THE PERIODIC SAFETY REVIEW OF HANARO REACTOR

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ABSTRACT

The first Periodic Safety Review (PSR) project for HANARO commenced in 2015 after operating for 20 years. According to the amendment to the National Nuclear Safety Act in 2014, research and training reactors in Korea mandatorily perform a PSR for 14 safety factors every 10 years. As the operating organization of HANARO, KAERI started the project by organizing a project management team and establishing a budget to conduct the PSR. The time schedule was set up to complete the PSR by the due date. A PSR basis document was developed, which includes the scope, major milestones, codes and standards, safety factors, a list of SSCs, and the methodology. A review of safety factors was performed by two domestic engineering companies and an internal division of KAERI. A global assessment was carried out considering all the findings derived from each safety factor review. Finally, the final PSR report was submitted to the Korean nuclear regulator by the due date. In this paper, the results of the periodic safety review of HANARO will be presented.

1. Introduction

HANARO (Hi-flux Advanced Neutron Application ReactOr) has been operating since 1995 for multiple purposes including radioisotope production, material irradiation, neutron transmutation doping, neutron activation analysis, and neutron beam utilization. Periodic inspections and in-service inspections have been regularly performed to ensure the safe operation of the facility. A special safety review after the Fukushima Daiichi Accident was also conducted to check whether the facility will remain in a safe state during and following natural or other external events such as an earthquake, flooding, loss of offsite electric power, or station blackout. As a result of the review, several recommendations were given to HANARO and their implementation for safety improvement was performed. However, a complete comprehensive safety review for the reactor facility had not been conducted before. In 2014, the National Nuclear Safety Act was amended to demand research and training reactors in Korea mandatorily perform a PSR for 14 safety factors every 10 years. As the operating organization of HANARO, KAERI composed a project management team (Task Force Team) and established a budget to conduct a PSR project. The team set up a time schedule in order to complete the PSR, which satisfies all of the requirements by the due date, and developed a PSR basis document for conducting the PSR, which includes the scope, major milestones, codes and standards, safety factors, a list of SSCs, and the methodology. A review of 12 safety factors was performed by two domestic engineering companies according to the contracts, while two safety factors, the emergency planning and the radiological impact on the environment, were reviewed by an internal division of KAERI. Considering all the positive and negative findings derived from each safety factor review, a global assessment was performed to identify the overall level of safety. The final PSR report of HANARO was submitted to the Nuclear Safety and Security Commission (NSSC) of the Korean government by the end of 2018. This paper describes the process by which the PSR of HANARO was performed and the results, which include the recommendations for safety improvement.

2. PSR Implementation
2.1 Project management team and tasks

A Task Force Team, whose members mainly consisted of staff of the HANARO Management Division, was established to perform the first PSR project of HANARO considering the available human resources in KAERI. External engineering companies and an internal division in KAERI conducted the review of the safety factors and the global assessment, whereas TFT members offered input documents, reviewed the safety review and global assessment report, and prepared the final report of PSR. The primary tasks of the project management team are summarized as follows:

- Project planning
- Budget planning
- Time scheduling
- Preparation of the basis document for PSR
- Preparation of specifications for making contracts with engineering companies for a review of safety factors and a global assessment
- Gathering input documents for the review of safety factors and offering them to engineering companies and internal experts
- Review of the safety factor review report made by engineering companies and internal experts
- Review of the global assessment report
- Preparation and submission of the final PSR documentation to the regulatory body

The quality assurance team in KAERI also participated in the project to prepare a quality assurance plan that defines the requirements for the preparation and verification of the PSR documentation. The quality assurance plan ensured the PSR documents have appropriate quality and format.

2.2 Preparation of the PSR

The project management team estimated the overall budget for the PSR project in consideration of the scope and depth of the review, the human resources available in the organization, the contracts with external companies, and the schedule. The process of estimating the project budget was supported by external consultants, who have experience in PSR for nuclear power plants. Different characteristics such as operating objectives, organizations, SSCs, safety classifications, documentation, activities, and procedures between research reactors and nuclear power reactors were taken into account while planning the budget. The project manager submitted a final proposal to the senior and executive management for the required budget and obtained approval from the government in 2015.

A time schedule including the major milestones and cut-off dates was set up to implement the project by the due date. The review of safety factors is considered to be an iterative process and time should be allowed for reviewing interfaces between the various safety factors. Thus, the project management team allocated sufficient time for the review of the safety factors and the global assessment report.

The project management team developed the PSR basis document in collaboration with an engineering company for the PSR project. The basis document identifies the scope and objectives, national regulations, codes and standards, safety factors to be reviewed, a list of SSCs, the methodology of the PSR, and the major milestones.

2.3 Review of the safety factors and global assessment
The amendment of the National Nuclear Safety Act in 2014 calls for the review of fourteen safety factors for the PSR consistent with those listed in IAEA Specific Safety Guide No. SSG-25[1] as follows:

i. Safety factors relating to the plant
   (1) Plant design;
   (2) Actual condition of the structures, systems and components (SSCs) important to safety;
   (3) Equipment qualification;
   (4) Ageing.

ii. Safety factors relating to safety analysis
   (5) Deterministic safety analysis;
   (6) Probabilistic safety assessment;
   (7) Hazard analysis.

iii. Safety factors relating to performance and feedback of experience
   (8) Safety performance
   (9) Use of experience from other plants and research findings.

iv. Safety factors relating to management
   (10) Organization, the management system and safety culture;
   (11) Procedures;
   (12) Human factors;
   (13) Emergency planning.

v. Safety factors relating to the environment
   (14) Radiological impact on the environment.

KAERI made contracts with two domestic engineering companies, KEPCO E&C and FNC Technology, to perform a review of the safety factors. They reviewed 12 out of 14 safety factors (emergency planning and radiological impact on the environment, were reviewed internally by the Nuclear Emergency and Environmental Protection Division in KAERI). Although the companies had abundant experience in conducting PSR for nuclear power plants, they needed to understand the different characteristics of structures, systems, and components of research reactors as compared to NPPs. They also considered that HANARO is an open pool-type 30MW research reactor for neutron applications and has only safety class III SSCs, for the graded approach. An objective for the review, a scope and tasks, and methodology recommended in SSG-25 were referred to in performing the review of each safety factor. An analysis of the interfaces between the various safety factors was carried out after finishing the review of separate safety factors. The global assessment was performed taking into account all the positive and negative findings from each safety factor review and what safety improvements are reasonable and practicable.

The project management team reviewed the safety factor review and global assessment report, delivered the review results back to the companies and the internal experts, and verified that feedback had been correctly reflected in the report in an iterative manner. The PSR report was also subject to an independent internal peer review through the Research Reactor Development Division in KAERI, which is in charge of developing and constructing a new research reactor in Korea. This review was incorporated into the final PSR report.

3. Results of PSR

The PSR of HANARO determined that the facility is as safe as originally intended and conforms to current national and international safety standards and practices. The review found no safety issues that can pose an immediate and significant risk to the health and safety of workers or the public or to the environment. But it identified a number of areas where improvements are necessary for achieving further safety of HANARO to ensure continued safe operation for at least the period until the next PSR. The recommendations for safety improvement listed in the final PSR report are as follows:
- Actual condition of the SSCs important to safety
  - Establishment of a maintenance management procedure for electric cables and connections, cable trays, and conduit tubes.
- Equipment qualification
  - Update of Environmental Qualification Master List (EQML).
  - Establishment of the managing procedure for Environmental Qualification.
  - Preparation of Environmental Qualification Evaluation Report (EQER).
  - Assessment of temperature and radiation conditions of the equipment rooms in the reactor hall for Environmental Qualification.
  - Corrective actions for incomplete anchoring parts of equipment for Seismic Qualification.
- Probabilistic safety assessment
  - Implementation of Probabilistic Safety Assessment (PSA).
- Hazard analysis
  - Implementation of Probabilistic Seismic Hazard Analysis (PSHA) for the area where HANARO is located.
- Safety performance
  - Improvement of the gaseous effluent sampling and monitoring system of the reactor building stack in accordance with ANSI N13.1-1999.
- Human factors
  - Improvement of the control panel interfaces of the main control room applying the principles of Human-Machine Interface.
  - Establishment of the design principles and guidelines of Human Factor Engineering (HFE) for human factor management.
- Emergency planning
  - Establishment of a managing procedure for the emergency plan distribution to the off-site organizations.

The final PSR report of HANARO was submitted to the Nuclear Safety and Security Commission (NSSC) of the Korean government by the end of 2018. Korea Institute of Nuclear Safety (KINS), as a technical support organization of NSSC, is now performing a preliminary review of the report and preparing questions and comments for requesting a supplement to the PSR report. There will be many issues to be discussed between KAERI and KINS during the review and approval process of the submitted PSR report. KAERI is planning to prepare a PSR supplement to address such issues and an integrated implementation plan for the recommendations.

4. Conclusions

The periodic safety review of HANARO has been performed consistent with Korean regulatory requirements and IAEA Specific Safety Guide No. SSG-25. It showed that the current facility design, actual conditions, operation, processes, and management system ensure the overall safety of HANARO conforming to national and international standards and good practices. The review found no safety issues that can pose an immediate and significant risk to the health and safety of workers or the public or to the environment. But it identified a number of areas where improvements are needed for achieving further safety of HANARO to ensure safe operation for the period until the next PSR. KAERI submitted the final PSR report to the regulatory body by the end of 2018 and KINS is now performing a preliminary review and preparing questions and comments. A PSR supplement and an integrated implementation plan will be prepared by KAERI.

5. References