

Key Factors of Regulation Process for NuScale Standard Design Approval

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1. Introduction

Small modular reactors (SMRs) are considered as one of the most important carbon free energy sources. Moreover, since Nuclear Regulatory Commission (NRC) approved NuScale design in 2020, SMRs have been getting attention due to their possibility.

NuScale design has different characteristics from the existing large nuclear power plants (NPPs); fully passive safety system, enforced defense-in-depth (DID) and natural circulation of reactor coolant system during normal operation. With these innovative characteristics, NuScale design achieves lower risk than large NPPs and similar economics with large NPPs [1].

NuScale produced technical and regulatory basis for approval of the innovative designs required to be departed from some regulatory requirements. NuScale found gaps between their designs and requirements during pre-application review with NRC [2]. After pre-application review, NuScale succeeded to submit a report requesting exemptions from some regulatory requirements and all requested exemptions were approved [3,4].

Recently, South Korea is planning to design innovative Small Modular Reactor (i-SMR) which has new designs from the existing large NPPs. For good regulation of i-SMR, it is required to find lessons learned from the regulation process of the NuScale design.

2. Regulatory basis for innovative designs

The most important requirements in nuclear reactor design process are 10CFR50 App. A, General Design Criteria (GDC). GDC are based on Structures, Systems and Components (SSCs) which have been used in large Pressurized Water Reactors (PWRs).

NuScale requested 17 exemption items departed from regulatory requirements [3]. NuScale NPP with fully passive safety systems shows highly safe features without some SSCs used in the large PWRs. NuScale's requests were approved due to their proper regulatory basis and technical basis about the exemptions.

10CFR50.12 (Specific Exemptions) is applied for innovative designs of NuScale. NRC allows exemptions or alternative approaches when two conditions in 10CFR50.12 are satisfied. The first one is that requested exemptions should not present an undue risk to the public health and safety, and be consistent with the common defense and security. The second one is that the requested exemptions present some special circumstances (6 types of special circumstances, single circumstance is enough to satisfy.). NuScale mostly

used circumstance (ii): Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule.

For complying the conditions of 10CFR50.12, NuScale conducted safety analysis and qualification experiments and submitted Topical Reports (TRs) with results of their works. Only passive decay heat removal system and emergency core cooling system are applied in the NuScale design and able to cope with all Design Basis Events (DBEs). 49 types of experiments were conducted to show safety of the NuScale design and Deterministic Safety Assessment (DSA) was conducted to show capability of the safety systems. Moreover, Probabilistic Risk Assessment (PRA) was also conducted, so complying the first condition of 10CFR50.12 was approved. For satisfying the second condition of 10CFR50.12, circumstance (ii) that the underlying purposes are achieved even the exemptions are approved. The underlying purposes of the regulatory requirements are based on safety principle and fundamental safety functions of the regulatory body. NuScale suggested the underlying purposes of the requirements, and NRC positively responded to their suggestions in the pre-application review period.

3. Pre-application review

NRC has a policy of encouraging early discussions (prior to submission of a license application) with potential applicants to offer licensing guidance and to identify and resolve potential licensing issues early in the licensing process.

NuScale requested pre-application review (2008) and produced gap analysis summary report (2012 and 2014). NuScale found 19 gaps between their design and regulatory requirements in the pre-application review [2]. NRC positively reviewed the report and priorly admitted that some gaps are not necessary to require exemptions [5]. NuScale and NRC tried to find optimized solutions for the gaps by agreement in the pre-application review, and NuScale finally submitted the exemption report [3] (2016 and 2020) about 17 exemption items at the time of the application documents and all exemption requests were approved (2020) [4]. Brief history of NuScale regulation process is shown in Fig. 1.

In the regulation of NuScale design, the pre-application review was a key factor that find potential issues and solution early in the licensing process. However, it was not easy way because the pre-application review was not well organized, so NuScale and NRC spent time and money a lot. In 2021, NRC

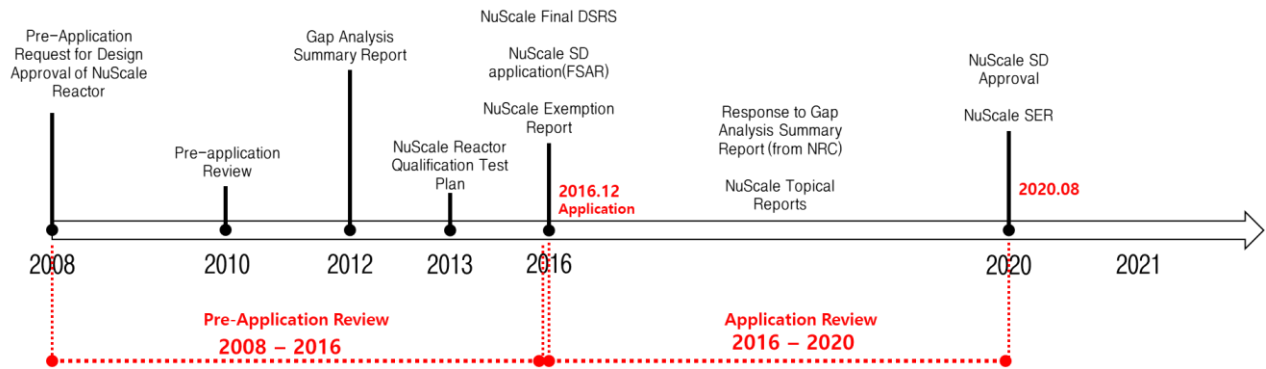


Fig. 1. NuScale design regulation process history

announced draft of detailed pre-application review process [6].

4. Discussion

For successful regulation of i-SMR in South Korea, reviewing NuScale regulation process is essential to find potential issues in the regulation process of i-SMR. The key factors are flexible regulation process and pre-application review.

First, regulation process for suggesting exemptions or alternative requirements when the designs satisfy the underlying purpose of the requirements is needed. The existing regulation requirements are well suited to large NPPs, but not to SMRs. Historically, NPPs have been developed to become large and add safety systems so that they can be both economical and safe, and these tendencies have been applied to regulation requirements. On the contrary, NuScale design achieved both economy and safety by small, simple, and innovative designs, therefore exemptions were approved due to its high safety features. The i-SMR also objects to be simple and safe design, the regulation process in South Korea should be flexible. It is not that the flexible regulation means relaxed regulation. In NuScale design, NRC approved the exemptions or alternatives due to lower risk than large NPPs and satisfying underlying purpose.

Second, pre-application review is required for organized and efficient licensing process. Identifying and resolving potential issue early in the licensing process help to shorten the total licensing period and reduce burden of regulatory body. In NuScale regulation case, almost gaps and solutions for the gaps were discussed and found during the pre-application review even the pre-application review was not well organized. In some issues, there were no consensus between NuScale and NRC, and NuScale finally followed NRC's positions [7]. Therefore, the pre-application review is required to be detailed, and conflicts in the pre-application review period is able to be properly managed by such as advisory groups.

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