TOPICAL SESSION 1

LEARNING FROM THE PAST, GOING FORWARD

Papers submitted

PAPERS SUBMITTED FOR TOPICAL SESSIONS ON LEARNING FROM THE PAST, GOING FORWARD

H. KHALAFI − Enhancing Organizational Effectiveness in Tehran Research Reactor (TRR)

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ENHANCING ORGANIZATIONAL EFFECTIVENESS IN TEHRAN RESEARCH REACTOR (TRR)

H. KHALAFI
Atomic Energy Organization of Iran (AEOI) - Nuclear Science and Technology Research Institute (NSTRI)
Tehran, I. R. Iran
Email: hkhalafi@aeoi.org.ir

N. MATAJI KOJOURI
AEOI-NSTRI
Tehran, I. R. Iran

E. SEDGHGOOYA
AEOI-NSTRI
Tehran, I. R. Iran

J. DABIRI
AEOI-NSTRI
Tehran, I. R. Iran

A. EZZATI
AEOI-NSTRI
Tehran, I. R. Iran

Abstract

Bearing in mind even one simple definition of "organization" as a social unit of structured people working together in a managed manner to achieve some common goal, we can understand the importance of the matter in achieving goals. Organization of the nuclear complex shall be considered, by all of the stakeholders not only in the national scale but also in the international relations and communities, as one of the most important pillars of the effective and reliable, and safe and secure use of the nuclear technology. Effectiveness of the nuclear technology is obtained through a good, safe and secure technology, skilled and committed personnel who work well in interaction with technology, established organization which conducts and regulates activities upon whole of the complex system via management and leadership in harmonized manner. The effectiveness of the nuclear complex is a complicate function of the above mentioned affecting factors, but a good organization besides solving its day to day business, can minimize the problems, resolve or eliminate unnecessary challenges, save resources, energies, help to identify issues and difficulties.

Simply any organization has a theoretical base and consists of necessary elements. In order to be effective one organization first of all shall include good theoretical base, then armed with good instruments and then shall be run well. Enhancing the effectiveness of any organization can be achieved by enhancing any of the above mentioned elements individually or collectively in a harmonic way.

For enhancing the effectiveness of the organization in relation to human resource activities, we introduced some changes in the following areas: organizational chart, internal working procedures, establishing consultancy committees and some activities in direct relation with human resources including spiritual, training and education programs as well as the job trainings.

1. INTRODUCTION

Organizational structure is the process of building a team of highly talented, professional, ambitious, and enthusiastic individuals to achieve set goals and targets. Effective employee management and expansion of researches and products are the main reasons for the necessity of a systematic organizational structure.

Simply any organization has a theoretical base and consists of necessary elements. In order to be effective one organization first of all shall include good theoretical base, then armed with good instruments and then shall be run well.

Organizational structure takes account all of the personals/ subdivisions/ divisions/ organizations (including the facility or operator, local and national governmental and nongovernmental organizations) working together in the normal conditions or responding to the emergency situations. Effectiveness of the nuclear technology will be obtained through out applying a systematic organizational structure and committed personals who work together responsible besides the other necessary infrastructure elements (e.g. Authorities and responsibilities, Co-ordination, Plans and procedures, Logistical support and facilities, QAP, Training).

Right establishment of an effective organizational structure and regular updated will be allowed to conduct the activities and working programs in nuclear facilities in form of the safe, secure and harmonized manner.

The effectiveness of the nuclear facility is a complicate function of the above mentioned affecting factors, but an appropriate organization besides the sequential tracking and solving the errors, overlaps, gaps and misunderstanding can minimize and / or eliminate unnecessary challenges and save the resources.

Considering the responsibilities of the operator of Tehran Research Reactor (TRR), this has an important role in national R&D programs and simultaneously in providing some certain medical radioisotopes for about one million patients all around the country. TRR objectives are providing services for all customers efficient (e.g. with accurate and sufficient, in due time and with satisfaction quality) in reliable, safe and secure manner.

For enhancing effectiveness of the Tehran Research Reactor (TRR) as a nuclear facility in order to satisfactorily meet research and production needs, must be effort in some different areas in parallel and simultaneously including technical, administrative, organizational and human resource issues. These efforts include:

— At the first should be preparing a plan to identify the errors, overlaps, gaps, failures, misunderstanding of the process implementation and facility real

situation in all interested subjects and areas base on a comprehensive Inspection & Test Plan(ITP) and review & assessment plan (RAP). This plan should be include problem definition, current situation / problems analysis, determine the required criteria and standards, determine goals, root case analyses of the problems and failures, propose the solution and how implementation of their corrective action (action plan),
- In the next step implementing the plans and record the results,
- And then audit, re-evaluations, determine the conformance and non-conformance items,
- Finally standardization, obtain the results from plan implementation.

For enhancing the effectiveness of the organization in relation to human resource activities, we introduced some changes in the following areas: organizational chart, internal working procedures, establishing consultancy committees and some activities in direct relation with human resources including spiritual, training and education programs as well as the job trainings.

Currently work is implemented and after that we shall evaluate the results, but up to now briefly we understood that selected way helped us to improve our organization

2. WHY NEED TO REVIEW AND UPDATE THE ORGANIZATIONAL CHART

In the beginning, purpose of the Tehran Research Reactor establishment as a nuclear center was research in the fields of agriculture, industry, medicine and education of students. But over 50 years now the main objects are:

- Research, development and production of industrial radioisotopes and radiopharmaceuticals and increased requirements on the type and amount of radiopharmaceuticals (approximately for 1 million patients);
- Increasing quantities of transients related to experiments;
- Test of material in the Tehran Research Reactor;
- Training of university students;
- Carried out various projects for universities and students;
- Maintenance, refurbishment and upgrading the TRR installations and equipment in accordance with updates standards and technologies and the lessons learned from 50years of operation;
- Aging the reactor facilities and the need to implement some programs as Aging Management Program(AMP);
- Training the TRR nuclear experts,
- Training human resources in the design and manufacture of reactors;

- Deal with sanctions against our country and the creation of very unusual restrictions;
- Increase the scientific and technological capacity and promoting technological systems and equipment.

According to the defined above objectives for the Tehran research reactor facility, the organizational structure had been assessed and reviewed to understand it's properness to accommodate new objects. Assessment the activities and Efficiency of the organizational structure was done in two steps. At the First by reactor management with self-assessment method and then performed by an independent assessor. In the evaluation we used Review and Assessment Program (RAP) – inspection and test program (ITP) and self-assessment plan (SAP).

3. REVIEW AND ASSESSMENT BASES AND REFERENCES

Review and assessment had been done based on:

(a) Recommendations and related documents of IAEA (management system, safety culture, safety of operation of research reactors, ext.) as reference basis;
(b) TRR operating experiences;
(c) Results and recommendations of peer reviews reports (including reports from IAEA expert meetings and other mutual activities);
(d) Results of interaction with regulatory body;
(e) Opinions of our customers and other stakeholders as reference arguments;
(f) Facts, evidences and indicators, which necessitate reorganization or modifications.

4. SOME RESULTS OF THE EVALUATION

RCA1 – Defined activities, working programs duties and authority were out of the expert capabilities, not suitable distribution of human resources in working groups.
C.A11 – Necessitate of revision of working groups and modifying the reactor organizational structure.
C.A12 – Necessitate of revision the duties, responsibilities and authorities of management, staff and working groups.
RCA2 – Too much focusing on experience not knowledge and lack of effective implementation of updated standards, requirements and IAEA technical documents and recommendations, lack of using the experiences of other research reactors as lessons learned, lack or improper knowledge management at the TRR facilities.
C.A21 – Necessitate providing the necessary continuous training from the beginning of employment and at different stages of work.
C.A22 –Necessitate to recruitment experts for needed positions instead of retired (or

near to retiring personnel 0 or due to new duties.
C.A23 – Necessitate of periodic on the job training and exchange of experiences with other experts from other countries (the transfer of best practices, exploitation and practical place),
RCA3 – Depreciation of equipment, facilities, buildings, and in some cases lack of equipment (due to sanctions), is evident.
C.A31 – Necessitate to create a working group to review, evaluating and identifying the depreciated operating equipment and to determine reliability of equipment, lack of required equipment, monitoring the real situation of the instruments and equipment spare parts and support services by the manufacturer or seller,
C.A33 – Necessitate training the personnel responsible to take advantage of the maximum capacity of the instruments and equipment.

5. ACTIONS AFTER ASSESSMENT

After declaring and adaptation of the results we prepared and implemented the Comprehensive action plan in response to results of the study and by using Graded Approach. Also we establish a mechanism for assessment of performed activities and then accomplishing correction actions if should be any deficiencies in performed actions and expected ones. Based on results of work of this mechanism we understand that the following enhancements are also necessary:

- Enhancing internal audits and interaction between Auditors and responsible persons of the TRR departments
- Enhancing Training program of TRR for improving skills and attitude of all workers of TRR
- Enhancing interactions with main stakeholders and customers
- Improving the mechanism for evaluating contractors and other organizations which involve in performing nuclear and safety related activities for TRR
- Establishing mechanisms for monitoring and periodic reporting the quality of works based on quantified proper indicator especially safety performance indicators.

6. MODIFICATIONS DUE TO RESULTS OF ASSESSMENT

Main modifications of the TRR organizational structure include:

- Improving the safety committee;
- Improving the training Committee;
- Establishing Technical Committee;
- Establishing emergency group;

- Review and Improving the composition of working groups and the number of their members;
- Review and Improving the structure and research group specialist;
- Review and Improving the working processes.

After the review, approval, adoption and implementation of reforms in organizational structure, it became necessary to review and revise documents and other components related to the structure and working processes. Some of the components and the programs that were created or modified are:

- Definition of Facility Strategic Plan (FSP) and redefining the vision, mission and Goals;
- Preparing the Aging Management Program;
- Establishing the Integrated Management Systems (IMS);
- Changed and modified the management system by considering recommendations of the GS-R-3;
- Modification of process stream and flow diagrams of work inter TRR departments for 3 major fields of activities: Isotope production, Research and Education and Training. Therefore modification of related procedures,
- Review the plans and procedures;
- Review the personnel training program and recruitment, according to extensive and variety of processes and activities;
- Review the facility and logistical support;
- Review the management, personnel and specialist responsibilities, authorities and tasks;
- Review the experiments safety program;
- Radiation protection and personnel safety review program;
- Review and reforming the working processes and other documents.

7. EFFECTIVENESS INDICATOR

The following items can be used as Indicators of the effectiveness of changes:

(a) Performance and quality of the Radioisotope Production (medical and industrial),
(b) Quantity of R & D activities on the production of new radioisotopes,
(c) Quality and quantity of trained students and workers,
(d) Provided Irradiation services to universities and institutions,

8. CONCLUSION

As our experience showed the nuclear facility is a dynamic object and capability and ability of its organizational situation and its properness to achieve goals and targets shall be assessed periodically using operating experiences, opinions of all stakeholders, worldwide experiences and recommendations of IAEA, other international valuable related documents. Managing system of the facility shall have necessary instruments for doing so and for monitoring and auditing and then have sufficient authority and resources to implementing the necessary modifications.

AN EVALUATION METHOD FOR TEAM COMPETENCIES TO ENHANCE NUCLEAR SAFETY CULTURE

P. HYUN SEONG
Korea Advanced Institute of Science and Technology,
Daejeon, Republic of Korea
Email: phseong@kaist.ac.kr

S. MIN HAN
Korea Advanced Institute of Science and Technology,
Daejeon, Republic of Korea
Email: gkstkdals@kaist.ac.kr

A. RYUM KIM
Korea Advanced Institute of Science and Technology,
Daejeon, Republic of Korea
Email: arryum@kaist.ac.kr

Abstract

Competency and Social Network Analysis (SNA) concepts were adopted to assess team safety culture. A wide consensus grew among researchers and nuclear-related organizations, that safety culture should be evaluated and managed in a certain manner. Consequently, each nuclear-related organization defined and developed their own safety culture definitions and their assessment methods. However, none of these methods provides tools for a team, which is the smallest working unit in NPPs. Therefore in the paper, a method to estimate nuclear safety culture of a team. Team safety culture competencies were defined as ‘underlying and sharing characteristics, outward attitudes, and pattern of behavior of team members that are causally related to a healthy and strong nuclear safety culture’. To derive team safety culture competencies, strategic success modeling (SSM) was applied through reviewing the criteria of existing international and domestic safety culture assessment methods. In order to evaluate the competencies of a team, SNA was chosen to be a strategy for investigating the relationship through the use of network and graphical elements. A guideline for an observation was also developed for an observer to check the team safety culture competencies from the behavioral characteristic of team members. This was used as an input value of various matrix operation provided in SNA. Matrix was operated to derive the density of team members, and the degree centrality of team safety culture competencies, which could represent the degree of deficient team safety culture competencies among team members, into both numerical and graphical ways. It is expected that the proposed evaluation method of team safety culture competencies not only provides concrete practices to enhance safety culture, but also enables to analyze the shared values and the underlying characteristics of team safety culture.

1. INTRODUCTION

1.1. Nuclear safety culture

Safety culture has received attention in all safety-critical industries including nuclear power plants (NPPs) due to various prominent accidents, such as the concealment of a Station Black Out (SBO) at the Kori NPP unit 1 in 2012, the Sewol ferry accident in 2014 and the Chernobyl accident in 1986. In various reports, it has been pointed out that one of the major contributors to cause those accidents is a "lack of safety culture". The Inter-national Atomic Energy Agency (IAEA), one of the most influential organizations in the nuclear industry, defined nuclear safety culture in the International Nuclear Safety Advisory Group (INSAG) report No. 4 published after the Chernobyl accident occurred.

> "Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted their significance." [1]

Although the definitions of safety culture are different among nuclear-related organizations, the assessment of safety culture clearly targets the management and improvement of the characteristics and attitudes of individuals and organizations. Moreover, there is a wide consensus among academic researchers that safety culture should be evaluated and managed in a prescribed manner.

To manage and improve the characteristics and attitudes of individuals and organizations, several methods have been developed from various nuclear-related organizations so far. There are three representative methods: 1) the Independent Safety Culture Self-Assessment (ISCA) developed by the IAEA, 2) the Independent NRC Safety Culture Assessment from the United States Nuclear Regulatory Commission (US-NRC), and 3) a Nuclear Safety Culture Assessment (NSCA) survey process developed by the Nuclear Energy Institute (NEI). [2-4]

However, there is no method that represents the safety culture of the team, the actual working group in NPPs. The target of safety culture evaluation are mainly the organization, and the evaluation is qualitatively performed. Even the evaluation of safety culture is performed quantitatively, the results of safety culture of an organization come from the gathered information of individuals' responses. Therefore, the safety culture of an organization could be only described vaguely, or represented with the sum or average of individuals' results. Moreover, individuals easily overlook their required jobs to improve nuclear safety culture, since there is no explicit statements for each individual. Therefore, in this study, the quantitative evaluation method of team safety culture is developed by using the 'competency' concept and SNA.

1.2. Team safety culture competency

Throughout this paper, the term, 'team safety culture competency' will be used. Generally, the competency is mainly focused on individuals to achieve a given goal. Competency has a clear difference to ability or capacity. Competency is behaviourally seen, so that can be observable. Competency is not a skill or a knowledge that individual possess, but revelation of skill and knowledge by behaviour. Moreover, competency is highly connected to the performance of a goal, and it is situation-specified [5].

The first step to derive competencies is to define the range and the goal of competency. Literature review should be accompanied to define competency. After defining the range and the goal of competency, derivation of competency list is performed generally by Behavioural Event Interview (BEI), Subject Matter Expert (SME), or Strategic Success Modelling (SSM). All the methods are merely different in methodology, but they are the same in finding a behavioural characteristics from a high-performed subjects.

In this study, competency is narrowed down to safety culture competency. The competency of individual is commonly defined as the "underlying characteristics of an individual that are causally related to effective or superior performance in a given job" [6]. Similar to safety culture, the definition of competency focuses on characteristics and attitudes of individuals to achieve the goal. Therefore it is defined that 'individual safety culture competency' is 'underlying characteristics and outward attitudes of individuals, in a safety plant that are causally related to a healthy and strong nuclear safety culture'. Moreover, 'team safety culture competency' is defined as follows; underlying and sharing characteristics, outward attitudes, and pattern of behaviour of team members that are causally related to a healthy and strong nuclear safety culture.

In case of individual safety culture, the competencies were divided into three levels according to individual's position, and ten categories according to the properties of competencies. Then the competencies were evaluated by the results suitably measured from questionnaire, observed behavioural index, and systemic index. [7]

Now we are beginning to focus on developing the evaluation method for team safety culture competencies. In case of team safety culture, the most important property of competencies is 'shared among team members'. Therefore we chose evaluation method as SNA, which will be introduced in the next section, in detail. SNA is a powerful method that can represent 'sharing' among elements, without structural modelling of the elements.

1.3. Social network analysis

As mentioned briefly above, SNA is a strategy for investigating the relationship through the use of network and graphical elements. Existing analysis methods were mainly individualistic, variable-centric. However currently, the structural and relational characteristics between variables are considered as important, and SNA is one of the method that reflects. The first study of SNA has has been developed from 1940s and 1950s. Concepts of social psychology, such as group and social circle, were started to be described with network terms to figure out the spontaneously produced relationship from network raw data. [8] Also, the group networks laboratory in MIT studied the how the network structure of communication of a group affects to the speed and accuracy of problem solving. [9] After 1980s, SNA became a dominant area in social science. SNA was applied to various fields, such as management consulting, public health, or prevention of crime. [10-12]

SNA result can be represented in both matrix form and graphical form, but graphical form is more preferable due to the legibility and the intuitiveness. Depending on the presence of the directivity of lines and measurability of nodes, graphs can be divided into directed graph and non-directed graph, and binary graph and valued graph, respectively.

Through abovementioned representations, SNA aims to describe the relationship among nodes and expect the performance of group. In other words, the result of SNA can be explained depends on the direction of cause-and-effect of nodes and their relationships. Network itself can be analyzed as an independent and explanatory variable to explain the cause of relations, or network can be analyzed as an outcome variable of the relations. When SNA is adopted to nuclear industries, team safety culture competencies can be investigated as follows: since the safety culture competencies are necessary to make able to maintain the high level of safety culture, team safety culture is a result of relations among team safety culture competencies.

By matrix operation provided in SNA, several results can be derived such as density, connection, centrality, power, and cluster. Among them, two are the most widely used; density and degree centrality. Density is defined as the sum of the lines divided by the number of possible lines. If the density is high, nodes are generally having a close relationship. Degree centrality is the number of relationships that a node has, out of the relationships that a node can have. A node which has high degree centrality means, a node is generally an active player, or in an advantaged position in the network. In this study, team safety culture will be also represented with the two numbers.

1.4. Research objective and scope

The aim of this study is to evaluate safety culture of team, which is the smallest working group of NPPs. To evaluate team safety culture we defined team safety culture competency, and listed the competency lists by using SSM. By using SNA, we investigate how team safety culture competencies are linked among team members to estimate team safety culture. Density of team members will provide the degree of deficiency of team safety culture competencies, and degree centrality of team safety culture competency will showed the competency which should be improved in the first place. Graphical notation will give legible glance of the relation between team safety culture competencies.

Through this study we expect to understand the characteristics of a team safety culture and to suggest the urgent team safety culture competencies to be improved for the safe operation of NPPs.

2. DEVELOPMENT OF EVALUATION METHOD OF TEAM SAFETY CULTURE COMPETENCY

2.1. Derivation of team safety culture competencies

We used SSM technique to derive the list of team safety culture competencies. Generally SSM proceeds in the following steps.
Step 1: Planning for an effective and optimized derivation of competencies. Also, the range and goal of competencies are defined. Plan the step to derive including the range and the goal of competencies.
Step 2: Information gathering from behavioural characteristics of high-performed subject. This stage is generally performed based on from the target goal, through interview, workshop, or survey. Etc.
Step 3: Defining the competencies based on the result of step 2. The list of competencies and their behavioural characteristics are derived.
Step 4: Validating the derived competencies. Validation is performed by statistical analysis and experts' judgment and modification is also performed based on the result of validation.

Through performing step 1 to step 4, 8 core competencies for team safety culture and behavioural characteristics of them were derived as shown in Table 2.

TABLE 2 CORE COMPETENCIES AND BEHAVIORAL CHARACTERISTICS

Competency	Examples of behavioral characteristics
Leadership	◆ Team members know their role and accountability clearly, a nd if it is insufficient, team leader alerts. ◆ Team leader clearly understands the plant situation, and deli vers to team members. ◆ Team leader arbitrates the dispute when team members viola te or implement procedures, regulations, and rules inappropr iately. ◆ Team leader continually supervise whether team members ar e performing tasks within the standardized processes to perf orm safely. ◆ Team leader positively encourage team members to successf

	ully perform tasks within plans.
Teamwork	◆ Team members actively help and advices to other team mem bers. ◆ Team members consider the abilities of other team members in performing the given tasks. ◆ Team members avoid non-constructive arguments, and coop erate with other team members to perform the given tasks. ◆ Team members positively accommodate helps and advices f rom other team members.
Communication	◆ Team members always have questioning attitude to the issue s that might degrade safety of the plant, and express their opi nions to other team members. ◆ Team members clearly deliver plant state to other team mem bers when performing the given tasks. ◆ Team members discuss about corrective actions of an event, which degrades the safety or comes close to degrading the sa fety. ◆ Team members mutually confirm their understandings after discussion of major safety issues. ◆ Team members actively make a question for clear understan ding of major safety issues. ◆ Team members share their experiences and information of m ajor safety issues with other team members. ◆ Team members follow the communication protocol.
Task management	◆ Team members continually concern with the activities of oth er team members, and alert them when they perform wrong activities. ◆ Team members cross-check the given tasks related to major safety concerns. ◆ Team members periodically inspect and manage the major s afety components. ◆ Team members decide task priority consider safety. ◆ Team members manage their own tasks not to cause any inc onvenience due to delay of performing tasks.
Situation awareness sharing	◆ Team members share the situation that might cause degradat ion of safety. ◆ Team members requesting information from other team me mbers when plant state is unassured. ◆ Team members share plans and information before performi ng the given tasks related to major safety issues.
Motivation	◆ Team members consider safety first, besides personal relatio nship between colleagues or boss. ◆ Team members pursue faultless decision-making. ◆ Team members actively support other team members to rais e teamwork
Decision-making	◆ Team members gather and analyze the all accessible informa tion to understand major safety issues. ◆ Team members confirm additional opinions or suggestions b

	efore decision-making. ◆ Team members endeavor to reduce uncertainty considering all the accessible information, such as time and methodolog y. ◆ Team members confirm and verify the effectiveness of decis ion after decision-making.
Emergency preparedness and response	◆ Team members are periodically trained for emergency situat ions, and mitigate the emergency situation based on the train ings. ◆ Team members are continually trained, reminding the preca utions of unaccustomed tasks. ◆ Team members share information to effectively manage the emergency situations and the abnormal situations. ◆ Team members judge the risk level of unaccustomed tasks, and plan the tasks to mitigate appropriately. ◆ Team members predict the latent hazards utilizing all the acc essible information.

By adopting SNA to evaluate safety culture competencies, it is necessary to measure each competency. Among various measuring techniques, we chose 'observation' from the outside of a team. Period of observation is basically 'any time', but at least once in a six-month. Also the observer could check the wrong competencies accumulatively and repeatedly within team members. Then the SNA is possible to check the team members who does not have appropriate competencies.

2.2. Application of SNA

As described in section 2-1, observed behavioural deficiencies from the safety culture competencies can be represented in the form of matrix. Matrix shows the lack of competencies shared among team members. Through matrix operation, density of team members and degree centrality of each team safety culture competency can be calculated. Equation 1 and 2 show how to calculate the value of density and degree centrality.

(1) $$\mathrm{D} = \frac{L}{{}_{g}C_{2}} = \frac{L}{\frac{g(g-1)}{2} \times i_m}$$

where, D: density of team members

L: number of lines

g: number of team members

i_m: maximum number of observations in one competency

(2) $C_D(N_i) = \sum_{j=1}^{g} x_{ij} \quad , \ i \neq j$

Where, CD(Ni): degree centrality of each competency

g: number of competencies

$\sum_{j=1}^{g} x_{ij}$: number of lines with other competencies

i_m: maximum number of observations in one competency

Additionally, we could calculate team safety culture through equation

(3) $\text{Team safety culture} = 1 - \text{D}$

Since the density of team members represents how team safety culture competencies are commonly insufficient among team members, team safety culture should be represented by subtracting density from 1. Therefore, it can be said that the density value of team members subtracted from 1, can be used as team safety culture index. Also, degree centrality of each team safety culture competency shows the priority of the competency to be improved in a team. In other words, the higher the degree centrality of competency is, the priority to be improved of the competency is urgent.

2.3. Production of the Prototype Module

Based on the developed method, prototype module was built to evaluate team safety culture conveniently. The module is composed of a server-cum-database, sub-module for observer, and sub-module for the subjects. The operational environment is shown in Table 3.

Table 3. Specification of Sub-modules

Module components	Operational Minimum Specification
Device for observer	Processor : Intel Atom Z3740 RAM : 1GB Capacity : 10GB

	OS : Windows 8 Hardware : 8-inch touch-screen tablet
PC for subjects	Processor : Intel i5 RAM : 1GB Capacity : 10GB OS : Windows 7
Server-cum-database	Processor : Intel Xeon E5-2630 v2 RAM : 16GB Capacity : 2TB HDD x 2 OS : Ubuntu Server 14.03.3 LTS

The selected device for observer is 8-inch touch-screen tablet with a digital pen. The module was implemented in the device, so the observer can check the team safety culture competencies easily, and anytime. All the sub-modules are produced in Korean for effectiveness and accessibility.

Sub-module for the subjects was made to be operated in the personal computer. High level specification for operating is not required, and the sub-module is also produced in Korean. Through the sub-module subjects can individually log-in to access their result and recommendations to improve team safety culture competencies. Also, there is a link to education web-site.

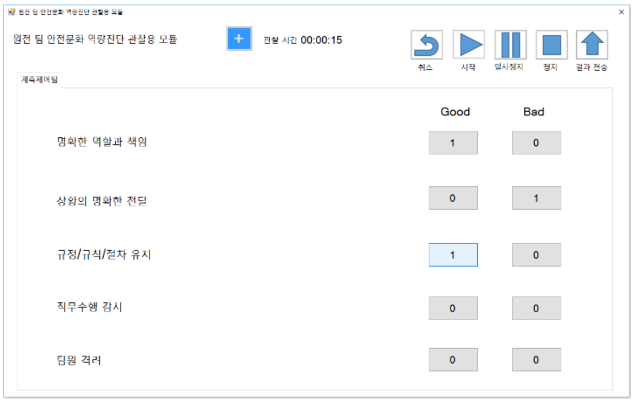

FIG. 1. Sub-module for an observer implemented in the device.

FIG. 2. Main Page of Sub-module for Subjects.

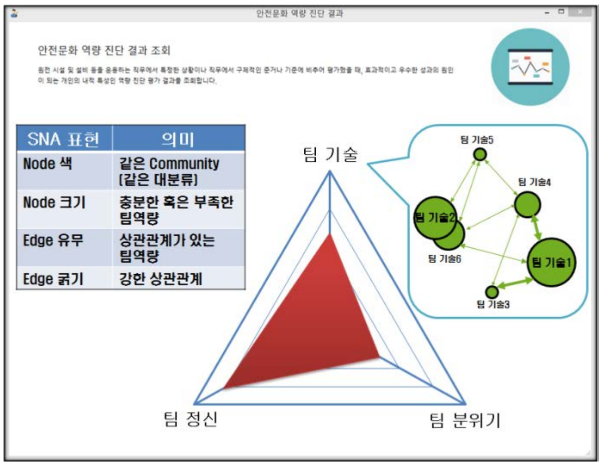

FIG. 3. Result page of sub-module for subjects.

3. SUMMARY AND CONCLUSION

In this study, team safety culture competency of a team was estimated through SNA, as a team safety culture index. To overcome the limit of existing safety culture evaluation methods, the concept of competency and SNA were adopted.

To estimate team safety culture competency, we defined the definition, range and goal of team safety culture competencies. Derivation of core team safety culture competencies is performed and its behavioural characteristics were derived for each safety culture competency, from the procedures used in NPPs and existing criteria to assess safety culture. Then observation was chosen as a method to provide the input data for the SNA matrix of team members versus insufficient team safety culture competencies. Then through matrix operation, the matrix was converted into the two meaningful values, which are density of team members and degree centralities of each team safety culture competency. Density of tem members and degree centrality of each team safety culture competency represent the team safety culture index and the priority of team safety culture competency to be improved.

Through this research, we expect that the suggested evaluation method of team safety culture will be useful to estimate the level of team safety culture and the urgent team safety culture competencies to be improved in the first place.

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BUILD NEW SOLUTIONS TO COPE WITH CHAOS

The Case study of Management of the Accident at Fukushima Dai-ichi

E. GISQUET
IRSN
Fontenay aux Roses, France
Email: elsa.gisquet@irsn.fr

Abstract

On March 11, 2011, an earthquake in eastern Japan caused the reactors in operation at the Fukushima Daiichi nuclear power plant (NPP) to trip. The emergency generators started and then suddenly failed following the tsunami. This event was not only beyond design basis, it was beyond any predictions. The accident management manual no longer could be directly followed. Human and organizational factors were decisive in determining the way the Fukushima Dai-ichi accident unfolded. With circumstances completely unforeseen in the manuals and procedures, actions at every level of the response structure were determined by group dynamics. How they build new solutions and what do they need to achieve it ?

Rather than looking at the causes of the accident, this paper examines the principles and rules of action that the stakeholders applied in response to the accident, particularly in the most urgent early stages, from March 11 to 15 on 2011. This study is based on an extensive literature review of sources related to the Fukushima Dai-chi accident. The information collected allowed to reconstruct the chronology of events and to analyze the way the main control room (MCR) and the emergency response center (ERC) act and react facing the nuclear accident.

At the MCR, people had to make sense of what happened and create new indicators. Since instruments and controls, as well as many communication technologies, were knocked out by the tsunami, all the standard means of determining the status of the reactors were impossible. Although they were under normal circumstances almost completely dependent on these indicators, and although (or because) their lives were most directly at risk, the operators managed this uncertainty through various means that will be successively presented.

At the ERC the decision to turn to an innovative solution was taken when it appears that the emergency systems will not work. Once the decision has been assumed, centralized coordination facilitated its implementation by assigning specific functions to the actors and setting up an intervention team dedicated to the care of ill-defined tasks.

At each level, would be identified human and organizational dynamics that have supported new solutions to enact sense making facing the chaos. The paper closes with a discussion of the design and implementation of crisis management systems, as well as potentially for the structuring and processes of organizations dealing with risk.

1. INTRODUCTION

On March 11, 2011, an earthquake in eastern Japan caused the reactors in operation at the Fukushima Daiichi nuclear power plant (NPP) to trip. The emergency generators started and then suddenly failed following the tsunami. This event was not only beyond design basis, it was beyond any predictions. Inside the plant people were attempting to connect the chaos they were experiencing with what Weick [1] refers to as “structural frameworks of constraint”: “a framework of roles, rules, procedures, configured activities, and authority relations that reflect and facilitate meanings”. However, procedures had not been prepared for a total station blackout (SBO), and the manuals were not applicable; they were left to interpret the chaos themselves. How people managed to create new solutions? What would they have needed? A closer examination of the process of constructing innovative solutions will enable us to move from a discussion "about what went wrong" in a discussion on enhancing the resilience of organizations.

We intend to investigate how the organizational framework consisting of rules, authorities relations is likely to help in the emergence of new solution [2, 3]. In particular, we will question whether centralization or decentralization of action supports the implementation of new solutions. In the question of organizational management of crises, there is continuing disagreement over the relative advantages of centralization, seen as facilitating command and control, quick decision-making, and big-picture overview; and decentralization, lauded for greater flexibility and opportunity for innovation, as well as closeness to the terrain. This paper would contribute to this ongoing debate[1].

In the end, the results will allow us to highlight what lessons we can learn from Fukushima accident in terms of crisis management. This issue has implications for the design and implementation of crisis management systems, as well as potentially for the structuring and processes of organizations dealing with risk.

1.1. Data

This study is based on an extensive literature review of sources related to the Fukushima Dai-ichi accident, primarily in English and French. The attention garnered by the accident means that, despite its relatively recent occurrence, there is already a wealth of literature available, from official reports to highly technical modeling to sociological articles. The most important documents for this study have been the official reports: those provided by the Tokyo Electric Power Company (TEPCO) to the Japanese government (hereafter cited as TEPCO 2011 for the interim report and TEPCO 2012 for the final); the report from the Investigation Committee on the Accident at the Fukushima Nuclear Power Stations (hereafter [5,

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[1] We would like sincerely to thank Malka Older who participated in the final report that originated this article 4. Gisquet, E. and M. Older, *A Human and Organizational Factors Perspective on the Fukushima Nuclear Accident-March 11-March 15, 2011.* 2015..

6]; and the National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission Report (hereafter [7]NAIIC report). The study also draws on the Ryusho Kadota's book [8, 9], a journalist who interviewed many of the key actors, including Masao Yoshida, the site superintendent of the plant at the time of the accident. Other reports, analysis and academic articles have also been examined. The combination of these different documents provides a relatively rich description of the events.

Nonetheless, two important constraints should be noted. Firstly, no additional interviews were conducted specifically for this study; there was no way to clarify discrepancies between the reports or try to fill in gaps with greater detail. Secondly, although almost five years have passed since the Great East Japan Disaster, knowledge of the events at Fukushima Dai-ichi is still evolving. There are still elements of the technical course of the disaster that can only be guessed at or modeled, as researchers wait for more access to data at the plant. Similarly, as more people become willing to talk about their role, the understanding of the human and organizational factors involved may also develop.[2]

The story of the first few days of the Fukushima crisis is dense and complex. For the purposes of this paper, we have culled the most relevant facts that allow us to understand how people were able to construct meaning to their actions and how group dynamics (structure) helped in this challenge.

At the first *level* we focus in on "those closest to the system, the operators," specifically the shift team on duty in the main control rooms (MCRs) during the disaster, and their relationship with the rest of the plant's teams and workers. Each MCR was shared between two reactors; since reactors 4, 5, and 6 were off-line at the time of the tsunami, we focus mainly on the shift teams for reactors 1 and 2, in one MCR, and for reactor 3, in an MCR shared with reactor 4. Each shared shift team had 11 members, including a shift supervisor and deputy shift supervisor; as the accident continued, several off-duty operators also reported to the MCR to assist. The operators were, for the most part, local, long-term employees. Considering this context, how operators have managed to support solutions? How do operators succeed in making sense when the means to build sense collapsed? A centralization of authority at higher levels it was necessary to identify and implement new solutions?

At the second *level*, we focus on the emergency response center (ERC) at Fukushima Dai-ichi. According to the NAIIC report agrees that "the primary decision-making authority rested with the site superintendent of the nuclear power plant." The superintendent in this case was Masao Yoshida, an experienced long-term employee of TEPCO who had worked at multiple plants. At this level, we

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[2] For example, on May 20th, 2014, the Asahi Shimbun reported that it had obtained the transcription of a key interview conducted as part of one of the government reports, and began reporting on discrepancies between the official report and the raw data. While these contradictions are relatively minor in terms of the focus of this study, they do highlight the possibility that additional information will continue to come to light.

intend to analyze how the ERC support innovative solution into the plant. Was it important that the ERC take power or could leave it to the MCR?

2. HOW DO OPERATORS SUCCEED IN MAKING SENSE THROUGH CAHOS?

Once the tsunami knocked out the diesel generators the operators no longer had light to read the accident management manuals; when they used flashlights to do so, they found the procedures not at all applicable to the situation they were facing. Without instruments, without functioning controls, and without standardized guidance, "*the shift team was forced to predict the reactor state according to a limited amount of information and take such procedures operators think best on the spot instead of following the instructions described in the standard manuals*" (ICANPS Interim p. 111). They were attempting to connect the chaos they were experiencing [1].

2.1. Creating new indicators

In the MCR, based on the last set of parameters and their limited experience with emergency shutdowns, they had no way of understanding the situation of the reactor or knowing what, if any, effect their actions had on it. The sensemaking process was on-going, and still vulnerable. However, they succeeded in creating new indicators. Although there was no way to directly observe the water or pressure levels inside the nuclear reactor, by physically going to the reactor building the operators would have access to other gauges that might tell them more about the situation. The shift supervisor sent several different missions to the field simultaneously to assess the situation and try to diagnoses key elements of the crisis: what equipment and system were working; what could be fixed; and what was useless. These missions were undertaken without the need for approval or suggestions from anyone outside the MCR. The sending of multiple missions more or less at the same time shows the operators' awareness of the complexity of the situation, and the need to explore multiple possible paths to a solution.

The operators manage to create new indicators on their own without the support of the rest of the organization. Communications with the ERC, located in an earthquake-resistant building several hundred meters away, were not eliminated but limited to a single phone line, whereas under normal circumstances the ERC would have all reactor parameters automatically available to them and multiple channels for communicating with the operators. This lack actually increased the autonomy of the MCR operators: since the ERC was totally dependent on them for what little information was to be had about the reactor, there was little second-guessing, and since the single phone-line was a non-continuous channel, it was only used when it was perceived to be necessary, rather than being open for every discussion. Those limited communication means prevent a centralized movement feared by Weick:

"*The danger in centralization and contraction of authority is that there may be a reduction in the level of competence directed at the problem*" [10 , p. 312].

However, this attempt to create autonomously new indicators has its limits. The missions also indicate the beginning of what Weick [10] refers to as "*enacted sensemaking*." In order to begin to process an unknown situation, it is necessary to take actions which start to provide data and support interpretation about what is going on; however, these actions also have an impact on the unfolding crisis, which can be positive or negative: "*individual actions involved in sensemaking can cause a crisis, but also manage it to lower levels of danger*." So, for example, when the operators wish to learn whether an emergency fire pump is still functioning, they turn it on. This answers their question, but also uses some of the remaining fuel available for the pump, thereby affecting the unfolding of the situation.

Their search for meaning continually impacted the unfolding of the crisis, whether it was the opening of an emergency system to see whether it would open, or running the fire protection system pump to see whether it would run. When operators trying to confirm IC operation turned back from the reactor building because of unusually high, but far from dangerous, radiation levels, it was a quite literal example of what Weick [10] describes as "*a delicate tradeoff between dangerous action which produces understanding and safe inaction which produces confusion*."

2.2. Interpretation of weak signal and culture

Later, operators have used other means to gather information for sensemaking process. When the parameters indicators had been partially restored, the operators had information that was confusing in a number of ways. For a group accustomed to conducting all its work based on indicators and lights on a control panel, the return of any of those indicators must have seemed, in itself, to be a positive development, regardless of what it told them about the status of the reactor: it was a slight move towards normalcy. On the other hand, because other indicators, such as reactor water level or discharge pressure of the IC, were not working, the operators were forced to depend on an ad hoc, informal and potentially unreliable indicator: the amount of vapor visible from a distance. This corresponds to what Vaughan [12] calls "*weak signals*," in which "*information was informal and/or ambiguous*" (p. 244). In this case, the operators took these weak signals very seriously, perhaps because of the absence of any more familiar, certain, or scientific data; some information at that point may have seemed more important to them than none.

Where the operators had received mixed and weak signals from unit 1 – the water indicator that worked temporarily (March 11th 16:42), the illumination of the IC vent indicator lamp (March 11th 18:18) and the strange question of the steam – they had gotten almost no information from unit 2. Interestingly, this complete lack of information – positive or negative – seemed to worry at least the ERC more than the mixed, weak, but overall negative signals related to the IC.

In addition, the team from the ERC had been working hard to restore the indicators, had in fact made it a priority. There was a commitment to that strategy, and as Weick [10] writes, "*The dark side of commitment is that it produces blind spots. Once a person becomes committed to an action, and then builds an explanation that justifies that action, the explanation tends to persist and become transformed into an assumption that is taken for granted.*" Weick in fact uses exactly the opposite situation as an example of this process: "*When people make a public commitment that an operating gauge is inoperative, the last thing they will consider during a crisis is that the gauge is operating*." In this case, there had been a commitment, if not that the gauge was operating, then at least that making it operational was a valuable if not essential first step to resolving the problem. With significant effort spent on that, at an opportunity cost of other possible initiatives for the limited workers and time available, discounting the information it brought them would not have been easy.

The explosion in the unit 1 reactor building (March 12th at 15:36) was in many ways a turning point in the response. Although not completely catastrophic, because the containment building remained intact, it was dramatic and utterly unexpected. If the tsunami had opened up an unforeseen realm of beyond design basis problems, the explosion was perhaps more frightening, in that it suggested that the progression of the accident itself was not well understood.

From the moment the tsunami knocked out power to their control room, the operators were plunged into a situation of extreme, almost complete uncertainty. They did not know at first what had caused the loss of power, and when they did learn it was almost unbelievable, the kind of event that Weick [11] describes as testing sensemaking to the extreme: "*an event whose occurrence is so implausible that they hesitate to report it for fear they will not be believed*." That was, however, just the beginning of the uncertainty; from that point the operators had to work in a way that they themselves perceived as disabled and deprived of their senses. Indicators and remote controls were so much a part of their working culture that without them they felt as though they had lost a part of themselves. (It is worth noting, too, that the most obvious risk to the operators – radiation – was imperceptible except via gauges and dosimeters, further reinforcing their reliance on technological senses rather than their own). The tools and signals that the operators normally used for making sense of the status of the reactor were gone; not only did they have an unprecedented situation to try to understand, but they had to develop new ways of doing so.

This disruption of normal sensemaking processes naturally had an impact on the way the shift team processed information and made decisions. As noticed in Gisquet and Older report [4], it was easy to trust the signals they had always relied on, even when those signals should have been put in doubt by the circumstances (as with the optimistic result of the water level gauge which was almost certainly false), and harder to believe in other types of information. Vaughan [12] traces a similar dynamic among the engineers at NASA, for whom "*the methods of positivistic science, emphasis on quantitative analysis, and multiple tests with data covering every known condition were the means by which uncertainty was converted to certainty.*" This data-based culture made it difficult for the engineers, and their supervisors, to perceive, understand, or accept other types of signals: "*The original technical culture mandated that engineering recommendations be backed by 'solid technical arguments.' The subjective, the intuitive, the concern not affirmed by data analysis were not grounds for formal action at Marshall [Space Flight Center]*."

In other words, even if the interaction of operators with the rest of the organization were limited, the organizational culture (i.e. technical culture) shapes the meanings, constructs the way things are. Alternatives become unthinkable [13] and the indicators are taken for granted.

2.3. The partition of roles to support sensemaking

Beyond their needs to create sense operators have managed to maintain the cohesion of the group, ready to act in a coordinated way facing new events and new tasks. The operators demonstrated a successful method for coping with uncertainty in their insistence on maintaining and even strengthening the social structures within their small working group by creating new rules to move on the field.

The normal shift supervisor for the team on duty in the MCR for reactors 1 and 2 during the disaster, named Hirano, was out for a routine medical examination, and he was replaced by the leader for a different team, Izawa. The first important decision Izawa took was to organize interventions outside the MCR. Rather than either continue with the status quo working procedures, or allow unregulated, individual determination of what constituted safe practices as the situation developed, Izawa set in place new measures, specifically changing the rules for going to the "field" (conducting any work outside of the MCR). Missions to the field would now require permission from the shift supervisor, would need to be conducted by at least two people, and would have a strict time limit of two hours, whether or not the objective had been achieved. Rescue missions would be sent after anyone who was away from the MCR for longer than two hours.

It is also leadership by continually supporting Izawa's leadership which helped to maintain and strengthen the group's structure. This is all the more remarkable for the fact that the leader of the group was a substitute on that day, and therefore there had not been any opportunity for team-building with that specific shift team-shift leader combination. Not only was Izawa's authority accepted, but when the normal leader for that shift, Hirano, joined the team, just after the earthquake there were no power struggles between them, and there seem to have been no divisions in the group's allegiance. Both the leader and other senior members of the team reinforced the social dynamics by asserting the authority of the leader and insisting that he stays in the control room while others took on field tasks.

The fact that the team, in an extremely stressful and dangerous situation over a significant period of time with very little fracturing[3] supports Weick's [1] hypothesis that resilience can be fostered by "*creat[ing] an inverse relation between meaning and structure (less meaning, more structure, and vice versa). […] When meaning becomes problematic and decreases, this is a signal for people to pay more attention to their formal and informal social ties and to reaffirm and/or reconstruct them*." In this regard, the organizational structure and more precisely, the local dynamics of the group have been particularly profitable for the implementation of new solutions, since it kept the cohesion of the group facing the chaos.

In summary, operators are able to create new solutions relatively autonomously with a field approach to enact sense making. The social structure of the group was very supporting. Nevertheless organizational culture that led to the indicators taken for granted without ever questioning them, worked against the sensemaking.

3. WHAT ARE THE CONDITIONS TO BUILD INNOVATIVE SOLUTION INTO THE PLANT?

3.1. Recognition of a new solution

The idea of using the fire trucks to inject water directly into the reactors in order to cool them came up to Mr. Yoshida, the Fukushima Daiichi NPP director, only few hours after the tsunami(March 11th at 17:15). The innovative solution appears very early in the management of the accident, at the top of the hierarchy, based on Yoshida experience on Kashiwazaki-Kariwa NPP during the Chu-Etsu-Oki earthquake.

However, this solution was only implemented later (March 12th at 2:03). In fact, three cooling solutions were envisaged in turn: the emergency systems (IC, RCIC and HPCI), an emergency coolant system (produced by linking three existing coolant systems together) powered by the fire protection system pump and, lastly, the use of this emergency coolant system powered by the fire trucks instead. The fire truck solution, which might appear extravagant and difficult to implement, became the only viable solution. If this solution has been implemented later, it is also because the recognition of this solution was shaping by the role structure inside the plant.

The solution to restore emergency system is one that satisfies all levels. The operators have their own interest in defending this solution inside what Kreps [14] might refer to as their intervention and expertise area, which was the control room

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[3] After the explosion in unit 1, some younger operators did ask what they were accomplishing by being in the control room, and Izawa let them evacuate to the ERC, but the core structure remained intact for the four days studied here.

and the reactor itself. Thus they remain in the choice of this solution trying to restart the emergency system.

On its side, the ERC considers easier to follow existing procedures than to create new ones with uncertain results. It does seem that preconceptions about the emergency system as a robust emergency water injection system that did not require electricity to function (semi-passive system), as well as a more generalized confidence in the technology they were working with, affected the cognitive balance of assumptions on what was working and what was not. Vaughan [12] defines a culture as "*a set of solutions produced by a group of people to meet specific problems posed by the situations that they face in common*" which then "*become institutionalized, remembered, and passed on as the rules, rituals, and values of the group*." The IC was a theoretical solution to a problem – loss of cooling function – that had long been seen as equally theoretical. It was also (at least potentially) an *existing* solution, a mechanism that did not need to be constructed or cobbled together in the midst of the crisis, which must have been appealing to the technical staff of the plant. Vaughan [12] notes that "*Engineering decisions are biased toward making existing hardware and designs work, as opposed to scrapping it and coming up with a better design.* […] *In the short run, a new design brings new uncertainties, not greater predictability*." For the staff of the ERC, believing in the emergency systems despite evidence to the contrary was easier than coming up with an alternative solution (March 11th around 18:00).

The solution is more innovative, the decision is more difficult to assume [2]. At least, the choice of innovative solutions is made assumed by the site superintendent. Hierarchical level needed to force the change of solution and gave credibility and legitimacy to future solutions.

3.2. The partition roles to support new solutions

Following up the decision, the implementation of the new solution has proved difficult. In particular, researching the possibility of using fire engines was challenging for the teams assigned to the task. According to ICANPS, this was at least in part due to the fact that *"Since the use of fire engines to inject water from the fire cisterns through the fire pump system line to the nuclear reactor was not defined as an emergency measure, the respective roles and responsibilities of the function teams were not clear" (ICANPS Interim, pp. 145-146).*

*Originally, thr*ee fire trucks were available on the site but only one was directly usable after the tsunami (one had been destroyed and the other could not move to the desired location because of debris). The ERC requested that additional trucks be sent. However, the earthquake and tsunami had caused considerable damage. The roads were damaged and blocked by large debris such as oil tanks and boats. These debris delayed the arrival of external fire trucks (and other equipment), and also created significant obstacles to movement within the plant once they arrived. One team within the ERC, the recovery team, therefore had to unblock the roads on the site to enable the fire trucks to reach the reactors.

The partition of roles was the facilitator in the implementation of the action. A centralized coordination helped to assigned new tasks, because no procedure was planned. In other words, while dividing the personnel into function teams was useful when tasks clearly fell into the defined functions, when new challenges did not fit easily into the work that the teams expected to do, it would have made it more difficult to assign roles and move forward. A centralized coordination allowed assigning specific functions to the actors and setting up an intervention team dedicated to the care of ill-defined tasks. This trend has also been supported by the recovery team able to take responsibility for poorly defined emergencies whose handling requires several fields of expertise.

In summary, the centralized coordination allowed to propose innovative solution, to assume responsibility for the decision and to assign stakeholder functions and roles.

4. CONCLUSION

There is continuing disagreement over both the likelihood and the relative advantages of centralization, seen as facilitating command and control, quick decision-making, and big-picture overview; and decentralization, lauded for greater flexibility and opportunity for innovation, as well as closeness to the terrain.

For Normal Accidents Theory (NAT), the conflicting requirements for centralization and decentralization lead to an inherent contradiction in any organization dealing with complex and tightly-coupled systems [15]. For systems that are complex and difficult to understand, the flexibility to improvise and react quickly is crucial; however, when the parts of these systems are likely to have rapid and important interactions with each other, a centralized overview of the crisis is also necessary. Because giving “those closest to the system” the freedom to take decisions and act immediately on them is incompatible with the idea of constant communication with and approval from a centralized authority, this leads to what Perrow calls “organizational contradictions.”

Roberts et al. [16], working on high-reliability organizations (HRO), argue that these contradictions may be at least partially resolved by organizations which have “a hierarchy which transforms from a rigid, centralized structure in some circumstances to a flexible, migrating structure in other circumstances” [16]. La Porte and Consolini [17] similarly describe “richly variegated overlays of structural complexity” that allow organizations to shift between “organizational modes” according to the needs of normal operations, peak times, or emergencies [17].

According to those previous scholars, it seems that a shift from centralization modes to decentralization mode (or reverse) should benefit to implement new solutions. According to our results, centralization and decentralization can and must coexist. The construction of meaning is supported by both decentralization and centralization trends. It is important that operators keep their strong degree of autonomy to find new solutions by moving on the ground, using their knowledge and expertise and especially maintaining the distribution of roles and thus more widely the social structure of the group. At the same time centralizing mode led the top of the hierarchy to shape the making sense. Top hierarchical levels recognize and impose the solution to the rest of the organization and support its implementation.

At least, there is something that transcends the logic of centralized or decentralized in the production of meaning; something that transcends all levels of the organization: the organizational Culture [12]. Our results have highlighted that technical culture led to take for granted the meaning giving by techniques, screens and indicators. Thus suggest an organizational culture have to keep a certain distance from technical arguments and could integrate empirical knowledge. Which could be suggestions for future research: How empirical knowledge enables us to respond to and tackle an unexpected situation? How can we encourage the development and dissemination of this empirical knowledge? To what extent can it coexist with "technological" knowledge in a highly proceduralized and technical environment?

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DEVELOPING AND STRENGTHENING OF SAFETY CULTURE AT UKRAINIAN NPPS
Experience of NNEGC «ENERGOATOM»

Y. SHEYKO
NNEGC "ENERGOATOM"
Kyiv, Ukraine
Email: y.sheyko@direkcy.atom.gov.ua

P. KOTIN
NNEGC "ENERGOATOM"
Kyiv, Ukraine
Email: p.kotin@direkcy.atom.gov.ua

Abstract

NAEC considers the constant attention to safety culture to be the key point for achievement of the goals of safe and reliable operation of the nuclear power plant. The driving mechanism of the progress in establishing and development of the safety culture throughout the operational organization is the wide awareness of international experience in the area of improving the safety culture, integration and introduction of the best international practices in your organization. The protection against wide range of non-standard situations can be achieved throughout the establishment of a commitment to a culture of safety, and the practical application of the safety culture to all organizational aspects of nuclear power plant activities. The Safety Culture is a main important step dividing us from the edificatory Chernobyl event past and connecting us to the bright future of our choice for safe and reliable nuclear power production.

1. INTRODUCTION

The moratorium, which was introduced in Ukraine after the Chernobyl accident for the construction of new nuclear power plants at the legislative level, was broken in 2004, when two new power units at Khmelnytsky and Rivne Nuclear Power Plants were put into operation. Now Ukraine operates 15 nuclear reactors at four different sites (13 power units with WWER-1000, and 2 – with WWER-440). Two units of WWER-1000 design are still under construction at Khmelnitsky NPP site. But their construction has been on hold for about 20 years already.

The well-known Chernobyl site is located around 150 km north from Kyiv, the capital of Ukraine. The centralized facility for spent fuel for all Ukrainian NPPs is being constructed there.

National Nuclear Energy Generating Company «Energoatom» (NAEC) is a state owned enterprise and the corporate operating organisation for all Ukrainian NPPs.

The current agenda of NAEC includes the following major objectives a top of safe and reliable operation of nuclear units:

- Improving the safety of NPPs;
- Improving the operational reliability and efficiency of NPPs;
- Construction and commissioning of two new units on site of Khmelnitsky NPP;
- LTO management of NPPs;
- Preparation of power units for decommissioning and nuclear waste disposal;
- The social programs development covering personnel and near-by population.

Following to 3 year lasted review, the final report on the "Safety Evaluation of Ukrainian Nuclear Power Plants" was published by IAEA in May 2010. The report confirmed basic compliance of Ukrainian NPPs with the essential requirements for safety. Based on the report recommendations the plan for further actions to improve safety was developed and put in force. The plan is under implementation now.

Currently, the nuclear energy sector plays the main role in the electric power industry of Ukraine. Nuclear Power Plants cover up to 60% of the total energy demand in Ukraine. (Fig. 1)

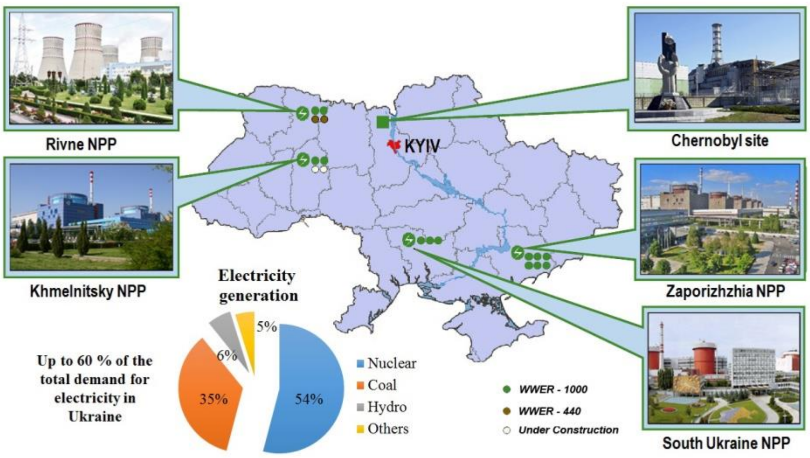

FIG. 1. Nuclear Generation in Ukraine.

2. ORGANIZATION FOR SAFETY CULTURE

NNEGC "Energoatom" (NAEC) as the operating organization is aware that the attitude and behavior of top management as well as organisational features and activities have a significant impact on the safety culture.

NAEC declares the absolute priority of safety over other objectives, in accordance with the principles of safety culture.

Beginning with 2009, in cope with the IAEA recommendations, and based on the introduced in Ukraine in 2008 new revision of safety rules "General provisions of safety of Nuclear Power Plants, OPBU-2008", NAEC activities for improving the safety culture are carried out under special programs.

There are three levels of management in these activities:

- Council on safety culture (top management) (Fig.2);
- Working group (representatives of all divisions of NAEC);
- Committees on safety culture (all NPP sites).

The programs are developed and updated every 2 years and the implementation of measures is provided on three levels of responsibility:

- Technical policy for the safety;
- Responsibility and leadership obligations;
- Personal responsibility and duties of every employee.

The main achievement of these programs was to define and establish the strategy and a set of permanent measures, which are aimed at improving the safety culture.

On the basis of the corporate programs the NPPs developed the programs of concrete actions aimed to establishment and development of safety culture, including:

- Self evaluation of safety culture;
- Questioning the staff;
- Independent audits of safety culture.

FIG. 2. The council on safety culture discusses NAEC corporate program for safety culture review.

3. INTERNATIONAL EXPERIENCE FEEDBACK

NAEC seeks to take into account international experience, and to participate in conferences (such as this one), seminars and workshops held under the auspices of the IAEA, as well as to follow the guidelines and standards of the IAEA in the organization of activities to improve the safety culture. Within the framework of the international programs of EC "soft" aid in recent years the projects that contribute to the development of a safety culture in NAEC have been either carried out or continued carrying out.

The projects address the solution of certain problems (for example, in the area of human factor – the task of «not punishment for error» approach establishment), as well as more common tasks of improving safety culture in overall, such as:

- Implementation of programs to inform senior staff and management, including the essential features needed to create a strong culture of safety; creating conditions for the improvement of the organizational and managerial impact on the safety of nuclear power plants and the development of a deep understanding of the importance of safety approach and the practical realization of the principles of safety culture in production activities;
- Creating an atmosphere of fruitful cooperation between management and staff, the improvement of collective action and of the behavior, developing a positive safety culture.

Currently NAEC is making efforts to improve the effectiveness of the implementation of these projects; to analyze the emerging issues in the implementation of project both at the pilot nuclear power plant and during its subsequent extension to the rest of the NPPs; to conduct generalization, systematization and integration of the results of these projects into a single management system of safety culture for NAEC.

Other sources of international experience in this field are assistance and guidance of other authorised international nuclear industry organizations such as WANO. In this regard, it should be mentioned WANO guidance document GL 2002-02 "Principles for Excellence in Human Performance" that identifies five fundamental principles relating to human factors, and important for the development of a sustainable safety culture in the organization:

- Even the best experts make mistakes;
- A situation fraught with errors is predictable, manageable and preventable;
- Human behaviour is determined by organizational processes and values;
- Highest efficiency operation is achieved through the promotion and support;
- Violations can be avoided if to understand the causes of errors and implement lessons learned.

Realizing the importance of safety culture to achieve the goals of safety, as well as performing for many years a whole range of measures to improve safety and to improve the safety culture, NAEC considers the need for constant attention to safety culture at all organizational levels to be the key to success, and the main driving mechanism of progress and development in this area - wide awareness of international experience and achievements in improving the safety culture, and their integration and implementation in your organization.

4. PRACTICAL APPLICATION OF SAFETY CULTURE PRINCIPLES

The following is just a slightly modified description of situation that really happened at one of the multi-unit NPPs. The staff had just started up the unit after an outage, and had gradually increased the power. The Staff – an aged Unit Shift Supervisor (USS) and a Turbine Shift Supervisor (TSS) (with 15 years of working experience in the position each), and a young Turbine Operator (TO) (less than a year of working experience in his position).

At the level of 40% of the nominal power the Plant Shift Supervisor (PSS) ordered to the USS to stop taking steam for start-up operations from the all-plant collector and switch to own steam, which is already available at this power level. Only closure of the plant collector valve and opening of the own steam valve were required for that, because the other interfacing valves had have been secured by the previous shift. But in reality they had not: an extra valve on own steam pipe stayed mistakenly in closed position. The TO, believing that the scheme was OK, followed the steps for switching valves. These actions resulted in a loss of steam for the turbine condenser exhaust ejector and the vacuum in the condenser began to deteriorate rapidly. The USS and TO noticed the deterioration of the vacuum, but they had not yet understood why, when, after a walk-down to the turbine building, the TSS entered to the Main Control Room.

The TSS immediately and directly got involved in the situation with vacuum loss. "I know what to do!" he said and carried out a number of minor actions that however did not affect the situation.

At the same moment the TO (recalling how he had been taught that if you are doing something before something wrong happens – you should better bring everything back to the original condition) switched the steam back to the plant collector. The vacuum in the condenser began to recover.

USS and TSS were celebrating victory.

USS: "What a good professional you are! Had you not come on time and not performed your actions we would have lost vacuum and gotten a scram!"

TSS: "Still, the experience – it's a great thing!"

In this situation, the young TO hesitated to report on his actions and just joined the elders, with the compliments to the TSS.

The universal joy on the occasion of the vacuum recovery was clouded by the PSS, who noticed that the plant steam continued to leave the plant collector and in irritated manner required from the USS to disconnect and finally go on their own steam. USS pounced on the TO: "Are you still on the plant steam?! Immediately transfer!"

So the TO again closed the steam off the plant collector and opened the own steam valve, still unaware that the own steam was blocked. Due to the lack of steam in the exhaust ejectors the vacuum in the turbine condenser began to deteriorate rapidly again and, when reached the alarm limit, the turbine protection was triggered. Finally they had a scram.

In this particular case, the coincidence of small individual errors in the behaviour of the staff with the shortcomings in the procedures and the psychology of relationships among the members of this shift were all present – the factors that are not individually that significant, but when combined could lead to serious consequences, leaving the staff without control of the situation and triggering the automatic protection.

Despite all the measures that are being taken to improve the administration, training, psychology, quality of procedures, the similar unexpected stupid situations could occur from time to time at different NPPs throughout the world. And the protection against this type of non-standard situations can be achieved only through the establishment of a commitment to a culture of safety, and the practical application of the safety culture in all organizational aspects of nuclear power plant activities.

5. FOR THE CONCLUSION

For the conclusion we would like to present the following artwork by the employee of Zaporozhye NPP Mr. Alexey Tishchenko (Fig.3). It is a poster dedicated to the safety culture and to our choice for better future within a world powered by safe and reliable nuclear power. This poster is now a property of Zaporozhye NPP. It is used as visual promotion of Safety Culture commitment throughout the plant personnel. It says: the Safety Culture is a main important step dividing us from the edificatory Chernobyl event past and connecting us to the bright future of our choice for safe and reliable nuclear power production. The future choice is yours!

FIG. 3. The Safety Culture dedicated poster by A.Tishchenko, Zaporizhye NPP.

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