

Strategic and Action Plans for the Implementation of Risk Information Utilization at Nuclear Power Plants

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Implementation of Risk Information Utilization

We, the nuclear licensees, have been implementing countermeasure work against earthquakes and tsunamis, and installing severe accident countermeasure facilities, as well as improving our risk management including utilization of Probabilistic Risk Assessment (PRA), based on the lessons learned from the accident at TEPCO's Fukushima Daiichi Nuclear Power Station that occurred on March 11, 2011, as well as relevant international experience. In addition, to address technology development regarding improvement of PRA and regarding mechanisms of occurrence and methodologies of estimation for infrequent external natural hazards such as large earthquakes, the licensees and the Central Research Institute of Electric Power Industry have established the Nuclear Risk Research Center (NRRC) within CRIEPI. The NRRC has been advancing research and development in an integrated fashion.

In the future, the licensees need a framework of risk utilization to identify areas for improvement and implement effective measures to achieve substantive improvement of plant safety without complacency. The licensees decided to introduce the risk-informed decision-making (RIDM) process into their management process at their stations as such a framework.

The objective of introducing the RIDM process is to bring about changes in the existing management process, where the licensees are primarily responsible for improving plant safety through correctly monitoring as-built and as-operated plant status, considering the risk significance of findings based on their own assessment as a decision criterion (risk-informed and performance-based), and implementing decision-making for improvement in timely manner, while compliance with the regulations is a prerequisite. This management process through the RIDM aims at the status of nuclear power station such that all the staff involved with the plant operation, under strong leadership, identify precursors of problems affecting the safety by broader monitoring, understand the risks without relying solely on limited experts for the safety assessment, prioritize the problems with the risks as the common yardstick, and resolve them in a timely manner.

All the licensees have conducted research and analyses on the history and current status of risk-informed activities in the U.S.¹ and other countries, where the RIDM has been instituted, and, as a result, we have specified the infrastructure and organization needed for the RIDM process, and have recognized how important the technical capabilities of station organizations are. The introduction of the RIDM process into our management system in nuclear power plants is a huge challenge, but all the licensees have extensively discussed the purpose and benefits of the RIDM and the policy of the initiatives in the future to promote the RIDM process.

This strategic plan is a compilation of the basic policy and action plans as a result of the above discussion so that the licensees will be able to successfully introduce the RIDM process. Each of the licensees will implement this strategic plan and will achieve safety improvement of nuclear power plants through self-disciplinary efforts beyond the regulatory framework.

Satoru Katsuno
Chairman of Federation of Electric Power Companies

¹ http://criepi.denken.or.jp/jp/nrrc/pdf/ridm_report_en.pdf?v2

Comments by the Head of the Nuclear Risk Research Center

As a result of the Fukushima Daiichi accident, Japanese utilities have decided to face squarely the risks of nuclear power generation and started to improve their risk assessment and management capability. The utilization of risk information in decision making has been widely pursued. For example, it has been practiced by American nuclear power utilities and the U.S. Nuclear Regulatory Commission for several decades.

The language of risk is the appropriate one for assessing and communicating the level of safety of a hazardous industrial facility including, of course, nuclear power plants. PRA views the plant as an integrated system (hardware and human personnel) and answers three fundamental questions: What can go wrong? How likely is it? What are the consequences, if something goes wrong?

To answer these questions, thousands of potential accident sequences are investigated and their likelihoods are assessed. Two very important potential consequences of accidents are damage to the reactor core and the release of radioactivity from the reactor containment into the atmosphere. The two risk metrics that correspond to these consequences are the core damage frequency and large release frequency. Both these metrics are very valuable communication tools regarding the safety of a plant. This communication is very effective both among nuclear engineers and with the public. In particular, telling the public that a plant is safe because it meets the regulations is a rather obscure statement. Communicating the risk metrics is much more transparent and easier to understand.

The value of performance-based regulation cannot be overstated. Performance objectives can be set deterministically, e.g., on pressures and temperatures, and/or probabilistically, e.g., on the availability of components such as pumps. The utility has the flexibility of choosing how to meet these objectives without micromanagement from the regulator. This results in much more efficient utilization of both the industry's and the regulator's resources.

The implementation of risk-informed and performance-based ways of conducting activities on an industry-wide scale requires much more than good PRA models. There are many technical, organizational and cultural issues that must be addressed for a successful implementation. The magnitude of these issues requires a systematic approach to building the necessary infrastructure. Such an approach is provided in the present plan.

The strategic plan is a major step forward for the Japanese nuclear industry. NRRC has contributed to the investigation of the RIDM implementation in the U.S. and other countries, the gap analysis between the US industry and Japanese industry, and the preparation of the draft of this plan. As a result of extensive discussions inside the industry and between the industry and NRRC, the industry finalized this strategic plan. It is significant that all the utilities have endorsed it. Its implementation will lead to risk-informed and performance-based decision making, i.e., a more rational management of risk.

Dr. George Apostolakis
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Introduction

This is a policy statement, which is committed to by the nuclear licensees² in Japan, to introduce the risk-informed decision-making (RIDM) process into plant design, construction, and operation. This document consists of two parts: A. Strategic Plan, and B. Action Plan. Part A discusses why the licensees are introducing this process, what the process is like and its benefits, and how the licensees will implement this initiative in order to facilitate stakeholders' understanding. Part B is the action plan that the licensees are now and will continue to be implementing with the collaboration of the industry, mainly NRRC and the Japan Nuclear Safety Institute (JANSI), by 2020.

² The nine electric utilities, J-Power, and JAPC

A. Strategic Plan

A.1 Motivation

The Fukushima Daiichi accident has led to the promulgation of many regulatory requirements that the nuclear licensees (hereinafter referred to as “the licensees” or “we”) are duly implementing, as well as voluntary efforts to improve safety that we are considering and implementing beyond the regulatory requirements. This accident has also led us to the realization that we need a broader framework that, in combination with the regulations, will lead to safety improvements and the continuous management of the risks³ from nuclear power plants.

An integral part of risk management is the risk-informed decision-making (RIDM) process. This means that decision making regarding plant modifications and operations is based on both traditional engineering assessments as well as insights derived from Probabilistic Risk Assessment (PRA). The licensees also realize that an important part of risk management is the quantification of risk (accident sequences and their frequencies) as provided by PRA. As a result, we have established the Nuclear Risk Research Center (NRRC) within the Central Research Institute of Electric Power Industry (CRIEPI), so that we can develop plant-specific PRAs of high quality which include the outcomes of the research that the NRRC is producing.

The objective of introducing the RIDM process is to bring about changes in the existing management process that is focused on demonstrating plant safety through compliance with the regulations and to establish a management process of self-disciplinary efforts to improve plant safety through monitoring the as-built and as-operated plant status, considering the risk significance of possible issues as part of the decision criteria (risk-informed and performance-based), and implementing decision making for safety improvement in timely manner.

RIDM is an important process for risk management of nuclear power plants. We have decided to introduce the RIDM process into the management process at our stations to achieve substantive improvement of plant safety beyond compliance with the regulations.

A.2 Purpose and Scope of Applications

The purpose of this strategic plan is to provide high-level direction to safety improvement of the nuclear power plants in Japan that, when implemented, will lead to a sound risk management framework. This framework will consist of a set of programs and behaviors that will facilitate the use of a structured risk-informed and performance-based process for decision making regarding plant modifications, operations and maintenance.

A.3 Risk-Informed and Performance-Based Decision Making

The management system that implements RIDM is described in Figure A.1. As explained in the figure, there are three main functions: “performance monitoring and analysis,” “risk assessment,” and “decision making and implementation.”

Performance monitoring and analysis is the process that monitors the performance of structures, systems, and components, as well as of human actions, of the as-built and as-operated plant. Actual performance is compared to deterministic and probabilistic criteria and objectives. If issues are raised, options for resolving them are formulated. If a change in design or operations has been implemented,

³ The concept of risk, as used here, consists of the probability of undesirable consequences and the magnitude of these consequences. Examples of consequences are damage to the reactor core and the release of various amounts of radioactive materials to the environment.

this process monitors its effectiveness also.

Risk assessment encompasses both deterministic and probabilistic elements to assess the options for resolution when problems are observed. Deterministic evaluations include the alignment with the defense-in-depth philosophy and the maintenance of safety margins. The probabilistic element consists of the standard PRA results, i.e., accident sequences and their frequencies, as well as the risk significance of individual potential failure events. The risk assessment also considers new knowledge and operating experience. The risk assessment provides information to the decision-making process.

In Decision making and implementation, the best option for resolving the issues observed in the performance monitoring process is identified, utilizing the information from the risk assessment. This process also implements the decision option that is deemed to be the best.

The three main functions are supported by two programs: the corrective action program (CAP)⁴ and the configuration management (CM)⁵ program. CAP finds problems including accident precursors at the plant, prioritizes them using risk information and deterministic criteria, and corrects them. CM provides the design requirements and facility configuration information (FCI)⁶ necessary for the execution of each main function, maintaining three elements of configuration management aligned: design requirements, FCI, and the physical configuration.

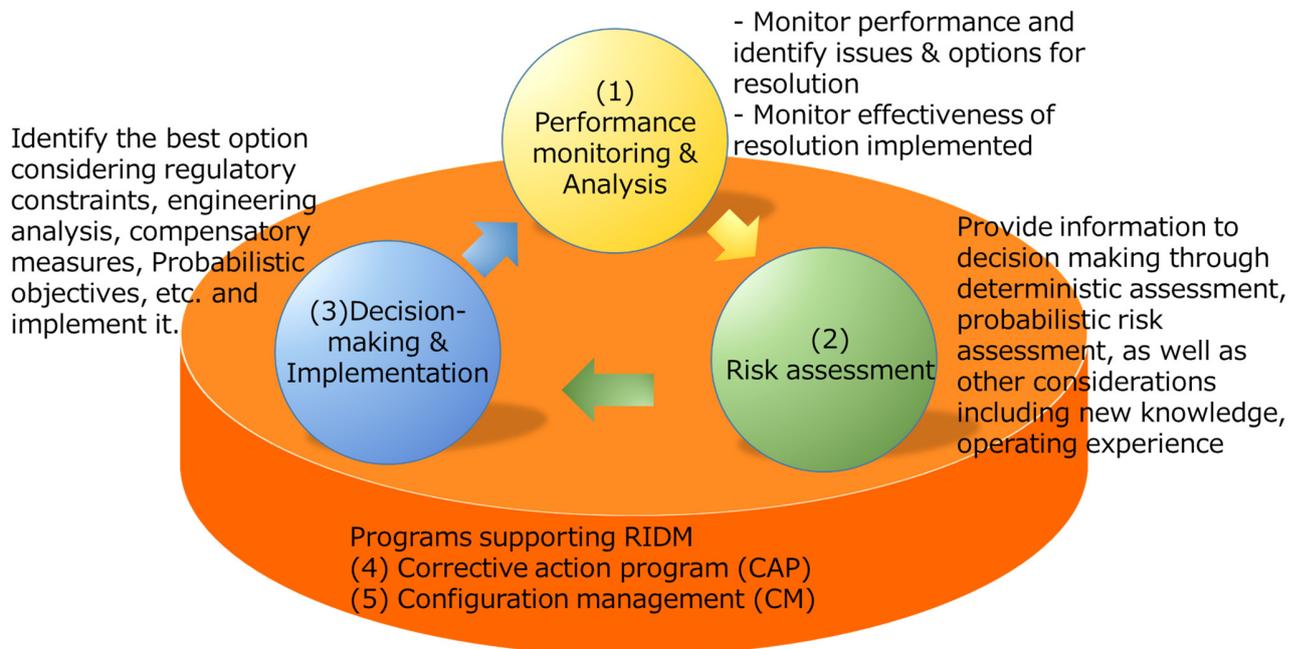


Figure A.1. Concept of risk management through risk-informed and performance-based decision making.

A.4 Basic Policy

The plan consists of two phases.

⁴ Corrective action program (CAP): Program by the licensees that identifies and resolves the problems, which includes evaluating safety significance of the problems, prioritizing the measures, and managing processes up to resolution.

⁵ Configuration management (CM): Program that maintain alignment of three elements; design requirements, physical configuration, and facility configuration information (FCI)

⁶ Facility configuration information (FCI): Recorded information that describes, specifies, reports, certifies, or provides data or results regarding the design requirements or design basis, or that pertains to other information attributes associated with the facility and its structures, systems, and components (ANSI/NIRMA CM-1.0-2015).

- Phase 1 shall be the period up to about the year 2020 or the plant restart. During this period, the licensees will develop the necessary technical infrastructure for the introduction of RIDM and establish a system of risk management to improve plant safety against the risk of internal events. At the same time, the licensees will utilize risk information assessed by their existing processes and tools of risk assessment to improve their performance as well as risk management skills.
- In Phase 2, the licensees will implement the management system introduced in Phase 1, demonstrate its effectiveness through the upcoming proposed inspection system⁷ to be introduced by the Nuclear Regulation Authority (NRA) in 2020, and continually work to improve it. The licensees will incorporate RIDM into the following daily plant activities:
 - Maintenance program
 - Technical specifications
 - Quality assurance system

The licensees will voluntarily modify the operator training program and procedures, and will enhance the plant's capability to cope with accidents beyond the design basis.
- For external events (earthquakes, tsunamis, volcanoes, others), the risk assessment will be deterministic for the time being, i.e., it will consider compliance with the regulations, operating experience, alignment with the defense-in-depth philosophy, and the maintenance of safety margins. Probabilistic risk assessment for external events will be introduced as the relevant results of research and development produced by NRC and others are becoming available.
- The management system shown in Figure A.1 is also applied to the plants that have not restarted, as appropriate.
- This strategic plan will be implemented and revised by the licensees, as appropriate, considering progress of implementation of the RIDM process, as well as research and development of the technologies associated with risk management.

Figure A.2 depicts this policy.

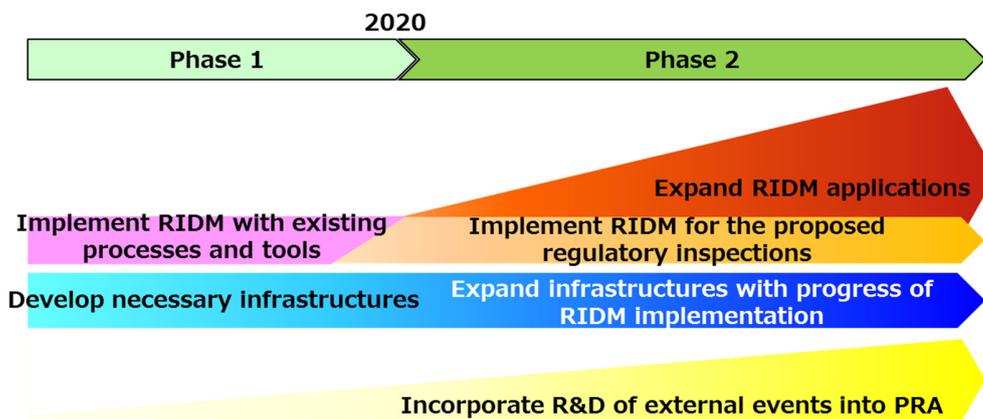


Figure A.2. Basic policy for the introduction of RIDM process.

A.5 Stakeholders

In addition to the utilities, there are several stakeholders who would benefit from this plan. They include the vendors, academia, , NRA, local residents, and the general public. The industry will engage in dialogues with the stakeholders to explain why the risk management system is introduced and what

⁷ NRA received the report of the Integral Regulatory Review Service (IRRS) mission by IAEA in April, 2016, and based on the recommendations provided in the report, prepares the introduction of a regulatory inspection framework that is performance-based and risk informed with reference to Reactor Oversight Process (ROP) of the U.S. Nuclear Regulatory Commission.

the safety benefits are.

A.6 Benefits

Perhaps the most important benefit is the use of the risk language. This facilitates communication among the utility's organizations, as well as among the stakeholders. The ensuing debates and arguments will be much more meaningful because the various risk metrics will provide a better understanding of the overall level of plant safety and of the risk significance of individual issues.

The early identification of problems and their resolution according to their risk significance is a major benefit. The licensees will be able to focus resources on what is really important from a plant risk perspective, thus managing safety effectively and efficiently.

Another major benefit is the ability to evaluate the risk reduction that proposed plant modifications would effect. This will allow for meaningful rational decisions that do not waste resources on issues that have no or minimal effect on plant safety.

The primary objective of the Strategic Plan is to manage the risk related to public health and safety as shown in A.2. However, an additional benefit to the utilities is that they can also avoid events that, while they do not threaten plant safety, may lead to problems with the regulators, the public, or serious financial loss.

A.7 Infrastructure

The implementation of this Strategic Plan requires changes in our management (e.g., switching from a regulatory compliance mindset to an excellence-focused mindset), as well as the establishment of business infrastructures such as various processes and protocols. These are discussed in more detail in the Action Plan that accompanies this Strategic Plan.

B. Action Plan

B.1 Preamble

The implementation of the Strategic Plan requires that the licensees establish processes to train personnel on the utilization of risk information in combination with deterministic considerations. The culture of the organizations should shift from a strictly regulatory compliance one to a culture whose focus is managing risks and achieving excellence in operations. Ownership of plant safety by the line organizations, such as operations and maintenance, and more involvement of management (in both corporate offices and stations) should be pursued.

According to the basic policy of the Strategic Plan, this action plan should be implemented by the licensees during Phase 1. The licensees will develop the necessary business processes to establish the functions necessary for introducing RIDM process, as well as the appropriate infrastructures.

Each licensee is expected to prepare for the proposed regulatory inspections to be introduced in FY 2020, and for the expansion of RIDM process thereafter. The regulatory inspections are planned to be changed to risk-informed and performance-based ones, therefore, the utilities will demonstrate our risk-informed and performance-based management system during this change.

Sections B.2 through B.6 provide specific time tables for the activities necessary for introducing the RIDM process. The activities where the responsible organization is specified as “Common to all” are implemented by NRRC or JANSI, or joint efforts by NRRC or JANSI and the licensees together. The activities where the responsible organization is specified as “individual” are to be incorporated into the individual licensee’s business plan.

B.1.1 Leadership and Safety Culture

Prerequisites for the successful implementation of this strategic plan are as follows: Top management issues a statement that safety is the first priority and encourages the implementation of RIDM process throughout the organization. Managers communicate to the employees their expectations based on this statement, oversee the implementation of RIDM process, and actively look for risk-significant conditions and behaviors to reinforce the expectations. Employees are encouraged to have a questioning attitude, to proactively identify risks and performance issues, and to communicate freely with their colleagues and management. Entire station organizations are involved in the project to establish the processes and infrastructures for RIDM process.

B.1.2 Training

Human resources are key to the successful implementation of RIDM process. The processes and infrastructures necessary for RIDM are implemented and supported by station personnel. To facilitate the introduction of the RIDM process, it is important that training programs be developed in alignment with the processes and the associated procedures that are established.

Personnel attend courses and workshops on the fundamentals of probability theory and statistics, PRA, and RIDM. RIDM examples from other countries are studied to learn about the challenges that have been faced and how decisions have been made. In this context, the NRRC report “Risk-Informed Decision Making: A Survey of United States Experience,” published in 2017, is useful.

Not all personnel are expected to be PRA professionals, i.e., capable to develop a PRA and perform uncertainty and sensitivity analyses. A small group of such professionals is sufficient; they are responsible for maintaining and updating the PRA and to answer questions that require PRA expertise. Most personnel, e.g., in maintenance, engineering, and operations, are trained to understand the insights from the PRA and how they should be used in a RIDM process.

B.2 Performance Monitoring and Analysis

B.2.1 Monitoring and analysis of the performance of systems, structures, and components (SSC)

- Define the scope of SSCs with risk significance and the associated parameters. Decision thresholds will be defined using the design and operating margin information, as well as PRA.
- Monitor the performance within the scope and understand the trends and identify the precursors to degraded performance.
- Analyze the condition and trends of degradation of SSCs, predict the time of deviation from the limiting condition, specify the issues, and develop actions to address the issues.

B.2.2 Monitoring and analysis of human and organizational performance

- Monitor the performance of operators and workers at field evolutions, identify the issues, and develop resolutions for the issues
- Monitor organizational performance through performance indicators, self-assessment, trending of information reported to CAP including operating experience and near-misses, identify issues, and develop resolutions for these issues

Action	Organization	FY2017		FY2018		FY2019	
		1H	2H	1H	2H	1H	2H
(1) Establish the process							
Review overseas standards, establish standard process	Common to all						
Internalize standard process	Individual						
(2) Develop technical infrastructures, tools, & manuals							
Establish performance indicators	Common to all						
Develop tools & manuals	Individual						
(3) Develop human resources	Individual						

B.3 Risk Assessment

B.3.1 Deterministic Assessment

Deterministic risk assessment assesses specified issues and options for resolution from the following viewpoints;

- Compliance with the regulations
- Consideration of operating experience and new knowledge
- Alignment with defense-in-depth philosophy
- Maintenance of safety margins

Design control process is important for deterministic risk assessment. Design control process is to be improved through establishment of configuration management program described in B.6.

Action	Organization	FY2017		FY2018		FY2019	
		1H	2H	1H	2H	1H	2H
(1) Establish the process							
Review overseas standards, establish standard process	Common to all	[Green hatched bar]					
Internalize standard process	Individual				[Blue bar]		
(2) Develop technical infrastructures, tools, & manuals							
Develop tools & manuals	Individual				[Blue bar]		
(3) Develop human resources							
	Individual				[Blue bar]		

B.3.2 Probabilistic Assessment

- Analyze hazards and the success criteria for the functions that respond to these hazards through probabilistic methods, and quantitatively assess overall plant risk (CDF, CFF, LERF, etc.) and the risk contribution of each SSC or operator action.
- Remove conservatism included in the deterministic analysis from the PRA as much as possible, and do the PRA based on the conditions reflecting the as-built and as-operated plant status.

Action	Organization	FY2017		FY2018		FY2019	
		1H	2H	1H	2H	1H	2H
(1) Establish processes							
Internalize standard process	Individual	[Blue bar]					
(2) Develop technical infrastructures, tools, & manuals							
【Enhance PRA model】	Individual	[Blue bar]					
【Reliability parameters】							
Develop a guide for plant-specific data collection	Common to all	[Green hatched bar]					
Collect plant-specific data	Individual	[Blue bar]					
Establish plant specific parameters	Individual					[Blue bar]	
Develop domestic generic parameters	Common to all					[Green hatched bar]	
【PRA peer review】							
Develop a peer review guide, establish peer review system	Common to all		[Green hatched bar]				
Trial and actual implementation of peer review	Common to all					[Green hatched bar]	
(3) Develop human resources							
Develop in-house human resources	Individual	[Blue bar]					
Develop domestic generic training programs for PRA practitioners and PRA users	Common to all	[Green hatched bar]					

B.4 Decision Making and Implementation

The process identifies and implements the best option for the resolution of issues considering information from risk assessment including its uncertainty as well as other information.

Action	Organization	FY2017		FY2018		FY2019	
		1H	2H	1H	2H	1H	2H
(1) Establish processes							
Review overseas standards, establish standard process	Common to all	██████████					
Internalize standard processes	Individual			██			
(2) Develop technical infrastructures, tools, & manuals							
Trial estimation, establish thresholds	Common to all	████████████████████					
Develop tools & manuals	Individual			██			
(3) Develop human resources							
Develop a domestic training program for decision-makers	Common to all	████████████████████					
Develop in-house human resources	Individual					██	

B.5 Corrective Action Program (CAP)

B.5.1 Collect information including minor issues from various sources

- Ensure condition reports to be reported by all levels of station personnel including precursors, minor issues of both SSCs and human performance, as well as non-conformance information.

B.5.2 Screen the issues with focus on nuclear safety

- Identify issues of safety significance out of condition reports, and address the issues appropriately based on their safety significance (consider their resolutions, and implement root cause analysis and corrective actions if the issues are significant), as well as manage and utilize the remaining minor issues within the system.

Action	Organization	FY2017		FY2018		FY2019	
		1H	2H	1H	2H	1H	2H
(1) Establish processes							
Review overseas standards, establish standard process	Common to all	██████████					
Internalize standard process	Individual			██			
(2) Develop technical infrastructures, tools, & manuals							
Develop tools & manuals	Individual			██			
(3) develop human resources							
	Individual			██			

B.6 Configuration Management

B.6.1 Collect facility configuration information

- Collect and organize the information of SSCs within the scope including design requirements, design and operating margins, drawings, and associated documents

B.7.3 Development of the Relationship with the Regulator for expanding RIDM Applications

The objective of introducing and implementing RIDM process is to improve the safety of nuclear plants by continuous risk management. The licensees acknowledge that the objective of the regulatory authority is the same and that it is possible to have a meaningful discussion of RIDM implementation with the regulator.

The licensees' plan is to develop the infrastructures of RIDM process and to introduce a risk management system in the daily operation and maintenance at stations during Phase 1. Then, in Phase 2, the licensees plan to verify the effectiveness of the management system and to introduce RIDM processes to the technical specifications of stations and other requirements. To be successful with this plan, it is necessary for the licensees to actively prove the effectiveness of the RIDM process. For that purpose, it is also important to appropriately understand and learn from implementation experience of the proposed nuclear regulatory inspection reform, which is planned to be effective in 2020.

From the viewpoint of safety improvement, the licensees are responsible for their plants' risk management. On the other hand, if the directions that the regulator and the licensees pursue are different, it will be difficult to establish activities toward safety improvement. Therefore, the licensees will engage in a dialogue with the regulator in order to ensure that we both have the same perspective on risk management and future directions, for instance, regarding the thresholds of performance indicators or the significant determination process.