Regulatory Approach for Establishing a Pre-Design Review Program for Standard Design Certification in Korea

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1. Introduction

Nuclear power has recently entered the spotlight worldwide as a viable means of achieving carbon neutrality, especially in the form of Small Module Reactors (SMRs), primarily because of their safety and economic feasibility. In 2020 the US NRC reviewed and in 2022 approved NuScale's Design Certification (DC). South Korea is also in the process of developing an innovative SMR (iSMR), with a licensing goal of 2028.

To identify licensing issues for various types of SMRs and other advanced reactors currently under development, it is necessary to establish a Pre-Design Review as a formal program.

In addition, the Korea Institute of Safety (KINS) has several experiences of preliminary safety reviews of the design of five new nuclear reactors: SMART-P (2006), SMART (2012), APR1400, APR+, and SMART100. However, these reviews were technical reviews similar to a licensing review, and did not make it easy to solve safety issues and licensing issues at an earlier stage, because they provided no systematic process for communication, scope or document submission for preliminary safety review.

This study compared and analyzed the advantages and disadvantages of the NRC's Pre-Application Review (PAR), the CNSC's Vendor Design Review (VDR) and the ONR's Generic Design Assessment (GDA). Also included will be an introduction of a domestic regulatory pre-design review program incorporating the benefits of the NRC and CNSC procedures under or around the domestic regulatory environment. The developed program will make it possible to check key licensing issues before the official licensing of new nuclear reactors in the future, so that applicants can reduce the risk of licensing. Also, the program can help regulators become more familiar with the design of the target nuclear power plant and preemptively prepare for licensing review issues.

2. NRC's Pre-Application Review [1]

The NRC encourages interactions between the staff and those entities before they submit an application under 10 CFR Part 52 (Standard Design Approval (SDA), DC, Construction Permit (CP), etc). These interactions, including all communications, correspondence, meetings, and document submittals/reviews, are collectively called Pre-application activities (PAA). The PAA is mutually beneficial to both the NRC staff and prospective applicants. In particular, the NRC foresees that such interaction early in the design process will contribute to stability and predictability in the licensing and regulation of new reactors. In addition, pending issues in terms of policy, technology, or licensing can be identified during the PAA, so it serves as an effective screening phase when preparing solutions to pending issues. The NRC encourages and recommends the PAA, but these are voluntary activities and are not required for prospective applicants.

The regulatory basis of PAA or PAR is as follows:

1) the Advanced Reactor Policy Statement (2008) [2]: the NRC encourages early interactions with advanced reactor developers and prospective applicants;
2) Section 103 of the Nuclear Energy Innovation and Modernization Act (NEIMA): the NEIMA required the NRC to develop staged licensing approaches that include early engagement; and
3) 10 CFR part2 (AGENCY RULES OF PRACTICE AND PROCEDURE): 10 CFR § 2.811 Pre-application consultation; and 10 CFR § 2.1010 Pre-License Application Presiding Officer.

The pre-application activities (review) include the following [3]:

1) the applicants' familiarity with the NRC's regulatory requirements and processes;
2) application-related plan and schedule information of interest to the NRC;
3) regulatory engagement plans (REPs) that represent communication protocols in the licensing interaction between the applicant and the regulator [4];
4) NRC staff's enhanced safety-focused review approach (ESFRA);
5) pre-application meetings (public and nonpublic meetings);
6) application-related documents (Topical Reports (TRs), Technical reports, white papers, etc) that may be submitted for the NRC staff's review;
7) application-related safety and environmental regulatory issues;
8) information requested by the NRC in regulatory issue summaries; and
9) the NRC staff's pre-application readiness assessment.

The NRC recently conducted a PAR from 2008 to 2016, before applying for NuScale's design certification (2016.12). Through the PAR process, a Design-Specific Review Standard (DSRS) was developed for items that were difficult to be reviewed when applying the existing

NRC Standard Review Plan (SRP), and this was applied to the official license process (DC).

3. CNSC's Vendor Design Review (VDR)

The CNSC operates a vendor design review (VDR) procedure similar to that of the United States (US) PAR, and has recently conducted VDRs on SMRs of various design concepts, including NuScale. The VDR is an optional process and does not lead to formal regulatory decisions. It is a process which allows CNSC to participate in the design process early, prior to Vendor's formal licensing application, to become mutually familiarized with regulatory procedures and design issues. It is a pre-licensing concept that is implemented under a separate agreement between developers and regulators, and reviews compliance with regulatory requirements and standards for SMR designs from a very high-level perspective.

The VDR procedure consists of three phases, which are described in RECDOC-3.5.4 [5] and are as follows.

- Phase 1 (Intent to comply with existing regulatory requirements (12-18 months)): the staffs assess the information submitted and determine if the vendor designs demonstrate implementation of CNSC design requirements (REGDOC-2.5.2, RD-367), and related regulatory requirements.
- Phase 2 (Identifying potential issues in future licensing (24 months)): This phase goes into further detail, with a focus on identifying whether any potential fundamental barriers to licensing exist or are emerging with respect to the reactor's design.
- Phase 3 (Pre-construction follow-up on one or more focus areas covered in the phase 1 and 2 assessment results)
- Appendix A: 19 key areas of review (Description of purpose and scope of review for each area)

Ultimately, like USNRC's PAR, it is understood to be a system that can increase the efficiency, effectiveness, and stability of licensing for new reactors expected in the future.

4. ONR's Generic Design Assessment (GDA)

The GDA is an upfront, step-wise assessment of a generic reactor design undertaken jointly by the Regulators (ONR / Environment Agency / NRW). It is not a mandatory process but because of its inherent benefits, it is expected that it will usually be requested for new Nuclear Power Plants.

The ONR's GDA consists of three phases (1 year of initiation in phase 1, 1 year of fundamental assessment in phase 2, and 2 years of a detailed assessment in phase 3), and a Design Acceptance Confirmation (DAC) is issued after completion of the phase 3 evaluation, as shown in Fig.1.

Phase 1 includes suggestions from operators on how to agree on the scope and schedule of the GDA, enhances ONR's understanding of the design, identifies gaps and subsequently resolves them compared to regulatory requirements. This is similar to the content of the REP and gap analysis report in the US.

Phase 2 identifies a fundamental assessment of common safety and security cases (the first practical technical assessment stage); and a potential 'show stopper' that may interfere with the conformity assessment and design of methodologies, approaches, code standards, and philosophy. This is similar to the PAR process.

Phase 3 is similar to the domestic SDA process. In other words, it confirms that the pre-design review and SDA are composed of systematic steps.

Currently, the Rolls Royce's SMR design is working on GDA Phase 1.

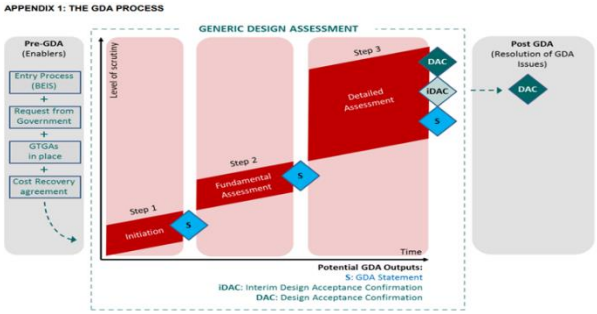

Fig. 1. GDA process of the ONR

5. Comparisons between PAR, VDR and GDA

This section summarizes the common ground, advantages, disadvantages, and features of PAR, VDR, and GDA, listed in Table 1.

Table 1. Comparisons between PAR, VDR and GDA

	PAR	VDR	GDA
Common Ground	- Procedures before the official licensing process - applicants' familiarity with the regulatory requirements and processes; and the regulators' design understanding - Efforts to identify and resolve potential issues early		
Advantages	-High completeness of the review results	- The review period is relatively short, -The scope of the review is clear, and -Effective use of regulatory resources	- Reduce the burden of a standstill or unexpected SMR construction project disruptions by reviewing various perspectives (such as Financial)
Disadvantages	The review period is relatively long, -Regulatory resource consumption is high	- Relatively low completeness of the review results	
Features	Legal basis (policy statement, NEIMA, 10 CFR part2)	-Phase 3 approach, -Implemented by a separate agreement between the developer and the regulatory agencies -Optional Process	- Achieving a DAC after reviewing -Step-by-Step systematic Connections (Phase 3: similar to SDA)

6. Regulatory Approach for Pre-design Review Process for iSMR

The i-SMR, which is currently in the conceptual design stage, is expected to have licensing and safety issues because innovative technologies unlike those of existing nuclear power plants are being applied. Therefore, as in the case of leading countries such as the US and Canada, it is necessary to review whether the design concept meets 'applicable' regulatory requirements or regulatory positions and to identify and prepare the technical information necessary for safety assessment and verification of both design and regulations.

The approach for setting up the iSMR Pre-Design Review process is as shown in Fig.2.

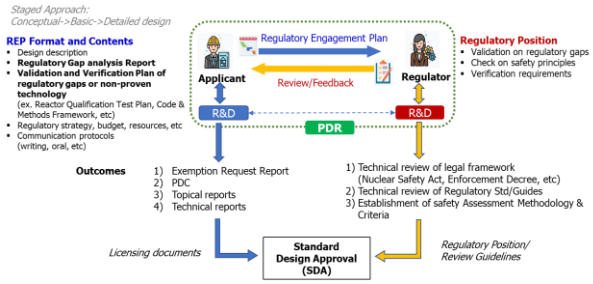

Fig.2. Concepts of Pre-Design Review Process

Through this pre-design review program, the reviewer can identify safety issues early by enhancing understanding of the design concept. In addition, technical information necessary for developing regulatory technologies can be obtained in advance, and guidelines for screening, evaluation and verification technologies (code, methodology, etc.) can be developed through regulatory R&D to prepare for screening and establish regulatory directions. Developers have the advantage of identifying, improving, and supplementing necessary parts for verification, and verifying the safety of design or technology development results, which can ensure the stability of the project.

Acknowledgments

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