Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 23-24, 2019

Periodic Safety Review of AGN-201K by Graded Approach

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1. Introduction

It is compulsory for all nuclear reactors including research reactors to be performed the periodic safety review (PSR) every 10 years in Korea. The Korea Atomic Safety Law[1] and the Enforce Decree of the Law[2] requires that 14 safety factors identified in IAEA SSG-25[3] shall be used for the evaluation and review of PSR. However, IAEA SSG-22[4] allows the adaption of graded approach in safety requirements of research reactors. Accordingly, AGN-201K, low power educational reactor operated by KHU, has also been initiated for its first PSR. Application of a graded approach was necessary for the practical and realistic purposes. This paper presents the process applied to the AGN-201K PSR and the tentative results of the evaluation.

2. Periodic Safety Review

2.1 Maximum Hypothetical Accident Analysis

IAEA SSR-3[5] and SSG-20[6] require that postulated initiating events shall be selected appropriately for the purpose of analysis present in the design of research reactors. The set of postulated initiating events shall cover all credible accidents that may affect the safety of the research reactor. They shall include all foreseeable failures of SSCs of the reactor facilities and experiments as well as operating errors and possible failures arising from internal and external hazards for all operational and shutdown states. AGN-201K SAR[7] updated for the power uprate in 2007 includes all postulated initiating events and describes the analysis results for each accident.

The maximum hypothetical accident (MHA) in AGN-201K is the reactivity insertion accident. The MHA assumes that the excess reactivity of 2% $\Delta k/k$ is assumed to be instantly inserted conservatively during the delayed critical state, which is impossible in the realistic condition. Table 1 shows the characteristics of the reactor core design. Except for the passive characteristics of AGN-201K and natural phenomena such as gravity, any active components or operator actions are not considered to mitigate the accident. The result of the radiation dose from the MHA is less than 32 mSv at the vicinity of reactor site. This value is much less than the regulatory limitation of 250 mSv at the exclusion area boundary in case of power reactors. In conclusion, AGN-201K was approved to give no environmental effect in the radiological viewpoint.

Table 1: Characteristics of AGN-201K Reactor Core

	HANARO [8]	AGN-201K
Owner/Operator	KAERI	KHU
Purpose	Research & Isotope Prod.	Education
Thermal Power	30 MW	10 W
Fuel	U_3Si+Al Metal	UO_2 PE Disk
^{235}U enrichment	~20%	20%
Control Material	Hf	U-235
Cooling Method	Open Pool (H_2O)	N/A
Seismic Design	0.2 g	N/A
Offsite Dose Effect	Small	N/A
2 Hr Accident Dose at EAB	49 mSv (WB) 124 mSv (Thy.)	32 mSv (Rx. Area)

2.2 Categorization, Classification and Grading

The application of graded approach presented in the IAEA SSG-22 begins with categorization of the facility in accordance with its potential hazard. In this step, a facility can initially be categorized into a range from facilities posing the highest risk to those posing the lowest risk. According to the MHA analysis, AGN-201K belongs to the category of the facilities with no radiological hazard potential beyond the research reactor hall and associated beam tubes or connected experimental facility areas.

The next step (Step 2) is analysis and grading of activities and/or SSCs important to safety. This second step provides more detailed grading to be applied to the particular characteristics of the facility. The appropriateness of applying a graded approach should be determined through analysis for each of the major activities and SSCs. The application of grading should be commensurate with the importance to safety of the activities and SSCs, and with the magnitude of the associated radiological risks. All SSCs (including software for instrumentation and control) that are important to safety are required first to be identified and then to be classified according to their function and significance for safety. In AGN-201K, no activities or SSCs is required in order to prevent or mitigate the consequences of accidents. That is, AGN-201K gives no radiological risks to personnel and environment without the help of operator actions or countermeasures. As a result, all SSCs are designated as non-safety-related, which rule out the necessity of evaluation on equipment qualification, aging, PSA and hazard analysis in the PSR evaluation of AGN-201K.

2.3 Implementation of Graded Approach

Evaluated are fourteen(14) safety factors identified in the IAEA SSG-25 for PSR. The evaluation on the deterministic safety analysis was conducted for the appropriateness of postulated initiating events in the accident analysis and the effectiveness of MHA analysis result. Five(5) factor are exempted since no safety-related SSCs are required in AGN-201K, such as actual condition of SSCs, equipment qualification, aging, PSA and hazard analysis.

Emergency planning is exempted according to the Korean Law on the Prevention of Radioactive Disaster[9]. By the law, educational reactors with the thermal power less than 100W are excluded from the duty of development of emergency planning. Therefore, the evaluation on emergency planning is not necessary since the maximum power of AGN-201K is 10W.

Environmental radiological impact is also exempted by the Korea Atomic Law. The law requires the radiological environmental impact assessment and radiological environmental survey only on commercial nuclear power plants, research reactors with the power of 100W higher, spent fuel storage facilities, and radwaste storage facilities. The maximum power of AGN-201K is 10W, hence the evaluation on the environmental radiological impact is exempted.

As a result, the IAEA safety factors considered in the evaluation of AGN-201K PSR are related to the safety factors including plant design, safety performance, use of experience, organization & management system & safety culture, procedures and human factors

Table 2: Evaluation Depth for Each Safety Factor

Safety Factors	Evaluation	Basis
Actual Condition of SSCs	Exempted	No SR-SSCs (MHA Analysis)
Equipment Qualification	Exempted	No SR-SSCs (MHA Analysis)
Aging	Exempted	No SR-SSCs (MHA Analysis)
Probabilistic Safety Assessment	Exempted	No SR-SSCs (MHA Analysis)
Hazard Analysis	Exempted	No SR-SSCs (MHA Analysis)
Emergency Planning	Exempted	Prevention of Radioactive Disaster
Radiological Impact	Exempted	Korea Atomic Law

Table 2 shows the safety factors exempted and the basis of the exemption. Detailed evaluation has been carried out for the safety factors selected above. As a tentative result of the effort, two(2) safety improvement items have been drawn from the evaluation, one(1) from procedures and the other one(1) from the human factors.

3. Conclusions

The PSR on a low power educational reactor, AGN-201K has been performed. A graded approach is implemented as a tool for the practical and realistic purposes. Since the radiological risks are very low and consequently no safety-related SSCs exist in AGN-201K, several safety factors are exempted from the evaluation. Some safety factors are excluded by the laws for its low power. For other safety factors, detailed evaluation has been performed to draw countermeasures for safety enhancement.

REFERENCES

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