

Comprehensive Review of Regulatory Actions to Enhance Nuclear Safety

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1. Introduction

In the wake of the Fukushima Daiichi Nuclear Power Plant Accident, international agencies and every nuclear safety regulatory authority in the world prepared its follow-up counter-measures. Based on these international initial regulatory activities, the Korea also prepared measures and made regulatory efforts to strengthen the nuclear safety by reflecting the lessons of the accident and assessing the nuclear safety of operating nuclear power plants.

Seven years after the Fukushima accident, the Korea needs to review the overall activities of strengthening nuclear safety and the safety improvement measures that Korea has achieved over the 7 years, as well as the lessons learned and policy implication of the process.

Therefore, this paper mainly covers the whole view of Korea's nuclear safety policies 7 years after the Fukushima accident, how each safety improvement measure analyses and reflects international trend, key contents of major performances, and identified future regulatory challenges.

2. Review of Regulatory Actions

2.1 General Chronology of Post-Fukushima Era

It needs to understand a comprehensive timeline of international efforts and the related Korean measures to strengthen nuclear safety during the 7 years after Fukushima accident.

EU decided to perform Stress Tests on operating nuclear power plants in the region. In accordance with the Stress Test method proposed by WENRA and approved by ENSREG, a national report was prepared and Action Plans are being implemented after peer review. In light of the Fukushima accident, the IAEA recognized the weakness of the international response system against nuclear accidents and adopted the IAEA Action Plan on Nuclear Safety at the IAEA General Conference in September 2011. The prestigious IAEA DG Report of Fukushima, which addresses the implementation results of the IAEA Action Plan on Nuclear Safety as well as the lessons, and cause and effect of the Fukushima accident was published in June 2015. The IAEA Convention on Nuclear Safety (CNS) held a diplomatic conference to consider a proposal to amend the CNS for the purpose of reviewing accident

lessons and measures to improve safety, as well information exchange. The IAEA CNS also adopted the Vienna Declaration on Nuclear Safety, which is the principle for the implementation of the objective of the CNS to prevent accidents and mitigate radiological consequences.

In line with such international trends, Korea identified 50 total Post-Fukushima actions to improve safety against severe accidents after conducting a special inspection on all domestic nuclear installations. In addition, Korea decided to initially perform stress tests on aged nuclear power plants Kori Unit 1 and Wolsong Unit 1 to verify the safety of domestic nuclear power plants and identify improvements by assessing the response capabilities of domestic plants against extreme natural disasters beyond design basis. This assessment reflected IAEA and US standards as well as Greenpeace recommendations to verify not only technical response capabilities, but also decision-making errors and ability to manage organization and personnel in extreme situations. Reflecting the verification experience and results of the stress test on Wolsong Unit 1 and Kori Unit 1, the stress test will be gradually performed from 2017 to 2020. Korea received an IRRS Mission in July 2011, and it provided the grounds to establish a regulatory authority and framework which ensures regulatory independence, and to adopt regulations related to severe accidents and PSA. Afterwards in October 2011, the Nuclear Safety and Security Commission was founded. The mission resulted in not only the recommendation to adopt and organize severe accident and PSA related regulations, but also the need for a legal basis for regulations on severe accidents. Thus, the Nuclear Safety Act was amended to clearly define accident management duties, including severe accident management, and regulatory requirements. In addition, the legal basis was prepared for oversight of the licensee's safety culture in the PSR phase, for the decommissioning and for the expansion of the Emergency Planning Zone (EPZ) for public protection in radiation emergencies [2].

2.2 Key Lessons Learned from the Accident Sequence Analysis

The Korea analysed the accident causes sequentially and key lessons learned from the Fukushima accident according to the accident sequence analysis were categorized as follows:

① In the case of natural disasters, conservative assessments must be applied and newly discovered knowledge must also be applied by performing periodic safety reviews. In addition, the possibility of natural disasters happening at the same time should also be considered when assessing natural disasters.

② The concept of DiD should be improved and implemented to cope against internal and external disasters through adequate independence, diversity and protection capacity for each level. Thus, the failure of safety function is unacceptable and it should be verified whether nuclear power plants are able to withstand accidents beyond design basis by conducting probabilistic and deterministic safety assessments.

③ To prepare against expected severe accidents, intensive preparation by operators such as training and exercises is needed and a disaster protection system formed among the central government, operator, and local government clearly defining roles and obligations needs to be established.

④ To effectively regulate safety, preparations for the independence and legal authority of the regulatory authority, technical competence, and strong safety culture are a must. In the process of a systematic approach to safety, the mutual process among human, organization, and technical elements must be considered.

2.3 International Efforts and its Feedback to the Korean Measures

In addition to the assessment of lessons learned from the accident sequences, international findings from the IAEA Action Plan on Nuclear Safety announced in 2012 and IAEA DG report on Fukushima published in 2015 were identified and reflected to the Korean regulatory actions as follows:

① In terms of evaluation on vulnerability of NPPs to external events, 50 action items were identified from the special safety inspection and stress test is expected to be performed on all NPPs by 2020.

② In terms of evaluation on beyond design basis accidents and accident management, the Nuclear Safety Act was amended to reflect beyond design basis accidents.

③ In terms of evaluation on human and organizational factors, the Nuclear Safety Act was amended to incorporate safety culture in Periodic Safety Review(PSR).

④ In terms of strengthening international cooperation on emergency response, Korea has been taking measures by joining the IAEA Response and Assistance

Network(RANET) for emergency response support among countries during radiation emergencies, and actively participating in joint radiation prevention exercises with TRM members and neighbouring countries.

Especially two regulatory actions can be highlighted. First, in regards to evaluation, Korea's stress test not only considers the EU's stress test, but also has a guideline which includes operational technical ability such as emergency response and human factors. In the evaluation phase, after the licensee's self-assessment, there is an independent review carried out apart from the review by the regulatory body by a group consisting of KINS and private experts to promote objectivity and transparency. The evaluation guideline is a comprehensive one that considers not only ENSREG, IAEA, American, and Japanese guidelines, but also recommendations by Greenpeace.

Next, through the amendment of the Nuclear Safety Act to legislate accident management plan by explicitly legislating the IAEA's Defense-in-Depth concept, the legal basis has been placed to implement the basic principles of the Vienna Declaration on Nuclear Safety.

2.4 Major Performances

As initial response to the accident, not only did Korea perform safety reviews including special safety inspection and the long-term stress test on all nuclear power plants which requires monitoring, but also completed the reflection of international trends and lessons through various effort. Thus major performances can be summarized as follows:

① After the Fukushima accident, though follow-up measures were immediately prepared through a quick inspection on domestic NPPs, as measures to ensure the performance of operators and workers were not incorporated in the 50 action items, 3 additional measures implementing the stress test experience on Wolsong Unit 1 and examples of overseas regulatory authorities were prepared. The additional measures not only consider natural disasters, but also take into account fire and flooding. They also help prepare strategies to cope against severe accidents by evaluating a plant's response capability in extreme situations, as well as multi-unit accidents.

② Next performance is preparing the legal basis for severe accident regulatory management through the 2015 amendment to the Nuclear Safety Act, reflecting past severe accident policy announcements, accident lessons, and IRRS Mission results. Thus, this has meaning in the sense that the legislation of severe accident was completed in a short period while reflecting the Vienna Declaration on Nuclear Safety.

③ The follow-up measures to recommendation and proposals from the IRRS Mission provided the opportunity to prepare detailed items necessary to maintain the organizational and regulatory competence of the newly formed organization and also provided the opportunity to establish the Korean regulatory framework such as regulatory basis for decommissioning of nuclear installations, and amendment to the management system manual of the Security General of the Nuclear Safety and Security Commission.

④ Next performance is the legal basis has been placed through the amendment of the Nuclear Safety Act to evaluate safety culture as part of PSR. Through a pilot inspection on safety culture, improvements to the licensee's safety culture were identified and follow-up measures are being reviewed.

⑤ Korea shared its regulatory body's and licensee's experience with the international community through not only bi-lateral and multi-lateral cooperation, but also actively receiving Peer Reviews such as IRRS and OSART Missions. And under the TRM framework with Japan and China, Korea has established an emergency cooperation system with neighbouring countries. Korea has also actively participated in safety networks under the IAEA and strived to develop regulatory personnel in embarking countries and to minimize gaps between embarking and developed countries.

2.5 Regulatory Challenges Addressed

Despite such effort and performance, there remains many issues to resolve. For example, follow-up measures regarding the 5.8 magnitude Gyeong-ju earthquake on September 12th, 2016 and preparation for Korea's first NPP decommissioning such as preparatory activities in the transitional phase from permanent shutdown to decommissioning. Regarding this issues, the Korea officially invited "The IAEA Advisory Safety Service on the evaluation of vulnerabilities and coping capabilities of the Hanul Unit 3 NPP against beyond design basis external events", and it will be carried out coming September in Korea. This service is a kind of independent review on the Korea's stress test methodology and on the operator's stress test result to the Hanul Unit 3. This advisory service is expected to enhance domestic nuclear safety and to be a good practice for the safety enhancement activities of member states [3].

In addition, Korea completed the preparation of the legal basis for opening nuclear safety information. Through the amendment to the Nuclear Safety Act, it is stipulated that even if there is no public demand, information must be actively opened and opinions of local residents must be collected and reflected when preparing environment impact assessment reports and

decommissioning plans. Because the Regulatory body's independence, transparency, and objectivity are key elements for public trust and there is a growing demand for information disclosure and public engagement in regulatory decision making in order to realize these elements. Korea has been putting effort to amend the Nuclear Safety Act in regards to information disclosure.

2.6 The Strategic Plan to Enhance Nuclear Safety (Planned) [4]

Based on expertise and scientific criteria, the Nuclear Safety and Security Commission has been exerting effort to enhance nuclear safety. However, it needs to be improved to reassure the nuclear safety from a general public standpoint. There is a need to once again review the current status more closely in order to provide information from the view point and on the level the public wants and to identify any shortcomings. Therefore, the Nuclear Safety and Security Commission has decided to present a comprehensive roadmap to reinforce nuclear safety criteria and enhance communication.

The strategic plan has been drafted early this year and will be finalized after the NSSC commissioners' review. At present, public opinions are being collected through various channels: on-line survey, a conference, public hearings, and briefings for residents living around NPPs.

3. Conclusions

This paper provides comprehensive review recalling the main lessons learned according to the accident sequences from the technical point of view and compares and updates the history, current situation and results of the post-Fukushima action items in Korea. This comprehensive review is expected to contribute to define what is needed to continue to enhance the nuclear safety in the future.

In conclusion, throughout the recent years, Korea has prepared various safety policies from a hardware aspect. And from a software aspect, it has been verified through changes in the regulatory framework that Korean NPPs are safe. Korea is continuously amending relevant laws and applying them to make nuclear power plants safer. Korea will not only continue to strive to prevent accidents, but also to reduce fundamental risks. Through implementation of various measures and monitoring of follow-up measures, Korea will continue to pursue nuclear safety.

4. Acknowledgement

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