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Development of Regulatory Technology for Commercial SMART

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1. Introduction

In Korea, a small-to-medium sized integral type of reactor, called as "System-integrated Modular Advanced ReacTor (SMART)," has been developed for both strengthening of international competitiveness of nuclear reactor technology and its export to the developing countries since the early 1990s. The reactor can be utilized in such areas as seawater desalination, ship propulsion, and district heating. The main feature of the SMART is an integral type of reactor in which the major components of the primary coolant system such as pressurizer, reactor coolant pump, and steam generator are installed within a reactor pressure vessel.

In order to demonstrate the safety and performance of the integral type of reactor, a project to construct a research reactor with the thermal capacity of 65MWt, called as "SMART-P," was carried out from 2002 to 2006 [1].

A pre-project service for the development of a commercial SMART has been launched out in 2006. And its conceptual design is being carried out now. The Korea Institute of Nuclear Safety (KINS), a nuclear regulatory expert organization, is also developing regulatory technologies for the preparation of licensing application of the commercial SMART.

In this paper, KINS' activities for the development of regulatory technologies for the commercial SMART were introduced. The development activities include identification of expected licensing issues, verification test items, development items of regulatory requirements/guides, and confirmatory evaluation technologies.

2. Expected Licensing Issues

In order to prevent unnecessary expenditure of resources due to repetitive design, and to reduce the time of safety review for the licensing application, it is desirable to identify and to resolve licensing issues as early as possible. For the commercial SMART, expected licensing issues are being reviewed and several issues have been identified. The expected licensing issues are classified into 3 categories: policy issues, technical issues, and requirement issues.

2.1 Policy Issues

The policy issues are the issues that require a political decision for their resolution. For the commercial SMART, 3 policy issues were identified: reduction of emergency planning zone (EPZ), severe accident design, and application scope of risk-informed regulation.

Due to the adoption of integral reactor concept, passive residual heat removal system (PRHRS), low power density of reactor core, and etc, it is expected that the possibility of the releases of radioactive materials will be reduced and that the capability to delay the releasing time of radioactive materials after accidents will be increased. Such safety enhancement may provide the possibility to reduce the size of the EPZ. Thus, it is necessary to review the possibility of reduction of the EPZ for the commercial SMART.

In Korea, the adoption of risk-informed regulation is being pursued to complement the vulnerability of and to relieve unnecessary regulatory burdens of the existing deterministic regulation. For the implementation of the risk-informed regulation, the KINS is establishing an implementation plan and pursuing it step by step. Thus, it is necessary to determine the scope of application of the risk-informed regulation to the commercial SMART considering its licensing schedule.

2.2 Technical Issues

Technical issues are the issues that need a detailed technical analysis to confirm the safety. Up to now, the following issues have been identified as technical issues through the review of the conceptual design of the commercial SMART: verification of prevention of multiple breaks of pipes penetrating the reactor vessel head, verification of prevention of ejection of reactor coolant pump impeller at the break of reactor coolant pump nozzle, use of physically based source terms in safety analysis and site selection related analysis.

2.3 Requirement Issues

Requirement issues are the issues resulting from that the design of the commercial SMART can't fulfill the existing regulatory requirements/guides. The expected requirement issues are: in-service inspection for steam generator tubes and nozzles of control rod drive mechanism, extension of the periodic inspection interval due to the extension of the fuel cycle, and performance criteria of the PRHRS. The requirement issues that need revising the existing requirements/guides to resolve the issues were addressed in the section 3 of this paper. Since the conceptual design of the commercial SMART is being carried out, additional requirement issues will be identified through the review of the applicability of the existing regulatory requirements/guides to the commercial SMART.

3. Development Items of Regulatory Requirements

The existing regulatory requirements/guides for the pressurized water reactor (PWR) can be applied to the commercial SMART since it is also a PWR [2]. However, the applicability of the existing regulatory requirements/ guides should be reviewed for new facilities like PRHRS. The Review results show that the PRHRS can't satisfy the performance criteria of the active residual heat removal system. Thus, the performance criteria should be complemented considering the characteristics of the PRHRS. Since the conceptual design of the commercial SMART is being carried out, additional development items will be identified through the review of the applicability of the existing regulatory requirements/guides.

4. Verification Tests

Since the commercial SMART adopts the integral reactor concept and new facilities (PRHRS, once-through type steam generator with spiral tubes, canned motor pump, and etc.), the safety and performance of the integral reactor design and the new facilities should be verified through tests by the designer. These verification tests are: separate effects tests for the verification of the safety and performance of individual components/parts, and integral tests for the verification of the safety of the interaction between the systems and for the demonstration of integrated performance of systems.

For the identification of verification tests, the following documents have been reviewed: safety evaluation report for the SMART-P by the KINS [3] and IRIS test plan by the Westinghouse [4].

The review results show that the separate effects tests should include: thermal-hydraulic characteristics of fuel assembly, departure from nucleate boiling (DNB) phenomena in reactor core, heat transfer characteristics of heat exchanger of the PRHRS, characteristics of heat transfer/pressure loss/ vibration of spiral tubes of once-through steam generator, performance/qualification of prototype components, and corrosion characteristics of newly adopted materials.

The integral tests should include: thermal-hydraulic performance during normal operations (startup, heatup, and cooldown), performance of reactor shutdown and passive residual heat removal, and safety related transients tests.

In the design of the SMART-P, several new computational design codes have been used in the areas including safety analysis, containment performance analysis, and structural integrity analysis, which have no experience of licensing [3]. Thus, it is necessary to verify the validity of analysis model, limitation, accuracy, and applicable range of the new design codes through verification tests.

5. Confirmatory Evaluation Technology

Through the project "SMART-P Regulatory Technology Development," audit calculation codes for confirmatory evaluation have been developed in the areas of nuclear design analysis, safety analysis, and structural integrity analysis. Comparing the design of the commercial SMART with that of the SMART-P, there are differences in: thermal power capacity, core lattice configuration, installation location of reactor coolant pumps, pressurizer design, and reactor pressure vessel design. Thus, reflecting the design changes, the audit calculation codes developed for the SMART-P should be improved for their application to the commercial SMART. The improvement items will be identified through the review of the design of the commercial SMART when the conceptual design is available.

6. Concluding Remarks

A pre-project service for the development of a commercial SMART has been launched out in 2006. And the KINS is developing regulatory technologies for the preparation of the licensing application of the commercial SMART. The KINS' current activities for the development of regulatory technology include identification of expected licensing issues, verification tests, development items of regulatory requirements/ guides, and improvement items in confirmatory evaluation technologies. The early development of regulatory technologies for the commercial SMART will contribute to determining the licensability in advance, preventing unnecessary expenditure of resources due to repetitive design, and reducing the time for the licensing safety review.

REFERENCES

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