety targets met in order to be able to achieve nuclear safety during all lifecycle phases of the NPP.

## 3. SAFETY CULTURE ASSURANCE IN THE FH1 PROJECT

In the domain of quality, “assurance” refers to that part of quality management that provides confidence that quality requirements will be fulfilled [11, p. 20]. Quality assurance puts emphasis on prevention of non-conformities through improvement of product, service and process design [12]. Safety culture assurance aims to proactively create and maintain good safety culture in the supply chain. This includes the facilitation and verification of such suppliers’ structures, processes and activities which aim to create and maintain a good safety culture in the supply chain. Focus is not only on detecting the deterioration of safety culture, but also on supporting its formation and development in the entire FH1 project.

In order to systematically carry out supply chain safety culture assurance activities, they need to be formalized. Fennovoima's supply chain safety culture assurance procedure is part of Fennovoima's management system. The activities specified by the procedure are coordinated by the safety culture manager with the assistance of other experts when needed. The implementation of the procedure is systematically followed-up in regular reviews, including annual follow-up report (see section 3.5), mid-year reviews and management reviews. The latter enables active top management involvement in supply chain safety culture assurance.

Finnish regulatory requirements state that all organizations participating in a nuclear power plant construction project "shall have a good safety culture in place" [6, p. 7]. Thus, safety culture related requirements apply to the RAOS Project and its suppliers, and also to other suppliers, based on graded approach. The requirements for safety culture assurance in the supply chain have been specified in the Finnish national legislation YVL Guides e.g., [5], [6], and in the EPC contract.

The supply chain safety culture assurance procedure consists of five primary functions, which describe the necessary elements of systematic and target-oriented safety culture work. The functions have been developed to facilitate continuous improvement while taking into account the special requirements of safety culture assurance in the nuclear industry (specifically, the importance of requirements, and coordination of activities). Fennovoima's supply chain safety culture assurance procedure specifies the following functions:

- **Establishment** and communication of shared values and expectations for the supply chain of the project, including the establishment of necessary structures for Fennovoima to carry out its assurance activities
- **Facilitating** and promoting nuclear safety culture improvement in the supply chain,
- **Coordinating** safety culture related activities and **collaborating** with other parties,
- **Monitoring** the manifestations of nuclear safety culture in the supply chain, and
- **Review** and reflection of Fennovoima's safety culture program to drive continuous improvement in the supply chain.

In addition, a reporting function exists to serve as an interface between other organizational processes and to guide the review function. Each of the supply chain safety culture assurance functions involves the use of a set of practical methods whose purpose is to ensure that the function is operational.

In the following subchapters we present examples of safety culture methods for each supply chain safety culture assurance function.

### 3.1. Establishment

The main goal of establishment is to create and maintain such structures that support safety culture. These structures include reporting systems, review practices, rewarding, and project management. Structures also include contracts and other formal expectations concerning issues having relevance to nuclear safety. This function aims to build organizational capability for safety culture and help to integrate safety culture issues into daily work practices and structures in the whole supply chain. Fennovoima has established its expectations for high level nuclear safety culture in the EPC contract. RAOS Project has responded to these requirements with their own safety culture program. Establishment of structures and shared expectations will be emphasized especially whenever there is a change in the project phase and new structures are required, or old ones need to be changed.

FH1 project has a very complex supply chain and it is vital that the expectations regarding safety culture are thoroughly communicated. A lot of attention has been paid to the establishment of shared values with RAOS Project and within the whole supply chain. The complexity of the supply chain also demands from Fennovoima allocation of sufficient resources to be able to create and maintain the necessary structures to carry out its safety culture assurance activities.

Safety culture assurance begins already when **approving** potential suppliers. Nuclear safety and safety culture specialists participate in the review and approval of suppliers providing safety related works or services. However, in practice, at this stage there is limited amount of information about the safety culture of the reviewed company. Thus, the review and approval process is mostly used to grade the company based on the mostly technical information available at that time.

Fennovoima and RAOS Project Oy have defined project-wide **nuclear safety culture policy**, which states their commitment and expectations with regards to nuclear safety culture. This policy defines four safety culture principles, which everyone is expected to follow (Figure 2). The four principles are commitment (giving nuclear safety priority in all decisions and actions), awareness (understanding the safety significance of tasks and duties), transparency (communicating, cooperating and sharing information) and continuous improvement (taking initiative and seeking to learn more). The principles are promoted in Fennovoima's internal materials and communications, and in the supply chain (see section 3.2).

**Figure 2. Cartoonist's illustration of the safety culture principles that is used in posters and screensavers since 2016**



In the nuclear industry, **graded approach** is applied to define the requirements of a product, system, structure or process commensurate with its relative importance, e.g., with regards to safety or quality [17]. Fennovoima applies graded approach in supply chain safety culture assurance to grade the safety culture assurance activities related to a given supplier on a four-level scale (A-D). The resulting safety culture assurance grades are not intended to serve as indicators of the safety significance of the supplier, but to define the extent of use of the safety culture assurance methods described in this document.

Graded approach in the context of supply chain safety culture assurance is utilized, for example, in definition of the requirements for safety culture related documents and organizational structures in the supply chain and definition of the manner in which the suppliers are to be monitored, and the frequency, scope and detail of the safety culture monitoring activities in the supply chain. Grading is revised twice a year and the final grade depends on several factors, including the safety classes of contracts, the scope of works, the position of the supplier within the supply chain, and the number and significance of its own suppliers.

Currently (March 2018) there are ten safety culture assurance grade A suppliers and nine grade B suppliers in Fennovoima's supply chain. Grade C and D suppliers number in hundreds. For grade A and B suppliers, Fennovoima requires a systematic and documented safety culture program. Grade A

suppliers send their programs for review and approval, and graded B suppliers send them for information.

Fennovoima also specifies requirements for **structural prerequisites** for safety culture in the supply chain. Structural prerequisites are organizational processes, procedures or other institutionalized methods that aim to influence safety culture. They are defined on the basis of the EPC contract, Finnish regulations and IAEA requirements. The extent to which structural prerequisites are required from suppliers is specified by graded approach. For grade A suppliers, these include, for example:

- Nominating a safety culture coordinator or manager with the resources and authority to carry out safety culture work
- Reporting channels for employees' safety concerns and safety initiatives, including the possibility for anonymous reporting
- System of safety culture ambassadors [18] or a similar way of involving employees in safety culture development
- Documenting the frequency, methodology and resources assigned to safety culture follow-up (cf. section 3.5), including a periodic follow-up report, and for regular independent assessment and self-assessment of safety culture

Fennovoima also requires contractually that all employees of suppliers performing safety-critical activities receive nuclear safety culture **training**. Everyone entering to the construction site participates in a site access training that includes a section on nuclear safety culture. Preferred way of providing the training is 1-2 hour small group session held by a safety culture expert with teaching or training experience. Fennovoima prepares safety culture training material in collaboration with RAOS Project. These training materials are distributed to other contractors for use in their own internal trainings.

### 3.2. Facilitation

Facilitation and promotion means highlighting the importance of safety culture issues to the project participants. It includes educating the significance of organizational factors, promoting safety culture related methods and approaches, providing information about nuclear safety and its cultural influences and arranging ways for employees to discuss and share ideas on safety culture.

Facilitating and promoting safety culture gets most emphasis in parallel with the establishment function. However, it is important to maintain the facilitating function even after the structures have been established in order to remind personnel of nuclear safety issues and maintain awareness and commitment to nuclear safety.

Fennovoima organizes various safety culture-related **events** which aim to increase awareness and knowledge of organizational and cultural influences on nuclear safety in the supply chain. This includes safety culture training days held by international safety culture experts where safety culture responsible from the suppliers are invited to, or the participation of Fennovoima's safety culture experts in project-wide seminars as lecturers.

To help concretize safety culture principles stated in project-wide nuclear safety culture policy (see section 3.1 above) Fennovoima has developed a **safety culture guide** in the form of a booklet. The guide is aimed at everyone working in the project and is distributed in Finnish, Russian and English to all participating organizations. To ensure applicability in all cultural and organizational contexts, the guide was modified on the basis of comments of safety culture experts from RAOS Project Oy. The guide contains general information about safety culture, and describes in concrete terms, how individuals, groups and organizations can contribute to good safety culture. Furthermore, the guide gives an overview of what kinds of special requirements organizing as a project network sets for safety culture and nuclear safety. The guide also describes examples of safety culture-related tools such as STARC-principle (stop, think, act, review, communicate).

### 3.3. Coordination and collaboration

Coordinating activities and collaborating with project participants seeks to integrate safety culture into daily life in the project. It also seeks to align different safety culture related activities to promote a joint purpose.

Activities in this function differ from the facilitation function especially in their reciprocity. In collaboration, as in all dialogue, both parties learn and change their behaviors accordingly. Facilitation activities are more unidirectional, with the main focus on sharing information from safety culture specialists to other people involved in the project. Coordination and collaboration is emphasized throughout the project phases.

Collaboration is always based on trust and respect. Thus, it is important to find and elaborate on the commonalities and shared interests of the different parties. Equally important is to strive to understand and acknowledge the cultural differences between the parties and how this may affect collaboration.

**Nuclear safety culture working group (NSCWG)** is the primary way of coordinating safety culture activities in the supply chain and creating a culture of collaboration in the FH1 project. The NSCWG consists of representatives (usually safety culture responsible) from the safety culture assurance grade A companies. The NSCWG organizes periodic one day long face-to-face meetings to achieve its objectives. The meetings are typically held five times a year. Additional meetings can be organized when necessary. The responsibility for chairing NSCWG meetings is on Fennovoima. The NSCWG has the following objectives:

- To align the supply chain safety culture assurance related activities by jointly **coordinating** and to build a shared understanding within the supply chain by **collaborating**
- To communicate the safety culture requirements **established** within the project, and best practices and lessons learned regarding safety culture
- To **facilitate** safety culture by promotion, education and jointly discussing relevant safety culture issues
- To support Fennovoima's **monitoring** of the state of safety culture activities in the supply chain

Due to the diversity of the NSCWG method, its objectives have been formulated to match supply chain safety culture assurance functions (except review). For the perspective of Fennovoima's supply chain safety culture assurance this means that in addition to its primary function (coordinate and collaborate), NSCWG's are also used to fulfil monitoring and establishment functions.

### 3.4. Monitoring

The manifestations of safety culture need monitoring in order to a) prioritize the development actions based on the current situation, b) avoid drifting of practices and assumptions to unwanted direction and c) make corrective actions when drift or other deficiencies are identified. As all organizations have latent conditions that make them vulnerable to existing hazards and other disturbances, monitoring the emergence of these conditions is vital to support high quality work and nuclear safety.

Monitoring pays special attention to the following thematic elements of safety culture:

- Safety leadership and top management commitment
- Planning of safety culture work and systematic development of safety culture
- Organizing and resourcing of safety culture development, including the tools and practices

- Integrating safety culture into daily work, including personnel's understanding of the nuclear safety significance of their tasks, competence in safety, use of various human performance tools, escalation of safety issues, etc.
- Assuring safety culture in the supply chain
- Assessment of safety culture
- Continuous improvement and learning from experience

These thematic elements have been developed using scientific knowledge, established characterizations of safety culture work in the nuclear industry, e.g., [13]–[15] and the ISO 9001 quality management standard [16]. Furthermore, Finnish regulatory requirements have been cross-checked during the development of the thematic elements.

To produce reliable results, the monitoring of the nuclear safety culture is conducted continuously and by using several methods. The results are periodically drawn together and summarized to produce conclusions of the status and development trends of the nuclear safety culture (see section 3.5).

**Audits** are a systematical method to gather objective evidence regarding compliance with predefined audit criteria [11, p. 36]. Since Finnish legislation and the EPC contract set requirements for safety culture, audits can be utilized in the context of safety culture assurance. Fennovoima utilizes several types of supplier audits to assure safety culture in supply chain. Lightest in scope (in terms of safety culture) are management system audits which have safety culture integrated as one of the topics. They can include, for example, a 60 min. safety culture session conducted by a safety culture expert. Safety culture-related findings may also be revealed in audits where safety culture is not a specific topic. To ensure the availability of the findings from supply chain audits to safety culture experts, all management system audit summary reports are sent to Fennovoima's safety culture manager. Further, all non-conformities are classified based on their apparent cause, and "organizational and safety culture" is one of the classes.

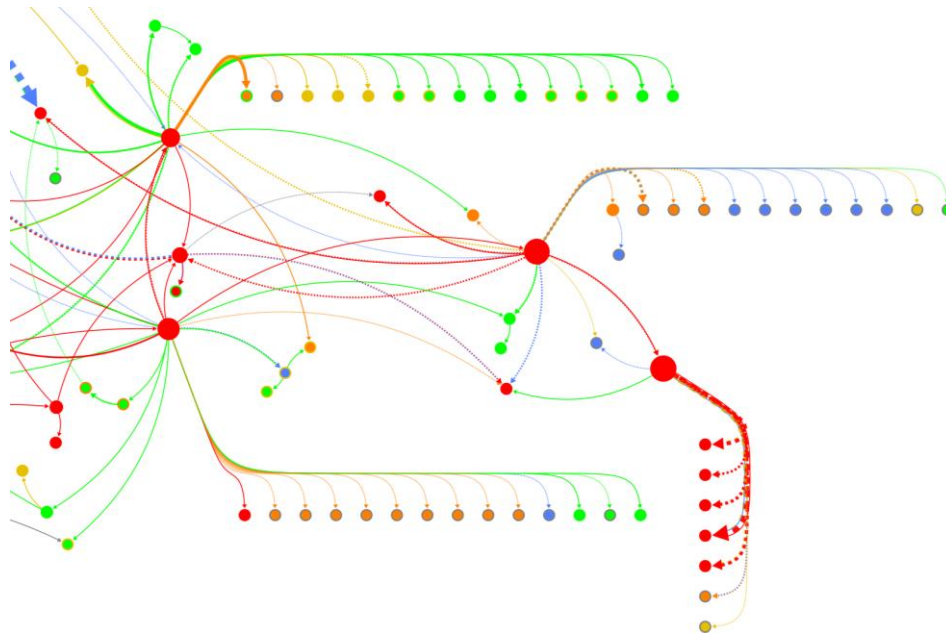
Fennovoima also conducts **safety culture audits**, which focus specifically in safety culture issues (for further details, see [19]). Safety culture assurance grade A suppliers are the primary target of safety culture audits. These audits are carried out annually in one supplier and are usually one and a half to three days in length. They are conducted by Fennovoima's safety culture experts with the assistance of external consultants when necessary. The audits focus on the topics of the monitoring function (see section 3.4). For example, all safety culture audits have an item where the content and current implementation of the auditee's safety culture program is reviewed. Sometimes topical safety culture issues are included in audit agenda. To ensure reliability and validity, triangulation is applied in data collection. This means that multiple sources of information are used to formulate audit findings. Methods used in the audits are interviews, review of documents before and during audit meetings and observations in the field. If non-conformity is made, the auditee is required to respond to this and formulate corrective actions. The proposed corrective actions are evaluated and approved by Fennovoima.

During the first round of safety culture audits in 2016-2017 of the five most important suppliers, 11 non-conformities, 17 comments and 15 positive findings were made [19]. Positive findings usually related to openness and care during preparation. Non-conformities or comments most often related to a lack of required organizational structure or their unsystematic implementation, or a lack of diversity in safety culture assessment or improvement methods. While deeper levels of organizational culture are rarely revealed by safety culture audits, they can be useful for identifying various types of manifestations of safety culture and verifying the supplier's organizational preconditions for safety culture development [19]. Furthermore, the audits can be used to steer the suppliers' safety culture development activities by focusing on certain topics that Fennovoima considers important.

A **network analysis** is carried out twice a year or when needed, to review the current contractual structure of the supply chain (Figure 3). The analysis is based on the data collected from Fennovoima's supply chain contract register, which includes contractual statuses and their safety

classes. Safety classes indicate the nuclear safety significance of the scope of work specified in the contract and are assigned on the basis of Finnish regulatory requirements [20], cf. [21]. The analysis results in a visualization of the whole supply chain. It uses graphical elements (e.g., line styles, widths and colors; polygon colors, shapes and sizes) to convey and summarize contract and supplier-related information. The analysis is mainly utilized in maintaining an overview of the supply chain, but it has also been utilized in supporting the grading of a particular supplier. For the latter purpose, the analysis can help identify important “nodes” in the supply chain, such as suppliers with multiple contracts, multiple customers or complex supply chains.

**Figure 3. Extract of the supply chain contractual structure visualization (company names removed)**



Other sources are also used as information about the status of safety culture in the supply chain. For example, Fennovoima has a safety concern system where all employees can report issues that they consider require more attention from the company. Typically, these issues concern Fennovoima’s own activities, but a few are targeted at the suppliers’ performance. In addition, non-conformities that are raised during audits or other inspections are analyzed bi-annually to identify their organizational root causes.

### 3.5. Review

The primary aim of the review function is to maintain an overview of the values, beliefs and assumptions concerning nuclear safety in the project. This includes an evaluation of the level of sharedness of these assumptions and whether nuclear safety culture is realized in actual organizational structures and practices. This feedback is used in improving the safety culture and the nuclear safety culture program by analyzing the various sources of information (including their reliability, validity and potential discrepancies in findings). It also aims at reviewing the way Fennovoima currently monitors (and facilitates) safety culture in the project. Thus, whenever possible, external information sources and independent experts are utilized for review purposes.

An annual safety culture **follow-up report** is prepared by Fennovoima’s safety culture manager. It is aimed at the top management and helps steering both Fennovoima’s internal work and supply chain safety culture assurance. The follow-up report describes, integrates and evaluates all safety culture-related information gained from implementing all five supply chain safety culture assurance functions. An overview of the status of safety culture in the supply chain is made and corrective actions as



specified when necessary. The overview includes elements such as the main challenges and opportunities of the supply chain as well as a summary assessment of the status of safety culture in the FH1 project. In the end-year follow-up report it will also be evaluated whether the safety culture facilitation methods and other activities conducted by Fennovoima in the supply chain have resulted in convergent or divergent influence on supply chain safety culture. For example, if the contract and supply chain management send one message and the safety department a different message about Fennovoima's priorities, neither message will be as convincing as when Fennovoima as a company and every employee as a representative of Fennovoima send a clear signal about the overriding priority of nuclear safety.

At the moment the way of systematically collecting and analyzing safety culture related data from the supply chain is under development. The developed tool will help in maintaining an overview of the entire supply chain.

## **5. FINDINGS AND DISCUSSION**

### **5.1 Assurance procedure**

Many of the safety culture assurance tools and methods have been used at Fennovoima for a longer period of time, but the supply chain safety culture assurance procedure in its current form was approved and implemented less than one year before the writing of this paper. This means that it is currently in pilot phase and experience of its effectiveness is limited. However, some benefits of the procedure can already be identified. For instance, the specification of supply chain safety culture assurance functions has helped ensure that safety culture work does not focus on only one type of activities but a balanced and diverse selection of methods is used. The functions have also been helpful in communicating towards the supply chain that for sustainable safety culture assurance, diverse selection of safety culture assurance methods are needed and helped establish a mind-set that acknowledges that safety culture methods and tools have different roles in the overall assurance strategy. Thus, the functions have directed attention towards actually understanding what is the purpose of the safety culture methods rather than implementing them haphazardly. This promotes a systematic and methodical approach to supply chain safety culture assurance.

The selection of the functions themselves appears to be quite comprehensive for the purpose of supply chain safety culture assurance. It follows, in principle, iterative improvement processes such as the plan-do-check-act cycle [22], with a more explicit attention on establishing requirements (cf. "plan" phase) and coordination and communication (has no clear counterpart in PDCA) and less on enactment ("do/act" phases). Establishing requirements is especially important in a turn-key delivery construction project with a dynamic and complex supply chain, and due to the strict regulation in the nuclear industry. The dynamic and complex supply chain is also part of the reason why coordination and collaboration warrants a distinct function, because this function helps align activities and ensure shared understanding among project participants. Since the actual improvement of safety culture in their respective organizations is primarily carried out by the suppliers, there is less attention put on enactment (although covered by the facilitation function). While it is conceivable that there are other functions that are relevant in addition to the current ones, a balance between generality and specificity is needed to maintain the manageability of the process. For the time being, the current five primary functions (and the one support function of reporting) can be seen as the fundamental functions that are necessary for sustainable supply chain safety culture assurance process.

### **5.2 Functions**

The establishment function lays the foundation for all supply chain safety culture assurance. Perhaps the most important method in this function is contractual requirements. Specifying contractual requirements sets the scene for all subsequent safety culture work and their effect reverberates over the whole construction project and beyond the completion of the plant. This means that special focus must be put on ensuring that necessary safety culture requirements have been specified in advance. A

proactive and anticipatory approach is needed along with close collaboration with safety culture experts during contractual agreements.

Fennovoima contractually requires RAOS Project to adopt the IAEA definition of safety culture as “that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance” [23, p. 1]. Fennovoima also requires a dedicated person with competence in safety culture who is responsible for managing the safety culture program of the organization. This, along with the requirement to send the program for approval to Fennovoima, provides a sound basis for developing safety culture. Other examples of essential requirements include access to the whole supply chain for auditing, which allows first-hand assessment of suppliers’ safety culture – a prerequisite for the formation of a general overview of the status of safety culture in the supply chain and for actualizing the monitoring function. Contractual requirements are also important in specifying more accurate or stringent requirements than the national or international requirements would do. For instance, Finnish regulations require “planned and target-oriented safety culture improvement” [5, p. 7], but leave it ambiguous what does this exactly mean, which can result in haphazard or inconsistent implementation of improvement activities. To (partially) address this issue, Fennovoima requires a regular integrative follow-up and a corrective actions process of all safety culture activities from the suppliers.

The need for facilitation stems from the licensee’s ultimate responsibility for nuclear safety. It is not enough just to wait for the plant to be designed and constructed, but the license holder has to take an active role in assuring the safety of the operational power plant. It has also been very important to interact with all safety-critical organizations, and not only with RAOS Project. Nuclear safety culture working groups (NSCWG) have been proven to be quite effective method for interaction, and for coordinating and collaborating with the supply chain. To date (March 2018), at total eleven full-day NSCWG meetings have been held with the participation of the most important (Grade A) suppliers. Fennovoima chairs the meetings. Participation of the grade A suppliers is mandatory and it is required in the EPC contract. The NSCWG also provides a forum for decision-making where the suppliers can have a say on various project-related safety culture assurance activities. This is important for creating a sense of shared purpose for safety culture development in the FH1 project. The NSCWG work strives to adhere to the FH1 safety culture principles of transparency (by sharing information), awareness (by clarifying requirements and informing of safety culture related concepts, literature etc.) and continuous improvement (the topics and ways of working at the WG are reviewed regularly).

A typical NSCWG meeting consists of safety culture experts from Fennovoima, RAOS Project Oy and all other participating suppliers presenting a progress report of their safety culture activities since the previous meeting. These reports are delivered in advance to RAOS Project. After the progress reports, a safety culture theme is discussed. In some meetings an external expert presents an introduction to the theme. Each participant holds a presentation on the theme from the perspective of their safety culture work. Joint discussing of others’ safety culture work is encouraged by prompting for questions and ensuring that there is time for the discussion. Quite often the approaches to safety culture activities presented by the organizations lead to follow-up questions as the other organizations wish to gain more information to support their own work. Thus the NSCWG is a potentially useful forum for sharing best practices in safety culture assurance and avoiding most pitfalls.

Fennovoima’s safety culture activities, processes and programs are also presented in the NSCWG. More often than not Fennovoima’s work is more advanced in terms of fulfilling the YVL-guides (which are more familiar to a Finnish organization) than the other participants’, which sometimes results in long discussions about the details of implementation and possible applicability in the supplier organizations. For instance, the safety culture ambassadors system implemented at Fennovoima quickly spread to the whole supply chain and was implemented in some form or another by almost every NSCWG participant. However, while many of Fennovoima’s approaches have been influential in the supply chain, some have been interpreted as almost unconceivable by the suppliers. For instance, the low power distance that characterizes Finnish culture and is also reflected in

Fennovoima's safety culture work (e.g., top management is not above criticism and can be the object of non-conformities or safety culture interventions), such approach was not perceived as directly applicable to the Russian organizations. Similarly, anonymous safety concern reporting systems have been implemented as per Fennovoima's requirement, but have remained relatively ineffective due to the negative connotations attached to "talking behind someone's back" in the Russian culture. This suggests that there are certain limits to sharing best practices. Safety culture programs cannot be standardized on detail level and a certain amount of organization-specific tailoring is probably always required, especially when the organizations are highly diverse.

## 6. CONCLUSION

In this paper we have presented a systematic supply chain safety culture assurance process and described how it is used by Fennovoima in the Hanhikivi 1 nuclear power plant construction project. To our knowledge, there is no previously published documentation of supply chain safety culture processes that have been used in practice in nuclear power plant construction projects. The evidence this far regarding the effectiveness of the process is promising, with examples of successful safety culture improvement actions. However, the long-term effectiveness of the process remains to be seen as its practical implementation continues.

The safety culture assurance activities have heavily relied on the EPC contract and YVL requirements. The approach emphasizes on compliance with requirements. In principle this would indicate that safety culture in the supply chain is still in quite reactive level. On the other hand, the requirements that concern safety culture are wide and sometimes a bit ambiguous and it is difficult to fulfil them with a "check-box mentality". Fulfilling the requirements actually requires proactive culture.

The different functions of the safety culture assurance process each have a specific purpose that relates to the complex and networked nature of the NPP construction project. Establishment seeks to build common understanding via shared structures and implementation of requirements as applicable based on graded approach. This makes the network manageable from the safety assurance point of view. Facilitation seeks to improve nuclear safety and safety culture proactively and continuously, with Fennovoima taking the role of a responsible license holder. Monitoring maintains an overview and gives input to corrective actions in case of deviations, whereas review allows a deeper analysis of the properties of safety culture in the supply chain. Finally, collaborate seeks to form a unified vision and shared identity among the safety culture participants; build trust and transparency. Each requires different kinds of methods and ways of working. This paper has been an attempt to elaborate Fennovoima's way of striving to assure the cultural conditions for the safe construction of the sixth nuclear reactor in Finland.

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