TO THE ASSESSMENT OF THE ROLE OF NATIONAL TRAITS IN THE PROCESSES OF THE SAFE OPERATION OF NUCLEAR POWER FACILITIES MAINTENANCE

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ABSTRACT

One of the features of the post-Fukushima development of nuclear technologies in terms of the impact of the human factor on safety is the analysis of the national context in the safety culture. The starting point for this thesis is the transboundary nature of the nuclear power safety problem, which, in turn, depends on the ability of people to act together at the national and international levels. Thus, exploring how the national context influences decision-making and the performance of production objectives, and a better understanding of national cultural characteristics, is an important topic to be developed in this article.

Keywords: Nuclear energy. Accident prevention. Safety culture. International cooperation. National traits.

PARA A AVALIAÇÃO DO PAPEL DOS TRAÇOS NACIONAIS NOS PROCESSOS DE OPERAÇÃO SEGURA DE MANUTENÇÃO DE INSTALAÇÕES DE ENERGIA NUCLEAR

PARA LA EVALUACIÓN DEL PAPEL DEL RASGOS NACIONALES EN LOS PROCESOS DE OPERACIÓN SEGURA DE MANTENIMIENTO DE INSTALACIONES DE ENERGÍA NUCLEAR

RESUMO

Uma das características do desenvolvimento pós-Fukushima das tecnologias nucleares em termos do impacto do fator humano na segurança é a análise do contexto nacional na cultura de segurança. O ponto de partida para esta tese é a natureza transfronteiriça do problema de segurança da energia nuclear, que, por sua vez, depende da capacidade das pessoas de agirem juntas a nível nacional e internacional. Assim, explorar como o contexto nacional influencia a tomada de decisão e o desempenho dos objetivos de produção, e uma melhor compreensão das características culturais nacionais, é um tema importante a ser desenvolvido neste artigo.

Palavras-chave: Energia nuclear. Prevenção de acidentes. Cultura de segurança. Cooperação internacional. Traços nacionais.

RESUMEN

Una de las características del desarrollo de tecnologías nucleares después de Fukushima en términos del impacto del factor humano en la seguridad es el análisis del contexto nacional en la cultura de la seguridad. El punto de partida de esta tesis es la naturaleza transfronteriza del problema de seguridad de la energía nuclear, que, a su vez, depende de la capacidad de las personas para actuar juntas a nivel nacional e internacional. Por lo tanto, explorar cómo el contexto nacional influye en la toma de decisiones y el cumplimiento de los objetivos de producción, y una mejor comprensión de las características culturales nacionales, es un tema importante a desarrollar en este artículo.

Palabras-clave: Energía nuclear. Prevención de accidentes. Cultura de seguridad. Cooperación internacional. Rasgos nacionales.

INTRODUCTION

The safety of nuclear power facilities is one of the cornerstones of development and promotion of this industry in modern economic and social conditions. The Chernobyl (1986) and Fukushima (2011) tragedies force to deep concern and even alertness considering the prospects of scaling of nuclear energy projects in areas with high population density. At the same time, the nature of mentioned alerts is quite contradictory. If we leave infamous political aspects aside (for example, Lithuanian's claims to develop the Belarusian project) and the statements of the inherent unsafe of the operation of power plants on nuclear fuel, which are extremely far from reality, it turns out that the main problem of criticism of the development of atomic energy is seen in the notorious human factor. As part of the submitted article, the task to provide an overview of the influence of the human factor on the trouble-free operation of high-risk facilities had been solved. In addition, during the study, the term "security culture" was analyzed and the impact of the factors of national affiliation on it is determinated. The objectives of the study are:

1. Analysis of the scientific literature, surveys and reports devoted to the problems of nuclear power objects security maintenance.
2. Identification of the features of actual directions of nuclear power industry development.
3. Determination of the notion of “safety culture” and the national traits impact on its development and exploitation.

In the framework of the presented work, the authors used the following research methods:

- at the theoretical level: study and generalization, formalization, analysis and synthesis, induction and deduction, axiomatics;
- at the experimental-theoretical level: experiment, analysis, modeling, synthesis, benchmarking.
- at an empirical level: observation, measurement, comparison, focus group discussions.

LITERATURE REVIEW

According to Rafael Mariano Grossi, Director General, IAEA, the main emphasis of the current development of nuclear power industry is to provide humanity with clean and dependable energy sources that are free from intermittency that is typical for renewable sources of energy (IAEA Bulletin, 2020). Nuclear power reactors around the world have programs to address long term operation (LTO) and ageing management. At the end of 2019, 263.3 GW(e) or more than 66% of available nuclear power capacity (i.e., 300 nuclear power reactors, an increase from 294 at the end of 2018) had been in operation for 30 years or more (Nuclear Safety Review 2020). This fact leads to the urgent need of fully comply with all provisions of IAEA memorandum of safe exploitation of nuclear power reactors. Regarding this fact, one of the most important aspects of ensuring the global safety of the operation of nuclear power facilities will be complete transparency of information about accidents at nuclear power plants and the exchange of experience to prevent these events (DONOVAN, 2020).

The accident at the Fukushima Daiichi nuclear power plant in 2011 led to a new impetus in the development of the concept of safety culture. which is formed on the basis of modern management concepts using modern digital technologies (GENKIN, 2020; VELIKOROSSOV, 2019). Government programs in many countries have begun to include alternative energy sources (ZAKHAROV, 2019; TARASOVA, 2020) and scientists are looking for an answer to the question: "How many nuclear power plants can humanity afford"? (MAKSIMOV, 2019)

The trigger of this process can be called the report of the independent commission of the Japanese parliament to investigate the causes of the accident. According to the chairman of this commission, Mr. Kiyoshi Kurokawa: "... we must admit with great pain that the fundamental reasons are in the deep-rooted traditions of national culture: reflexive submission, unwillingness to ask, blind adherence to procedure, groupism and isolationism" (The official report of the Fukushima, 2012). Thus, at the turn of the second decade of the 21st century, a request arose to consider the peculiarities of the national culture when carrying out activities at nuclear facilities (NF) in

order to minimize the risks of accidents and incidents. The leadership in this process belongs to the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD NEA), which, since 2018, has been holding Country Safety Culture Forums to support activities to study the impact of the human factor on nuclear and radiation safety. Such Forums were held in Sweden (2018) and Finland (2019), and now it is planned in Canada (NEA, 2018; NEA, 2019).

Relevant activities were also carried out in the Russian Federation. In 2018, within the framework of the International Summer School on Safety Culture, organized by ANO DPO "Technical Academy of Rosatom" operative shifts of Paks NPP (Hungary) and personnel of the owner of Hanhikivi-1 NPP, Fennovoima Oy (Finland) were trained on the field of cross-culture communications (ROSATOMTECH, 2018). This setting of the task becomes even more relevant in the context of the economic turmoil caused by the COVID-19 pandemic. The economic downturn in several countries was accompanied by an unprecedentedly cold winter, which led to the complete failure of most of the energy systems operating on renewable energy (solar panels, wind turbines and similar installations). It became clear that without a sustainable source of energy, no economy could function with any success. At the same time, at the moment, two options are seen in the role of such an energy source: thermal power plants using hydrocarbon raw materials (gas, fuel oil, coal) and nuclear power plants (IUNIKOVA, 2021; DONG, 2021; VELIKOROSSOV, 2021).

RESULTS

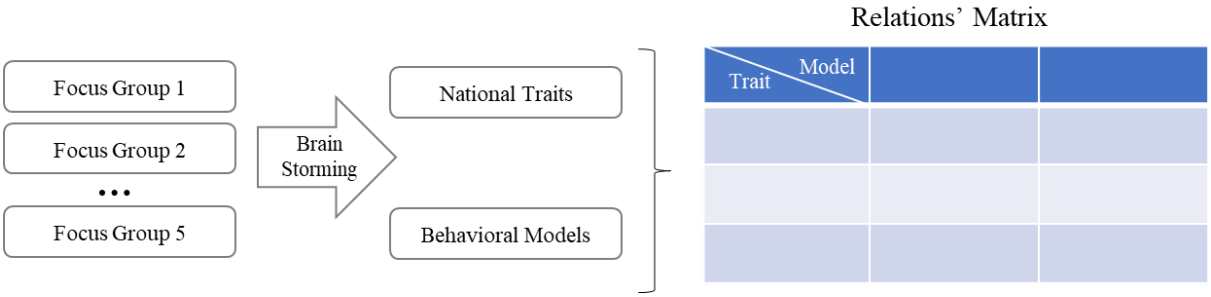
On March 11, 2011, the Great East Japan Earthquake struck. The earthquake and tsunami resulted in the death of a large number of people and widespread destruction in Japan. More than 15,000 people died and over 6,000 were injured, about 2,500 people were left unaccounted for missing. Significant damage was caused to buildings and infrastructure, in particular along the northeastern coast of Japan. At the Fukushima Daiichi nuclear power plant (NPP) operated by the Tokyo Electric Power Company (TEPCO), an earthquake damaged power lines at the site, and the tsunami resulted in significant destruction of operational and safety infrastructure at the site. Taken together, this led to the loss of external power supply and failure of power supply sources at the site.

Despite the efforts of the Fukushima Daiichi NPP operators to maintain control over the plant, the core of the reactors of the power units overheated, the nuclear fuel melted and the integrity of the three protective shells has been broken. Hydrogen was released from the reactor pressure vessels, which led to explosions inside the reactor buildings of the blocks, and as a result, structures and equipment were destroyed and personnel were injured. Radionuclides from the station entered the atmosphere and then deposited on the surface of the land and ocean. In addition, there have been direct discharges into the sea. One of the main factors contributing to the accident was the widespread opinion in Japan that the country's nuclear power plants are so safe that an accident of this magnitude is simply unthinkable. This opinion was supported by the operators of nuclear power plants themselves and was not questioned by either the regulators or the government. As a result, Japan was inadequately prepared for a severe nuclear accident in March 2011.

The Fukushima Daiichi accident exposed certain flaws in the Japanese regulatory system. Responsibilities were divided among several bodies, and it was not always clear who had certain powers. While the responsibility for nuclear safety remains the responsibility of each country individually, nuclear accidents can transcend national borders. The accident at the Fukushima Daiichi nuclear power plant clearly demonstrated the importance of effective international cooperation. Considering the experience of the Fukushima accident, one should ask the question: to what extent can psychological factors affect the efficiency of managing a nuclear power facility in critical circumstances? In addition, the concept of safety culture is becoming vital. According to the IAEA definition, safety culture is a set of characteristics and features of the activities of organizations and the behavior of individuals, which establishes that the problems of protection and safety, as having the highest priority, are given attention, determined by their importance [6]. Thus, safety culture is considered as a combination of two basic elements: a person's own state and behavior and the professional environment in which he functions.

Based on this definition, the group work to determine the impact of the national context on security activities was structured according to the following scheme (see Fig. 1): the participants were divided into five focus groups, each of which highlighted several main national traits of the modern Russian character and behavioral models in production process. At the next stage, the identified national traits and patterns of industrial behavior were combined into a matrix of relations, the cells of which were filled in by answering the question "What are the positive and negative effects of a national character trait on the corresponding model of industrial behavior?"

Fig. 1. Revealing the positive and negative influence of national traits on industrial behavior (group stage)



Source: Search data.

Nuclear safety transcends national boundaries and depends to a large extent on the ability of people to act together at the national and international levels. Thus, studying how the national context influences decision-making and performance of production tasks, and a better understanding of implicit cultural characteristics, is an important task. The term "intercultural communication" was first proposed in the works of the researcher of interaction of cultures E. Hall in the 1950s (ROSATOMTECH, 2018), who later introduced the concept of context as one of the fundamental characteristics of societies (MAKSIMOV, 2021). In the period from 1967 to 1980. a large-scale study of the peculiarities of national cultures was carried out by the sociologist G. Hofstede. His typology of cultural dimensions is the basis for intercultural communication and offers six dimensions of national culture: power distance, collectivism-individualism, femininity-masculinity, uncertainty avoidance, and a time horizon of future orientation (DONG, 2021).

As part of the group work, cultural dimensions were considered according to the methodology of G. Hofstede and E. Hall in relation to Russian society. During the discussion, the following six distinctive national features of the modern Russian character were identified, including several additional cultural dimensions: adaptive abilities and agency-non-agency. Table 1 shows the identified six cultural dimensions and their manifestations in the Russian national character.

Table 1. Cultural dimensions of actual Russian national character

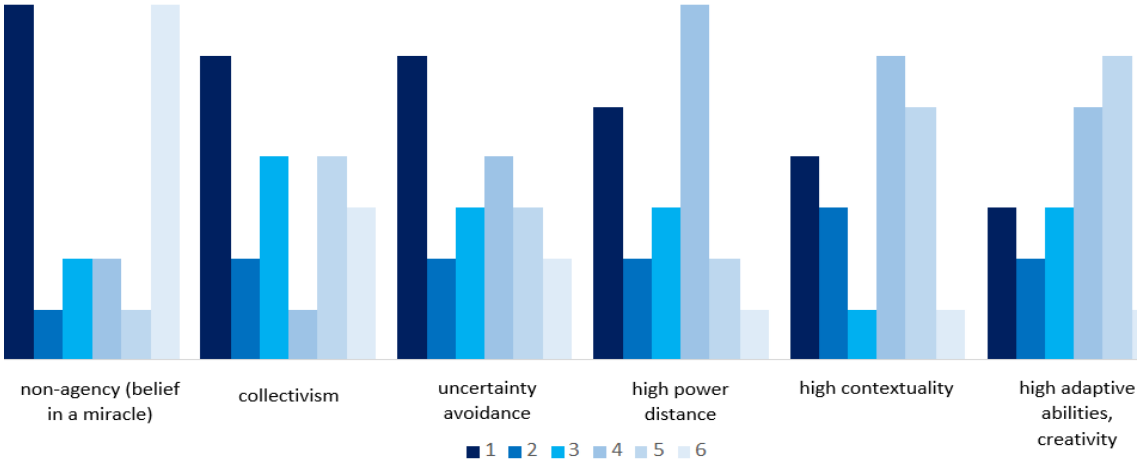
	Low Level	*High Level*
Power Distance	-	*Top management distances itself from employees, who, in turn, do not consider them as colleagues*
Contextuality	-	*Personal and professional qualities, desire to work mean less than belonging to a certain stratum*
Collectivism/Individualism	*Management is group oriented, not personality oriented. The success of the team for each employee is more important than his own. There are difficulties in expressing criticism within the team.*	-
Uncertainty Avoidance	-	*Describes the measure of proximity to reality. Many employees are characterized by anxiety about the future, a low propensity to take risks, and a lack of motivation.*
Adaptive ability	-	*Developed ability to search for non-standard solutions, the ability to adapt to various conditions*
Agency/Non-agency	-	*Inability to act proactively, withdrawal into the world of the imaginary and surreal*

Source: Search data.

In addition to identifying the main national traits, the participants in the group work ranked them according to the degree of impact on security, from 1 (strong influence) to 6 (weak influence). As a result, the sequence shown in Fig. 2:

1. non-agency (belief in a miracle);
2. collectivism;
3. uncertainty avoidance;
4. high power distance;
5. high contextuality;
6. high adaptive abilities, creativity.

Fig. 2. Ranking of the main national trait of Russians



Source: Search data.

Models of production behavior aimed at ensuring the safety of activities

Having considered the individual cultural traits inherent in the actors of production, it is necessary to assess and analyze the collective patterns of behavior in the professional environment in relation to security at the organizational level. This will allow us to determine how the identified national traits manifest themselves in the framework of organizational behavioral models. As a result of group work, the following six basic behavioral models were identified, aimed at ensuring safety in the implementation of production activities: leadership, self-learning and self-development, identifying and solving problems, ensuring sustainable performance, responsibility, and the climate in the team.

Building a matrix of relations

Based on the identification of national features of the modern Russian character and models of industrial behavior oriented towards ensuring safety, a matrix of their relations was formed (see Table 2). For the purposes of this preliminary analysis, three main features of the modern Russian character were selected, which, according to a survey of participants in group work, have the greatest impact on ensuring the safety of activities: non-agency (belief in a miracle), collectivism and avoidance of uncertainty. Among the behavioral models, the objects of analysis were: leadership and the ability to learn and develop. The choice of production behavior models is due to one of the key activities of ANO DPO "Technical Academy of Rosatom", namely: training leaders of nuclear energy programs in newcomer countries within the framework of joint nuclear energy management schools with the IAEA for managers and young professionals, and also conducting training courses on elements of nuclear infrastructure as part of the IAEA's Technical Cooperation program.

Table 2. – National Traits and Industrial Behavior

Model / Trait	Leadership	Ability to learn and develop	Problem's detection and eradication	Steady results of performance providing	Responsibility	Team climate
Non-agency	4	3	2	3	2	3
Collectivism	2	3	4	4	3	6
Avoidance of uncertainty	2	2	4	3	4	4
High power distance	1	2	2	3	2	2
High contextuality	2	2	3	2	3	3
High adaptive abilities, creativity	5	4	6	5	4	6

Source: Search data.

Analysis of the influence of national character traits on patterns of production behavior

The result of the work in the groups was a completed matrix of relationships between the traits of the modern Russian national character and models of industrial behavior focused on ensuring safety. Each cell of the matrix is divided into two parts with a positive and negative influence of reference national traits: non-agency (belief in a miracle), collectivism and uncertainty avoidance, into behavioral models - leadership and the ability to learn and develop.

Non-agency

The participants in the group work noted that the inherent *non-agency* of the Russian person dulls leadership initiatives. Employees fully trust the leader, and often shift responsibility to him, misunderstanding and downplaying their role in ensuring safety. The leader, in turn, may also not feel his role and responsibility in solving problems, expecting a more active position of the team. In terms of the positive impact of *non-agency*, the participants identified: mutual trust, knowledge and understanding by the leader of the abilities of each employee (see Table 3).

Table 3. Influence of non-agency on the Leadership behavior model

Positive	Negative
▪ Leader is the ultimate truth. ▪ The leader knows his team and the abilities of everyone. ▪ Trust in the leader.	▪ Blunting of leadership initiatives among employees. ▪ Transfer of the wrong approaches. ▪ Inflated expectations from the leader

Source: Search data.

The behavioral model of "Learning and development ability" also depends on the degree of *non-agency*. In the opinion of group participants, employees often consider the training provided to be sufficient without critically evaluating it. This aspect also manifests itself as a positive attitude towards learning and belief in its effectiveness. There is a general trend towards a decrease in cognitive motivation (see Table 4).

Table 4. Influence of non-agency on the Learning and development ability behavior model

Positive	Negative
▪ Confidence that training is sufficient for a skilled and safe job. ▪ Belief in the effectiveness of training.	▪ False confidence. ▪ •Passivity and lack of independence.

Source: Search data.

Collectivism

This national trait promotes effective teamwork. A recognized leader brings the team together and combines formal and informal leadership skills. However, there is a risk of suppressing the individual initiative of team members and the ability to think critically (see Table 5).

Table 5. Influence of collectivism on the Leadership behavior model

Positive	Negative
▪ Ability to combine formal and informal leadership. ▪ Team building. ▪ Effective teamwork.	▪ Suppression of individual initiatives in favor of collective ones. ▪ Lack of critical thinking. ▪ Striving not to stand out from the team.

Source: Search data.

In terms of learning ability, *collectivism* contributes to the development of mentoring and knowledge transfer. Each member of the team strives to correspond to the professional qualifications of colleagues, a positive development experience is disseminated. Despite the positive aspects, *collectivism* at the same time can hinder the advanced professional development of the individual. An unfavorable environment is created for expressing a critical position, concern about any aspects of security (see Table 6).

Table 6. Influence of collectivism on the Learning and development ability behavior model

Positive	Negative
▪ Developed mentoring. ▪ Motivation for self-study. ▪ Transfer of good practices.	▪ Motivation for learning of individuals depends on the general level of motivation of the team. ▪ Striving not to stand out from the team. ▪ Support for collective loyalty.

Source: Search data.

Uncertainty avoidance

In teams where the line of *uncertainty avoidance* prevails, the leader knows the team well, its weaknesses, and regularly engages in planning. However, the leader often uses prohibitions as a mechanism to influence the team to avoid risky situations. Distorted communications may prevail in the team. The frequency of leadership positions change is low (see Table 7).

Table 7. Influence of Uncertainty avoidance on the Leadership behavior model

Positive	Negative
▪ An experienced leader. ▪ Advanced planning. ▪ Search for the truth.	▪ Suppression of individual initiatives in favor of collective ones. ▪ Lack of critical thinking. ▪ Striving not to stand out from the team.

Source: Search data.

Uncertainty avoidance promotes effective planning, knowledge transfer, responsible learning and an understanding of the importance of gaining the necessary knowledge and skills in advance. However, an employee may be faced with false goals for self-development or with a complete lack of goals, relying on familiar and certain working conditions (see Table 8).

Table 8. Influence of Uncertainty avoidance on the Learning and development ability behavior model

Positive	Negative
▪ Obtaining pre-requisite knowledge and skills. ▪ Responsible teaching. ▪ Understanding the value of knowledge transfer	▪ Low motivation. ▪ Fear of failure. ▪ False goals for self-development.

Source: Search data.

DISCUSSION AND CONCLUSION

1. The Fukushima Daiichi accident showed that it is difficult to identify weaknesses in systems that involve complex interactions between people, organizations and technology, as a basic assumption about nuclear safety may remain undetected. For understanding the functioning and interaction of the components of the entire system during normal operation and in emergency conditions, it is necessary to apply a systematic approach that considers human, technological and organizational factors.

2. The analysis and statistics given in the article allow us to make a preliminary analysis of the cultural norms of attitudes towards ensuring safety at nuclear facilities on the territory of Russia. This work includes: analysis of the characteristics of national culture, determination of their positive and negative impact on the basic behavioral patterns of production activities in the framework of ensuring the safety of the facility. This analysis was carried out within the framework of remote group work with the participation of 59 employees from more than 20 subordinate organizations of PJSC Rosatom, who took part in the process of managing the safety culture.

3. As a result of this study, the cultural attributes forming the Russian national context and influencing safety the most were identified. They are, namely, non-agency, collectivism and avoidance of uncertainty. The impact of these national attributes was analyzed in relation to two behavioral models aimed at ensuring safety - leadership and the learning and development ability.
4. Now, almost all IAEA Member States with nuclear power plants have completed "stress tests", and many use the services of IAEA expert missions for expert assessment of the state. It was agreed by the countries that further interaction of the participating countries should be based on actions taken at the national and international levels to exchange factual information on the real consequences of the accident at the Fukushima Daiichi nuclear power plant and to further improve global nuclear safety, combined with constant innovation in design and performance of reactors, as well as long-term prospects.

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