Regulatory Policy Perspectives to Enhance Nuclear Safety: Global Trends and Issues

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1. INTRODUCTION

As in the past, events such as the Fukushima Daiichi accident will provide motivation for further reviews and changes on how regulatory authorities will need to function that ensuring that nuclear installations are operated and maintained in such a way that their impact on public health and safety is as low as reasonably practicable and will continue to be the cornerstone of nuclear regulation.

Seeking to enhance the present level of safety by continuously improving the safety level of nuclear installations is seen as one of the ways to strengthen public confidence. Regardless of the reason, the global nuclear community also continues to make progress in strengthening and improving safety notwithstanding significant challenges. In general, the challenges are aimed to strengthen the global nuclear safety framework through various national and international programmes and activities.

Hence, this study has reviewed the current trends and efforts underway in major regulatory authorities in the world as well as in international organisations so as to realize the common elements among safety concerns and perspective of major regulatory authorities in the world which remain to be addressed.

2. REGULATORY PERSPECTIVE AND PROSPECTIVE

In this section some of the trends and efforts in major regulatory authorities and international organisations are explored. .

2.1 IAEA

The Nuclear Safety Review 2017 includes the global trends and the Agency's activities in 2016 which were a focus on the safety of nuclear power plants (NPPs) as followings.

(a) Operational Safety: Operating Experience and Long Term Operation

The need for effective and proactive leadership and management to promote continuous safety improvements to:

- Reinforce consideration of the interactions between technological, human and organizational factors;
- Improve the use of operational experience to prevent the recurrence of safety significant events, identify safety upgrades and complete the programmes of safety improvements;
- Manage the challenges associated with an ageing workforce; and
- Further strengthen accident management and on-site emergency preparedness and response (EPR).

(b) Site and Design Safety

The International Nuclear Safety Group (INSAG) noted that modern reactor designs are being developed to reduce the risks to arise from external events and the followings are also considered: the uncertainties associated with the evaluation of extreme external hazards; the need for using historical and prehistoric data in the evaluation of external hazards; consideration of external hazard combinations; consideration of the impact of external hazards on multi-unit sites; and the use of a probabilistic approach to the analysis of external events. The Agency continued to update safety standards and issued detailed Technical Documents and Safety Reports supporting the protection of nuclear installations against external hazards.

Besides, practical elimination concept was also introduced in IAEA Safety Standards Series No. SSR-2/1 (Rev. 1). IAEA-TECDOC-1791 elaborates on the practical incorporation of design extension conditions into the plant design as part of the defence in depth approach and on the demonstration of 'practical elimination' of large or early releases.

(c) Severe Accident Prevention and Mitigation

The lessons arising from the Fukushima Daiichi accident highlighted the need for accident management provisions to be clear, comprehensive, well designed and based on the challenges that operators and decision-makers may face when dealing with a severe accident.

The Agency will provide forums for Member States to share knowledge and experience in their efforts to strengthen their severe accident management guidelines. The Agency will further develop technical documentation in this area. The Agency will undertake the following activities in relation to these priorities:

- The Agency will finalize the development of a revised Safety Guide on severe accident management;
- The Agency will prepare a Technical Document to

share the available information on severe accident management and guide Member States in their further development of SAMGs; and

(d) Safety of Small and Medium Sized or Modular Reactors

The development of SMRs involves the use of passive safety features, and an increased use of factory construction and inspection techniques. Currently, there are about 50 SMR designs under development.

The Agency has initiated a study on the application of the design-related Safety Requirements to SMR designs intended for near term deployment. This study includes a review of current practices in Member States with regard to the application of the Agency's safety standards to SMR technologies, and the development of an IAEA Technical Document on their applicability to SMRs.

The Agency will assist Member State activities related to small and medium sized or modular reactors, particularly their efforts to develop safety requirements, build capacity for design and safety assessment, and share best practices.

2.2 Korea

(1) Establishment of Comprehensive Nuclear Safety Plan

The Nuclear Safety and Security Commission (NSSC) completed the deliberation and resolution of 1st Master Plan for Nuclear Safety (2012-2016) in October 2012, based on the Nuclear Safety Act (NSA) Article 3 (Establishment of Comprehensive Nuclear Safety Plan), the top notch plan of the nation to guide the mid- and long-term policy direction for better response to the environmental change of domestic and foreign nuclear industries.

Accordingly, a hierarchy of nuclear safety policy system that consists of Nuclear Safety Charter, Nuclear Safety Policy Statement, and Comprehensive Plan for Nuclear Safety and Annual Action Plan is established as follows:

1-1 Establishment of accident management framework including severe accident conditions

1-2 Application of comprehensive analysis and evaluation system for safety operation of nuclear power plants

1-3 Strengthening safety management of major SSCs during whole life cycle

2-1 Active openness of nuclear safety information

2-2 Promotion of communication with public

3-1 Pre-active planning and actions for future decommissioning of nuclear installations

3-2 Update and restructuring radwaste management regulatory infrastructure for future regulatory demand

4-1 Preparation of countermeasures to external hazard including geological surveys near nuclear power plants

4-2 securing on-site emergency response facility having seismic resistance structure

4-3 Improvement of effectiveness for preparedness and response system for radiation emergency

4-4 Enhancement of response capability to radiation terrorism

5-1 Preparedness and response to the security treat by reconsideration of regulatory framework for physical protection

5-2 Establishment of implementation framework of cyber security for nuclear installations

5-3 Contribution for strengthening global NPT framework by enhancing implementation of safety measurement

5-4 enhancement of nuclear export control system and nuclear NPT policy capability

6-1 Re-establishment of regulatory framework taking into account of radiation application process

6-2 strengthening preventive safety measures for minimizing radiation exposure

6-3 Establishment of radiation safety environment for radiation in everyday life

7-1 R&D for timely response to the regulatory needs

7-2 Enhancement of education and training efficiency of nuclear safety and security

7-3 Achievement of Global leadership in nuclear safety and security community

(2) Implementation of Vienna Declaration

The Nuclear Safety Acts was revised to clearly stipulate the responsibility for and the regulatory requirements of accident management including severe accident management (promulgated on June 22, 2015 and effective on June 23, 2016). The NSSC promptly promoted follow-up legations and revisions to complete the legalization of what is necessary for regulatory control on severe accident. Here explains key regulatory control whose legalization has recently been completed to lay a legal basis for implementation of Vienna Declaration. In addition, regulatory activities to be performed henceforth based on the new regulations on severe accident are explained in terms of applicable CNS Articles.

(3) Legislation and Revision of the NSA and Subordinate Statues for Regulatory Management of Severe Accident

The Nuclear Safety Acts and subordinate regulations that stipulate matters related to regulatory control of severe accident amended on June 2016 to include severe accident into the scope of accident management:

accident management is defined as overall actions to: (i) prevent the escalation of the accident; (ii) mitigate the consequences of the accident; and (iii) achieve a long-term safe and stable state after the accident, which includes severe accident management

The detailed contents that needs to be included in the accident management program is also prescribed (scope of accident management, equipment used in accident management, strategy and implementation system for accident management, and evaluation of accident management capabilities)

- To expand the scope of Radiological Environmental Impact Assessment to include severe accident
- To carry out periodic inspection on accident management including severe accident against operating NPPs: It is prescribed that the criteria for periodic inspection on NPPs include the criteria for accident management.

Risk Assessment

Regarding the prevention and mitigation of severe accident, probabilistic safety assessment needs to be carried out along with deterministic safety assessment and the goals are as follows:

- Early and cancer fatality risk should be less than 0.1% of the total risk, or equivalent performance goal should be met
- The total frequency of the accidents with the release of more than 100TBq of radionuclide Cs-137 should be less than 1.0×10-6/year

2.3 USA

(1) Fukushima Lessons Learned

Based on assessment of lessons-learned from the accident, the Near-Term Task Force (NTTF) recommendations were identified an imminent hazard to public health and safety as following three steps:

Tier 1 Recommendations

The first tier consists of actions that the NRC determined should be started without unnecessary delay and for which sufficient resource flexibility, including availability of critical skill sets, exists.

Tier 2 Recommendations

The second tier recommendations are actions that originally could not be initiated because of a need for further technical assessment and alignment, dependence on Tier 1 issues, or lack of availability of critical skill sets. These were recommendations that the staff determined did not require long-term study and could be initiated when sufficient technical information and applicable resources become available.

Tier 3 Recommendations

The third tier consists of actions that required further staff study to support regulatory action, relied on the result of an associated short-term action to inform the long-term action, depended on the availability of critical skill sets, or related to potential revisions to the regulatory framework that balances defence-in-depth and risk considerations.

The NRC took prompt action following the Fukushima accident through the issuance of orders, implementation of focused inspections, development of Inspection Manuals (INs) to the industry, and issuance of bulletins to confirm that there were no imminent safety concerns at nuclear facilities. Because no imminent safety issue existed, no nuclear power plants were shut down as a result of the accident in Japan. The NRC continues to implement Fukushima lessons learned within existing regulatory processes that include review of industry response to orders, requests for information, inspections, use of operating experience, rulemaking, and conducting additional research.

(2) Vienna Declaration on Nuclear Safety

In light of the Fukushima accident, the NRC has taken many actions to strengthen the protection of nuclear plants against events that could exceed a plant's design basis. For example, the NRC issued regulatory requirements, in the form of three orders, based on the lessons learned from Fukushima. The three orders required safety enhancements of operating reactors, construction permit holders, and combined license holders. These orders required nuclear power plants to implement safety enhancements related to: (i) mitigation strategies to respond to external events resulting in the loss of all AC power at plants, (ii) ensuring reliable severe accident capable hardened containment vents for Mark I and II boiling-water reactors designs, and (iii) enhancing Spent Fuel Pool (SFP) instrumentation. Operating plants were required to begin implementation of the safety enhancements promptly and complete implementation within two refueling outages or by December 31, 2016, whichever came first. In the case of the containment vents, the NRC revised its original order for hardened vents for BWRs with Mark I and II containments to include additional requirements for those vents to have capabilities to be operated under severe accident conditions. This revision resulted in a change to the required date for full implementation to be achieved. The NRC has taken other actions to address the adequacy of nuclear power plant design with respect to natural hazards (e.g., seismicity, and flooding). The NRC is continuing its post-Fukushima activities through the development of a new regulation for mitigating beyond-design basis events.

(3) Safety and Regulatory Issues, and Regulatory

Accomplishments

Shield Building Laminar Cracking at Davis-Besse

The shield building at the Davis-Besse nuclear power plant is a reinforced-concrete structure that surrounds the freestanding steel containment vessel, and has nominal wall thickness of 30 inches with vertical and horizontal rebar grids on both the inside and outside face. The functions of the shield building are to provide: (i) biological shielding, (ii) environmental protection of the containment vessel, and (iii) control release of annulus atmosphere during accidents.

The NRC has completed an inspection of the licensee's apparent cause evaluation for the crack growth. The NRC staff determined that the shield building laminar cracking condition remained bounded by the licensee's structural evaluation. The NRC has concluded that the licensee provided reasonable assurance that, with the current condition, the shield building will perform its safety function, including withstanding earthquakes and tornadoes. The NRC staff continues to follow the licensee's corrective actions related to this issue under the baseline inspection program.

Alkali-Silica Reaction Concrete Degradation at Seabrook Station

Alkali-silica reaction is a slow chemical process that can cause degradation over time in hardened concrete. For this reaction to occur, it is necessary for the concrete to contain reactive aggregate, high alkali content in the cement, and adequate moisture to form a gel. The gel expands by absorbing water initially, resulting in a network of microcracks in the concrete.

Depending on its progression and severity, the alkali-silica reaction can reduce or affect mechanical properties of concrete (i.e., compressive, tensile, shear, and bond strengths, elastic modulus, and the Poisson's ratio) used in design to different extents, and could also affect empirical code relationships between concrete mechanical properties assumed in the American Concrete Institute design and construction codes. Alkali-silica reaction expansion could also lead to structural displacement or deformation and discrete macrocracking not considered in the concrete design, and could affect structural performance over time.

The NRC's oversight review of this issue determined that there are no immediate safety concerns based on existing safety margins, the slow nature of the degradation, and ongoing monitoring. This review has included an evaluation of the licensee's prompt operability determinations for various structures affected by alkali-silica reaction. These operability determinations address the alkali-silica reaction impacts on material properties due to microcracking, as well as the impacts due to macrocracking and building deformation due to alkali-silica reaction expansion. The NRC's oversight includes ongoing assessment of the continued acceptability of the operability determinations. The NRC continues its oversight of the alkali-silica reaction issue and has formed a multioffice, multidiscipline working group to guide the agency's ongoing approach to respond to this safety issue.

(4) NRC Strategic Plan

The strategic plan, covering the period 2014–2018, describes how the NRC plans to achieve its two strategic goals: (1) to ensure the safe use of radioactive materials and (2) to ensure the secure use of radioactive materials. The plan provides an overview of the NRC's responsibilities, describes how stakeholders participated in plan development, summarizes key challenges the agency will face during the planning period, and lays out the objectives, strategies, and key activities that will be used to achieve the agency's goals. In order minimize the likelihood of accidents and reducing the consequences of an accident, the key elements for achieving the NRC's safety goal are as followings:.

- Safety Strategy 1: Enhance the NRC's regulatory programs as appropriate using lessons learned from domestic and international operating experience and other sources.
- Safety Strategy 2: Enhance the risk informed and performance-based regulatory framework in response to advances in science and technology, policy decisions, and other factors.
- Safety Strategy 3: Ensure the effectiveness and efficiency of licensing and certification activities to maintain both quality and timeliness of licensing and certification reviews.
- Safety Strategy 4: Maintain effective and consistent oversight of licensee performance to drive continued licensee compliance with NRC safety requirements and license conditions.
- Safety Strategy 6: Ensure that nuclear facilities are constructed in accordance with approved designs and that there is an effective transition from oversight of construction to oversight of operation.

2.4 France

(1) Implementation of the principles of the Vienna declaration

Complete and systematic safety assessments must be carried out periodically and regularly throughout the life of the existing facilities, in order to identify the safety improvements needed to achieve the above-mentioned objective. The reasonably possible or feasible safety improvements must be implemented in good time.

With regard to the existing power reactors, France carries out periodic safety reviews of the facilities,

enabling operating experience feedback to be integrated and modifications to be made to improve reactor safety. These periodic safety reviews comprise not only an assessment of the control of equipment ageing, but also a reassessment of the safety of the facility, based on the safety objectives of the more recent facilities. On this occasion, the French Nuclear Safety Authority (ASN) asked the licensees to make modifications to the facilities in order to ensure closer compliance with these objectives with the order "setting the general rules relative to basic nuclear installations", called the "BNI Order". The Environment Code requires that the licensee of a BNI periodically conduct a safety review of its facility, taking international best practices into account. The purpose of this periodic review is to assess the situation of the facility in the light of the rules applicable to it and to update the assessment of the risks or drawbacks that this facility presents with regard to the above-mentioned protected interests, more specifically taking account of the condition of the facility, the experience acquired during its operation, changes in knowledge and in the rules applicable to similar facilities. These safety reviews are held every ten years.

(2) Safety outlook for the next three years

(a) Regulation of the NPPs in service

Regulation of the NPPs in service remains a priority for the regulatory authority (ASN), which considers that improving the facilities in operation first of all requires control of the condition of the reactors, of the operating baseline requirements (including the general operating rules) and of routine work such as maintenance, oversight and operations. With regard to environmental protection,

The periodic safety review for the 900 MWe reactors, with a view to extending their service life beyond 40 years, is the framework adopted by ASN, on the one hand to query operation organization, EDF's ability to maintain its installations and their operating documentation in conformity with the defined requirements and, on the other, to reinforce the safety objectives of these installations.

(b) Experience feedback from the Fukushima Daiichi NPP accident

Following on from the actions of 2012, ASN is paying particular attention to how Électricité de France (EDF), French Alternative Energies and Atomic Energy Commission (CEA) take account of experience feedback from the accident at the Fukushima Daiichi NPP. ASN is specifically monitoring the steps necessary for implementation of the additional safety measures requested following the stress tests. ASN issued a position statement on the proposal by these licensees to deploy a "hardened safety core" of material and organisational measures to control the fundamental safety functions in extreme situations. ASN supplemented its requests by a range of resolutions to clarify certain provisions of the "hardened safety core" and associated requirements. It is currently reviewing the natural hazard levels to be considered for the situations adopted for the hardened safety core and the design of these systems as related to the prevention and accident control strategies proposed.

3. CONCLUSIONS

This study provides an overview of the current trends and efforts underway in major regulatory authorities in the world as well as in international organisations, and attempted to deduce the common elements among them to provide a regulatory concerns and perspective on the major safety issues.

In order to enhance the present level of safety by continuously improving the safety level of nuclear installations, it is suggested that the challenges are needed to be implemented under the national nuclear safety framework through various national and international programmes and activities. The challenges are focused on the safety of NPPs and improvement of regulatory programme using lessons learned from operating experience and continued licensee for long term operation, site and design safety and severe accident prevention and mitigation for Fukushima lessons learned

In conclusion, the major challenges and issues are included in the Nuclear Safety Policy Statement, and Comprehensive Plan for Nuclear Safety and Annual Action Plan. It is also expected that this Comprehensive Plan could strengthen the nuclear safety framework as well as ensure the public confidence. While conducting the Comprehensive Plan, it is also recommended to consider implementing international regulatory issues and activities.

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