Licensees activities for nuclear safety: organizational culture and leadership

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Abstract: The IAEA Report on Fukushima Daiichi Accident indicated that a basic assumption or preconception was widely shared by the nuclear industry in Japan and it led to a thought which made Japanese nuclear operators not being proactively prepared for unexpected severe accidents. To prevent the recurrence from holding such an assumption, organizational culture for nuclear safety led by top management and followed by all employees will be a key issue. Top management of Japanese nuclear operators have been making much efforts to improve their corporate culture, not only complying with the regulatory standards but also enhancing self-regulated excellence. This paper introduces their voluntary efforts in the light of human and organizational aspects and analyzes their ex-assumption and discusses measures to break negative thought chain.

Keyword: leadership; culture for safety; organizational culture; human factor

1 Introduction

After the devastating Fukushima Daiichi accident in 2011, new safety regulatory standard in Japan has been come in to effect July 2013. The operators strengthened equipment modification and operation management to meet this new regulatory standard, and applied for conformity examination for 26 nuclear reactors. As of July 2018, fourteen nuclear reactors have passed the Nuclear Regulation Authority's conformity review, and nine units among them currently in operation.

This paper describes operators' voluntary activities by focusing on operators' efforts of strengthening the organizational culture and discusses on the countermeasures for thorough utilization of operating experience based on the lessons learned of Fukushima Daiichi accident.

First, challenges of nuclear operators by focusing on organizational perspectives which are derived from the lessons learned of Fukushima Daiichi Nuclear accident are described in chapter 2.

Second, in chapter 3, activities for strengthening safety consciousness are introduced, which are divided into four categories such as 1) enhancing safety consciousness 2) reinforcing risk management 3) improving communication environment 4) strengthening governance of operator's activities.

Third, in chapter 4, consideration on the measures which would enable nuclear operators to avert falling into basic assumptions that negatively affects nuclear safety is explored in light of the necessity of more focusing on the human-organization aspects.
Finally, conclusion is summarized in chapter 5.

2 Challenge for organizational culture

The government accident investigation report [1] and the Diet accident investigation report [2], which summarized the causes and lessons of the Fukushima Daiichi Nuclear Power Plant Accident (hereafter, the "Fukushima Accident"), indicate that the nuclear operators in Japan (including Tokyo Electric Power Company; hereafter TEPCO) were laboring under the assumption that a severe accident could not happen in Japan and were unable to comprehend a hazard as a potential reality that could occur. Now that this assumption has been recognized, it is important that it gives rise to an organizational culture reform for operators.

This assumption resulted in Japan's nuclear power industry being vulnerable in its preparation for a situation where a reactor core is seriously damaged due to a tsunami or other natural disaster. When this situation actually arose, the emergency response

Received date: August 13, 2018

demonstrated how an organization was powerless or less leadership toward unexpected situation. The government accident investigation report describes that, at the time of actual emergency response, the sense of a vertically-structured organization was not strong, which made flexible response difficult for tasks that had not been assumed previously.

TEPCO's reported activities [3-4] aim to change the organizational culture that resulted in such a situation by breaking the organization's negative "chains of thought" from the following three viewpoints.

The first viewpoint is cutting off certain chains of thought: of underestimating the uncertainty of the risk of external events, of not trying to learn from the operating experience of other companies, and of not recognizing that safety improvement should be tackled every day. This will result in outgrowing the assumption that safety has already been established.

The second viewpoint is outgrowing the chain of thought of not incorporating the design technical capabilities into the company by considering availability as an important issue for management, being devoted to equipment modifications that contribute to the current availability improvement, and excessively depending on the design technique of the manufacturer to put it into practice, as well as the chain of thought of depreciating on-site capabilities (such as the employees not having practical technical capabilities) as a result of leaving all site work to partner companies and the company's having treated emergency training as a formality.

The third is the viewpoint of outgrowing the atmosphere in which employees believe that the current level of nuclear technology is sufficient to ensure safety and are hesitant to raise issues proactively, even if they notice a risk that exists in their facilities.

In the next chapter, the current activities of nuclear operators for improving organizational culture such as 1) strengthening safety consciousness which focuses on top management's safety consciousness reform, activities of instilling safety attitudes and leadership training for emergency 2) risk management which focuses on handling of hazards, utilization of operating experience and emergency commanding and on-site capabilities in an emergency 3) securing communication environment and 4) strengthening governance of operator's activities are introduced.

3 Improving organizational culture

3.1 Strengthening safety consciousness

3.1.1 Reform of top management's consciousness

The most important matter in strengthening the organizational culture of safety must be reforming the top management's consciousness. JANSI educates CEOs, CNOs, or other senior executives of nuclear operators on the concept of independent oversight in order to supervise and perform surveillance of the unconscious, inherent risks that undercut safety for the purpose of risk management. JANSI also provides leadership training programs focused on human skills, including conductor's skills at the time of emergency and communication skills.

3.1.2 Permeation of Culture for Safety

The government accident investigation report says of the organizational culture of TEPCO that "the attitude of the employees of the company was not proactive enough to face the situation by themselves, and the flexible and positive thinking needed for crisis resolution was lacking." To improve this aspect of the employee passive attitude, TEPCO started establishing a behavior pattern to fix the organization's safety culture. The behavior pattern is that each day, every worker takes about 10 to 15 minutes to ask themselves if their behavior that day was adequate in comparison with the excellent attributes of safety culture. The results are then scored and entered into the computer system to calculate the total score. When the total shows unusual or abnormal trends, TEPCO holds both a regular group discussion and a special discussion to find out the cause. Naturally, the status of this activity is reported to the management meeting, which then brings it to further action, if necessary.

The purpose of these company-wide activities is for each employee to regularly take the opportunity to reflect on familiar safety-related matters and develop it into way of thinking that they try to master nuclear safety for themselves.

3.1.3 Leadership training for emergency

On-site Emergency Management Drill is one of the courses of leadership training that JANSI provides to operators. JANSI developed this program based on the individual experiences at the control rooms and the on-site headquarter. Some of the experiences had been openly described in accident investigation reports as semantic memories. On the other hand, other experiences had been only kept personally as episodic memories. These seldom experienced lessons should be shared among all nuclear operators and transferred to next generation. Therefore, by integrating their semantic and episodic memories into a training drill scenario, training drill program is implemented in the simulated alternative conditions of Fukushima accident with the very difficult mission.

Participant who joined this training program would be able to have the similar experience of Fukushima accident as an episodic memory. JANSI expects that participants will bring their individual episodic memory back to their site and they will make similar scenarios of drills for their colleagues at their site, finally leading their training experience to their unconscious skills as their procedural memories. The concept of this program is aiming at an exercise in which participants come to realize that the situation is one that they cannot bring to an end if they don't try proactively to solve a problem.

3.2 Strengthening risk management process

3.2.1 Risk identification

Risk management procedures generally begin from risk identification and risk profiling first. Corrective action program contributes to gathering potential risks and hazard analysis also contributes to precise risk profiling. The ability to efficiently carry out both corrective action program and hazard analysis are both fundamental elements in risk recognition.

The government accident investigation report says that, before the Fukushima Accident, operators were not proactive about taking measures for events that seemed to be infrequent or uncertain. It means that the attitude of risk identification and hazard analysis revealed unfortunately insufficient for unexpected severe accident. After the accident, operators have been trying to revise such attitudes. For example, TEPCO established a full-time team to carry out hazard analysis. The mission of this team is to positively put potential hazards to an agenda of company-wide risk management meeting without hesitation, even if they occur infrequently and it is uncertain to what extent they may cause serious damage. As a company-wide risk management objective, operators in Japan are paying attention not only to events that would have an economic impact on their economic performance but also to those that pose a risk to nuclear safety and social trust.

3.2.2 Importance of operating experience

Also, given that the Fukushima Accident was caused by a lack of understanding of the risk of external events, it is understood that both the willingness to study continuously and the willingness to express doubt are indispensable to an organization.

To strengthen the willingness to study continuously, all TEPCO personnel who are engaged in the nuclear business participate in a training program that reviews operating experience from around the world. Participants engage in debate comparing the lessons obtained from accidents such as the accident at the Three Miles Island nuclear power station with the Fukushima Accident.

3.2.3 Emergency commanding

Nuclear Operators in Japan (including TEPCO) had prepared manuals that define the establishment of an emergency headquarters *etc.* to cope with nuclear hazards. They had also prepared functional groups such as a power generation group, a restoration group, and a technical support group in the headquarters, and they have allocated roles for event response. However, looking back on the situation at the time of the Fukushima Accident, these functional groups were not able to effectively make decisions or give directions quickly and appropriately because they were confused by facing a situation where multiple nuclear reactors were damaged. In such chaotic situation there were naturally miscommunications between the on-site headquarter and the head office headquarter.

Taking this into consideration, TEPCO for example, has reduced the range of the conductor's management

span by introducing an incident command system and decentralizing the plant director's role in the unit directors responsible for each unit. This is to ease the burden on the plant director, who is the highest director of the on-site headquarters. Emergency staffs are also repeatedly carrying out exercises that simulate the Fukushima Accident to confirm information sharing and instructions with the head office and the regulatory body.

3.2.4 On-site capabilities in emergency

It was also made clear that conventional table-top training and book knowledge alone are not sufficient for the inherent qualities and abilities needed in the event of a severe accident like this one. Emergencies necessitate the abilities to consider all possibilities based on the available information, to sort out the cases obtained from the information, and to quickly determine which matters require action and then take such action. Considering these lessons, to support the conductor's decision making, TEPCO is making efforts to develop systems engineers who comprehend the design requirement functions and can propose measures from the viewpoint of defense in depth.

Also, the nuclear operators in Japan recognize that it is difficult to receive external support in such a serious situation, especially in the early stages of accident, and that the top priority is first to master for themselves the ability to react quickly so that they can complete the countermeasures that are necessary for the time being.

3.3 Communication

3.3.1 Internal communication

Looking back the history of Fukushima plant, pre-alarms were occasionally sounded based on the latest technology and similar operating experiences. The question has been raised of to what extent these alarms were truly comprehended among management level, in the height evaluation of the tsunami that directly caused the Fukushima Accident and in the review of experience of the unavailability of emergency diesel generator due to leakage from sea water pipe line, for examples.

More than a few people must have felt that it was risky to have an emergency DG or switchboard installed in the turbine building on floors below sea level. It is recognized that there is a need to enhance communication abilities so that the risks that workers perceive can be shared in the organization. Accordingly, it has been decided in TEPCO to appoint a new, full-time executive manager called the Corporate Functional Area Manager (CFAM) and the Site Functional Area Manager (SFAM) to play the role of the facilitator who reports such concerns to upper-level personnel.

3.3.2 External communication

There are variety of stake holders including regulatory body and local governments around nuclear plants. When the Fukushima accident happened, huge communication gaps between the operator and stakeholders were recognized. It seems to take long time to close these gaps by gaining mutual trust. To strive for this difficult challenge, TEPCO assigned the special staff to sincerely deal with local government and residence people.

3.4 Corporate governance

3.4.1 Oversight

To strengthen defense in depth philosophy comprehensively, it is important to secure diversity in risk awareness. So that they can obtain advice from objective, external viewpoints and from different perspectives, some Japanese operators have established an oversight committee that reports to and advises a certain management level.

For example, TEPCO is undertaking organizational management reform as described above, and other operators are also working on organizational culture improvement activities to outgrow the assumption that was a background factor of the Fukushima Accident, albeit in different forms and depths as suits each operator. For TEPCO, the independent oversight department is separate from the company's execution line, and it checks these line activities whenever necessary as is called nuclear oversight.

TEPCO has also established a nuclear safety advisory committee of very experienced external experts who had been involved in nuclear business for long times. In this external committee, management member is advised objectively based on the external different viewpoints and experiences toward nuclear safety at

the site activities, which is called external oversight. Further, to perform surveillance of whether these companywide activities toward nuclear safety reform are being carried out smoothly, TEPCO has established a nuclear reform surveillance commission of domestic and overseas experts as the consultative body of the board of directors. By reporting the progress of these activities every year and releasing all the results to the public, TEPCO is making efforts toward restoring society's trust.

It is expected that the activities of this committee will bring to light the basic assumption that safety is already ensured, which was indicated as a background factor of the Fukushima Accident.

The function of checks and balances among peers, peer pressure in other words, is also an important keyword. It is expected that the CEO's commitment to the results of peer review (in which the behavior of people in the field is compared with the global excellences of the industry) is shared among the CEOs of operators, and thereby serves as peer pressure. Peer pressure among top management of each operator will certainly increase the safety consciousness of people of the on-site field.

So far, the current state of operators' activities for improving organizational culture for nuclear safety has been introduced. The discussion points to make these activities more effective will be described in the following chapter 4 from the viewpoints of human characteristics. First, the elements of concern of why operating experience and the latest knowledge cannot be utilized are described in section 4.1. Second, the countermeasure towards each element is described in section 4.2.

4. Discussion

4.1 Why operating experience and the latest knowledge cannot be utilized

4.1.1 Selective attention

The IAEA Director General Report on the Fukushima Accident [5] states "The reinforced basic assumption among the stakeholders about the robustness of the technical design of NPPs resulted in a situation where safety improvements were not introduced promptly."

Certainly, the operators had pride in their technologies based on the remarkably low scram rate on an international level and other index and were overconfident in their belief that the Japanese nuclear industry had high safety awareness and that a serious accident would not occur. This had become an unconsciously shared preconception and had permeated the awareness of those involved in the nuclear business.

We cannot deny the possibility that this assumption acted as a cognitive bias, causing underestimation of the scale and the probability of hazards. If the assumption is a major factor behind the Fukushima accident, it is necessary to review the characteristics of human beings and organizations.

One of the characteristics can be "selective attention [6]," a universal human characteristic. As a behavioral trait, once we are given a task and our attention is focused on that task, then we begin to select information necessary for efficiently achieving the task at hand. Experimental psychology has proven that "beliefs" affect this selection mechanism and that we all have a train where we adopt "tunnel vision," a state of narrow-mindedness where despite seeing things with our eyes, we do not see them with our brain. This is called "selective attention." When this characteristic is at work, we concentrate too much our awareness on the target and fall into a state where our visual field narrows, meaning that our brains may not recognize the objects in our surrounding vision. This mechanism illustrates that once this switch is flipped, it engages the information choice function of the reticular activating system, and the brain preferentially intakes information with a high degree of necessity and urgency to itself. Conversely, if information is considered as a low level of necessity or urgency, the brain eliminates it unconsciously. In a behavioral psychology experiment, when subjects were asked to observe an experimental video and given a task–such as to answer how many times a sports team in a white uniform successfully exchanged passes–the result was that subjects concentrated excessively on carrying out this task, with many failing to notice the other peripheral information entirely.

When considering nuclear safety, first of all, the following must be recognized as a human physiological characteristic: because of the underlying preconception at work (that the Japanese nuclear industry has high safety awareness and a serious accident will not occur), there is a tendency to unconsciously suppress the feeling of cognitive dissonance (registering that something is wrong from the viewpoint of nuclear safety), and selective attention causes a tendency to underestimate the hazards.

4.1.2 Protective attitude for organization

The second of the characteristics can be an instinct which is naturally possessed by a member of organizations. The people of an organization, especially those responsible for management, have a way of thinking as a member of the organization, whereby they are careful in how they treat the information that could have a major impact on their organization. When considering the measures necessary for what may be a highly unlikely, "once in a thousand years" event, for example, it is natural for a manager to make judgment based on economic rationality and to try to avoid damaging the organization which he/her works for. The author believes that the desire to minimize the impact on management may have led them to adopt a cautious decision, delaying the investment in anti-tsunami measures.

When managing such a risk, the decision-making on whether to execute the measures is not performed just by obtaining technical information on the event's occurrence probability and impact level on equipment (core damage); rather, it must also be recognized that an important factor in decision-making is the judgment standard of organizational defense, namely, the desire to minimize the impact on management. The preconception that a serious accident would not occur in Japan was shared by the parties, and this is thought to have acted as a bias in the decision to postpone the measures for low probability events.

4.1.3 Judging other stakeholders by yourself

The management of nuclear power plants involves many parties, including municipalities with nuclear power plants and supervisory authorities. These parties are called stakeholders. These stakeholders also shared the preconception that Japan's nuclear technology is very safe and a major accident would not occur. Since adding a new risk factor would reverse this shared awareness, there can be a strong mental resistance to doing so. It is thought that the stakeholders' feelings are inferred so as to prevent a mental mismatch between the awareness shared with the stakeholders so far and the addition of a new risk factor, and the mental position to want to avoid causing unease as much as possible and to affirm the present condition may have acted.

This resulted in the preconception shared by the parties being considered absolutely true and inviolable, and the stakeholders' feelings were inferred, causing less recognition of the urgency in the evaluation of the anti-tsunami measures.

4.1.4 Influence of vertical prioritized authority

The fourth is the characteristics brought by the organizational structure. Cultural anthropologists have contended[7] that organizations in which personal relationships are strongly influenced by a layered structure or rank with upper and lower levels, vertical societies in other words, are weak in the ability to show interest in the outside in which it is considered important for the attributes of the individuals constituting the organization align with the same quality or the same rank, horizontal societies in other words.

Therefore, in vertical society organizations, the propriety of an activity is not judged by the experience of others or by the idea professed by the organization, but rather by inferences about personal relationships with one's superiors. In this way, organizations that value vertical personal relationships tend to easily share preconceptions that are convenient for the organization, and if such preconceptions are shared for a certain period, it leads to an organizational culture. If that is the case, the organization will show no interest in the activities to internalize the important operating experiences of others and prevent failures beforehand.

Based on the characteristics of this vertical

organization, one lesson learned from the Fukushima accident seems to be that there is a need for measures to strengthen the scheme to learn the operating experiences of others.

4.2 The way to break basic assumption

4.2.1 Questioning attitude

To escape the preconception described in Section 4.1.1 above, which serves as the start of selective attention, it is considered to be effective for us to make intentional question by oneself, which is called "critical thinking" [8].

If a shared idea takes root in an organization, a bias effect acts on the function of selective attention in the brain, giving rise to the possibility of overlooking the elements necessary for nuclear safety. This aspect of human psychology is inconvenient for nuclear safety. To combat it, it is considered effective to ask "Is this sufficiently effective in light of nuclear safety?" and to generally question oneself. Asking questions like this trigger the brain to start to look for the answer, increasing the possibility that previously overlooked risks will be reviewed.

Needless to say, it is important to recognize that questioning oneself involves awareness of and responsibility for actions as a person involved in the inherent risks of nuclear power. This "awareness and the accompanying responsibility" means to be aware of the spatial and temporal size of the impact of a nuclear accident all the time, as well as to recognize one's role in a community. The term "hostage of each other" [9], expresses the characteristics of the nuclear industry. This term implies that in ensuring nuclear safety, it is not satisfactory just to grasp nuclear safety by focusing on the average level of a community group, and that even the lowest level members of a group should play the role of concentrating firmly on maintaining nuclear safety, with a strong awareness of the magnitude of the spatial and long-time impact that is inherent to nuclear power.

4.2.2 Oversight function

To avoid basic assumption which can be a cause of protective attitude for an organization stated in 4.1.2, a variety of trials have been performed and proposed from past experience of management.

One of these proposals is a monitoring organization in which the organization establishes a line that is different from the execution line and that objectively investigates the activities of the execution line in pursuit of nuclear safety, which is generally called "internal oversight" or "corporate oversight and nuclear oversight." Another is a monitoring organization that consists of experts with significant experience in nuclear safety and that provides suggestions to management from the outside of the organization, which is called "external oversight" or "Nuclear Safety Review Board."

Moreover, these activities are stratified into voluntary activities carried out by the operator, regulatory activities by regulatory organizations, mutual monitoring activities carried out by an international framework, *etc.* and are proposed by IAEA as a deeply structured monitoring system [10] [11].

In the U.S. nuclear industry, for example, internal monitoring system which is called "nuclear oversight" as an independent function of monitoring is provided. In addition, another internal monitoring system called "corporate oversight" which checks the attitude of on-site managers for nuclear safety from the corporate strategic viewpoints is also provided. Moreover, external monitoring system called "Nuclear Safety Review Board" which provides the thought insight with board members and/or CEO based on the rich experiences of management of nuclear business is established. All these functions are non-regulatory activities of nuclear operators.

In addition, the peer review activities carried out by organizations such as WANO (World Association of Nuclear Operators), INPO (Institute of Nuclear Power Companies), JANSI (Japan Nuclear Safety Institute) are an example of monitoring activities carried out from outside of the organization as an operators' framework. IAEA's OSART (Operational Safety Review Team) is a regulatory framework as an international framework.

These multilayered activities serve to provide advice on the activities of said operator to ensure nuclear safety in light of the standard activities being

conducted internationally or good practices. This will provide the parties with an important viewpoint for breaking through the preconception to carry out an actual condition survey of the field by using this function from viewpoints such as whether the pursuit of nuclear safety is obstructed by the shared value in the organization, or whether a risk is recognized properly in the same manner as others.

4.2.3 Communication and transparency

To prevent nuclear operators to adverse action for nuclear safety in too much consideration of the relationship with the stakeholders mentioned in 4.1.3, it is necessary to ensure that high transparency between the two parties must be necessary. Intensive risk communication can be one of the measures for keeping transparency. For example, it has been already introduced that publicly operate the reviewing committee in which stakeholders participate. Furthermore, it will be necessary to reform the double regulation structure between the national government and local governments, which is behind the fact that operators feel burdensome for implementing proactive measures. The dual systems for securing nuclear safety, one is implemented by the national government from the viewpoint of state of the art technology and the other is implemented by the local governments from the viewpoint of securing peace of mind of residents, both can be requisite. However, it should be necessary to analyze the reason that this dual social systems have resulted in the delay of accident management measures.

4.2.4 Systemic approach

When analyzing the human behavior and organizational culture aiming at avoiding the negative impact of organizational culture as stated in 4.1.4, it can be vital to focus on the interaction between management and employees, or how the authority exerts its invisible power to the individual attitude. Social cultural scientists assume that the belief that technology does not exist without human or organization has been getting familiar among nuclear industry. For example, some scientist points out that "To depart from technology in itself without recognition of its interaction with human and organizations makes little sense and depart from "culture" in itself without understanding how technology and organizations shape beliefs, moral, value, attitudes and behaviors is also problematic." [12]

IAEA General Safety Requirement GSR Part 2[13] proposes a method called systemic approach to look for preconceptions in an organization which invades nuclear safety; analyze the correlations between the people, the organization, and the technology; and try to evaluate the organizational culture comprehensively. The IAEA Report on the Fukushima accident [14] describes the effect of systemic approach: Taking into account the interaction between all the individual, technical and organizational factors reveals the complexity and non-linearity of the operations at an NPP. It is necessary to better examine the ways in which the weaknesses and strengths of all these factors influence one another in order proactively to reduce or eliminate risks.

To utilize this approach, we need knowledge not only of the natural sciences but also of the social sciences, such as organizational theory and psychology. Namely, it is necessary to have profound insights about issues such as the humility to question responsibility at all times, the leadership to act in the aim of raising the organization to a higher goal, and what the organizational culture should be in order to enhance safety.

Also, in order for an organization to discover its preconceptions and see itself objectively, the scientist[12] on organizational culture assumes that it can be important to consider dividing the organization into the following three layers: the surface level comprising the organizational structure, rules as well as other artifacts and behaviors, the middle level comprising goals the organization is to achieve, strategic means and other such administration, and a deeper level embracing unconsciously shared values and other behaviors that are taken for granted. To more accurately understand the organizational culture, it will be effective to conduct the investigation using the above monitoring function based on this organizational structure theory.

The expression "You cannot see the forest for the trees" warns us about seeking to improve the part but missing the whole. It is considered essential to constantly

enhance technical capabilities from the social science viewpoint of how the technology is used for people in society, without focusing only on improving the technology of natural science.

5 Conclusions

The lessons from the Fukushima Daiichi accident served as a trigger to teach the importance of organizational culture for safety and the difficulty of creating such a culture, and to realize the role of a nuclear specialist.

As stated in Chapter 2, Nuclear Operators in Japan (including TEPCO) were laboring under the basic assumption that a serious severe accident could not happen in a nuclear power plant in Japan. This left them unable to comprehend a hazard as a potential reality that could occur. If an organization's sensitivity to nuclear safety has deteriorated and it has developed negative chains of thought, it is not easy to change the organization so that it will continuously make efforts to enhance safety. In order to do this, it is necessary to start by having the top management tackle consciousness reform with a strong sense of will, then improve the system and develop human resources.

As stated in Chapter 3, nuclear operators have commenced the activities aiming at change of organizational culture. To realize the effect of such efforts, countermeasure for creating robust organizational culture for safety stated in Chapter 4 should be required, not to be influenced by negative assumptions.

In light of the pursuit of nuclear safety, the managers, engineers, and researchers involved in nuclear power business face many occasions for decision-making. The knowledge required in pursuing nuclear safety is not limited to natural science and technology and logical thinking, such as nuclear reactor physics, reactor control theory, and radiation protection. It is also necessary for them to be aware that they themselves bear responsibility for the consequences of the risks inherent to nuclear power. They must learn from the operational experience of their predecessor and others and should be proactive in adopting and incorporating the latest knowledge based on their experiences.

After all, it is human beings who make judgment in each situation, and the influence of an organization is certain to arise there. To ensure nuclear safety, it is important to have a good understanding of the characteristics of human beings and of organizations. The lessons learned from the accident at Fukushima Daiichi Nuclear Power Station remind us of the importance of an organizational culture for safety and the difficulty of creating one, and provides us with the opportunity to once again realize our roles as nuclear power experts.

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