

Introduction

- ❖ South Korea’s Nuclear Safety Act classifies reactors into two categories : Power Reactors and Research Reactors.
→ This classification doesn’t sufficiently account for differences in risk levels based on reactor thermal power and radioactive material inventory.
- ❖ In research reactors, Hanaro (30 MWt) and AGN-201K (10 Wt) are subject to same regulatory standards, leading to regulatory inefficiencies. → “**Graded Regulation**” is considered internationally.
- ❖ Zero power research reactors have physical characteristics that more closely resemble radiation-generating devices because of their low thermal power and radiation levels. Therefore, a tailored regulatory framework that considers these characteristics is necessary.
- ❖ A previous study proposed several regulatory improvements for zero power research reactors. Among them, there was a proposal to exempt zero power research reactors from Periodic Safety Reviews (PSRs) and instead supplement the regular inspection system.
- ❖ So in this study, we conducted a comparison between the PSR requirements with the regular insepctions conducted for the AGN-201K reactor. Plus, we proposed methods to exempt the AGN-201K from PSRs while strengthening the regular inspection system to compensate.

Graded Regulation Proposals

- ❖ **Graded Regulations for Zero Power Research Reactors**
 - 1) Classify existing research reactors into two categories based on their thermal power levels: “zero power research reactors” and “medium and low power research reactors”.
Zero power research reactors will be designated as a separate graded regulatory category, reflecting their low thermal power characteristics.
 - 2) For zero power research reactors or critical assemblies with simple equipment structures, the construction permit and operating license may be integrated and operated accordingly.
 - 3) For zero power research reactors, *PSRs may be exempted and replaced with regular inspections.*

Status of Activities at AGN-201K

- ❖ **Status of PSR activities at AGN-201K**
 - In accordance with South Korea’s Nuclear Safety Act, all nuclear reactors must undergo PSRs every 10 years.
 - Following the Fukushima accident, research reactors were also required to undergo PSRs, and AGN-201K, an educational zero power reactor also underwent its first PSR in compliance with domestic regulations since 2018.
 - Table I provides details regarding the status of the first PSR. Seven items were not performed, six were partially performed, and one was fully performed.

Table I. AGN-201K 1st PSR item performance status

No	Details	Full Not Performed	Full Performed	Partially Not Performed	Reason for not performing
1	Matters concerning the design of reactor facilities			O	No SSC safety-classification scheme in place
2	Matters concerning the actual status of structures, systems and equipment crucial for safety	O			No SSC safety-classification scheme in place
3	Matters concerning deterministic safety analysis			O	Consideration of the SFC judged not applicable
4	Matters concerning probabilistic safety reviews	O			No SSCs credited with safety functions and insufficient data to support a PSA
5	Matters concerning hazard analysis	O			Bounding MHA analysis indicates no environmental hazard
6	Matters concerning equipment verification	O			No safety-function SSCs requiring EQ
7	Matters concerning aging degradation (referring to physical or chemical process that causes damage to the system, structure and equipment of a nuclear power plant by passage of time or use)	O			No SSCs within the scope of Aging Management evaluation
8	Matters concerning safety performance			O	No ESFs or SPIs; no radioactive effluents or radwaste generated
9	Matters concerning the utilization of nuclear power plant operating experience and research findings		O		
10	Matters concerning operation and maintenance procedures, etc.			O	EOPs not established
11	Matters concerning the organization, management structure and safety culture			O	Accident likelihood attributable to safety-culture deficiencies considered negligible
12	Matters concerning human factors (including matters concerning the situation of members, etc. necessary for the operation of a nuclear reactor)			O	Very low task/workload; HFE evaluation not warranted
13	Matters concerning radiation emergency plans formulated under Article 20 of the Act on Measures for the Protection of Nuclear Facilities and Prevention of Radiation Disasters	O			Outside the scope of REPP requirements
14	Matters concerning radiological environmental impacts	O			Not subject to REIA requirements

- ❖ **Regular Inspections at AGN-201K**
 - Regular inspections for AGN-201K have been conducted every two years. They are conducted by the Korea Institute of Nuclear Safety (KINS) and consist of performance inspections (5 items) and operational inspections (4 items).
 - In terms of performance, inspections are performed on the reactor core, fire prevention facilities, and radiation management facilities.
 - In terms of operation, inspections are conducted on the operating organization, qualifications and training, operational experience, and human factors management.

Detailed Comparison for AGN-201K: PSR Requirements VS Regular Insepctions

❖ Comparison of PSR and Regular Insepctions at AGN-201K

No 1. Design of reactor facilities

- PSR : re-evaluates design documentation against current codes and standards
- Regular inspection : verifies only the continued functional performance of SSCs.

No 3. Deterministic Safety Analysis

- PSR : reselects applicable DBAs according to the latest criteria and re-runs the reactor’s accident analysis.
(AGN-201K also evaluated only a reactivity insertion accident as a DBA).
- Regular inspection : conducts performance tests and checks without reanalyzing the entire reactor.

No 9. Operating experience and research findings

- PSR includes internal recognition of the system’s appropriateness and validity, as well as statistical analysis.
- Regular inspection: primarily confirm compliance with procedures, review actual records, and verify the implementation of measures
mainly focus on document review and on-site verification, with no explicit mention of conducting survey activities.

No 10. Operation and Maintenance Procedures

- Although the establishment or revision of procedures is prompted by regular inspections, explicit evaluations of the procedural system are not conducted. Furthermore, regular inspections do not assess the clarity of these procedures.

No 11. Organization, Management structure and Safety Culture

- Although quality assessments are conducted during regular inspections, the regular quality assurance audits involving independent assessors and detailed evaluations of the quality assurance plan itself performed by PSR are not specified in the regular inspections. Furthermore, regular inspections do not include specific items related to safety culture.

No 12. Human Factors

- Regular inspections verify the maintenance and management of human-system interface equipment but do not employ detailed validity assessment techniques such as PSR, which involves the actual execution of procedures. Additionally, specific workload assessment methodologies are not applied.

Proposal for improving Regular Inspections

❖ Suggest comprising inspecions conducted on *two* and *ten* year cycles

- To apply graded regulatory approach that considers the low risk and unique characteristics of zero power research reactors, we propose a new regular inspection system that exempt PSRs and replace them.
- This system comprises inspections conducted on two and ten year cycles.
 - At 2-year cycle inspection is conducted the same as before.
 - At 10-year cycle, the parts performed only by PSR are supplemented so that it can be a comprehensive regular inspections.
- For 10-year cycle,
 - 1) evaluate design documentation against current codes and standards,
 - 2) re-select the applicable design-basis accidents in accordance with the latest criteria and re-perform the reactor’s accident analysis,
 - 3) conduct a survey on the employee’s perception of the appropriateness and validity of the operating experience and research results application
 - 4) conduct preliminary reviews of the procedure manual’s structure and clarity,
 - 5) evaluate effectiveness through control panel about MMI devices.

Furthermore, we suggest to exempt quality assurance audits and evaluations of the quality assurance itself. Because AGN-201K does not have safety-related structures, systems and components.

Conclusion

- ❖ The need for graded regulation, considering the low-risk characteristics about zero power research reactors,has been emphasized due to regulatory inefficiencies.
- ❖ We conducted a detailed comparison and analysis of PSR and Regular inspection details for AGN-201K, confirming that regular inspections do not adequately address certain safety assessment components..
- ❖ As a complementary measure, we propose a new regular inspection system that includes a 2-year inspection conducted in the same way as before, along with a comprehensive evaluation conducted every 10 years.
- ❖ In the future, we plan to systematize more elaborately to supplement regular inspections.