Considerations for Applying Design Extension Conditions to Domestic Nuclear Power Plants

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1. Introduction

The IAEA defined the design extension conditions in its new safety standards Series No. SSR-2/1 for the purpose of applying it to the design of nuclear power plants (Table 1). The concept is designed to include more serious accidents than the existing design basis accidents considering additional failures. Design extension conditions can be derived based on engineering judgments, deterministic analysis or probabilistic analysis of the nuclear power plants. They are used to secure practical response capabilities to prevent or mitigate accidents. They may also require the deployment of additional safety equipment for existing nuclear power plants currently in operation.

Though the general requirements of design extension conditions are described under the IAEA standards, no specific guidelines have been presented as required for their actual application to the nuclear power plant design. Furthermore, there is great variation between countries in implementing the requirements of design extension conditions. Therefore, for the actual application, considerable effort should be made among relevant organizations to establish detailed requirements of the design extension conditions. Such activities could constitute a part of the efforts of the nuclear community to meet the general public's expectations concerning the safety of nuclear power plants.

Table 1. Plant states [1]

Operational states		Accident conditions	
Normal operation	Anticipated operational occurrences	Design basis accident	Design extension conditions

2. Necessity for applying design extension conditions

The introduction of design extension conditions can be viewed as a part of the comprehensive efforts to upgrade the safety of nuclear power plants after the severe accidents of nuclear power plants at Three Mile Island, Chernobyl and Fukushima. There is a common understanding, based on the experience of such accidents, that the existing design basis alone cannot ensure the safety of nuclear power plants. As severe accidents are confirmed in reality, the safety analysis limited to traditional design basis accidents needs to be improved. It is both required and feasible to introduce design extension conditions considering the following reasons: 1) safety should be enhanced to eliminate public concern about nuclear power plant safety; 2) international standards should be obeyed under the global safety regime of nuclear power plants; 3) Korea, as an exporter of nuclear power plants, need to follow the IAEA provisions which have been adopted by the newcomers such as Middle Eastern and Southeast Asian countries; and 4) FSAR contents of the Reg. Guide 1.206 already has been applied in connection with the APR1400 NRC design certification.

Currently, as international trends concerning the design extension conditions are being prevailed and intensified, a proactive approach is required to establish a comprehensive safety analysis framework covering extended areas concerning nuclear power plant safety. Discussion on the design extension conditions should be expedited.

3. Considerations for applying design extension conditions

3.1 Nuclear power plants to apply design extension conditions

The design extension conditions could be applied in a different manner according to the phase of nuclear power plants, i.e. operating one or new construction. For operating nuclear power plants, as a primary option, periodic safety assessment could be used for implementing the requirement of the design extension conditions. In this case, there may be disagreement concerning whether the analysis of design extension conditions should be included in the safety analysis report or not. As a second option, safety analysis process for reloaded core could be utilized. But this is not desirable as safety analysis for reload does not encompass the overall safety of a power plant. Also, it is not applicable to the CANDU plants.

For new construction, the design extension conditions should be considered from the design phase. It is no longer easy for the Korean industry, as an exporter of new nuclear power plants, to import necessary safety analysis technology from overseas. Under this circumstance, the decision to apply design extension

conditions will provide a good opportunity for the self-reliance and enhancement of safety analysis technology.

3.2 Determination of analysis methodology

Contrary to design basis accidents whose definition is well established, the design extension conditions will likely be defined in detail through consultations with the regulator and licensees. It is expected that design extension conditions will likely expand continuously in the future as well. Therefore, a flexible and progressive approach is required in the position of regulators as well as licensees. The technical position on design extension conditions should be established in the following: 1) definition of design extension conditions; 2) analysis scope of design extension conditions; 3) acceptance criteria for design extension conditions; and 4) analysis method of design extension conditions.

The best estimate approach would be allowed for design extension conditions. Active uncertainty assessment is not required and conservative assumptions such as the single failure criteria are not mandatory. Although there may be some cases where compulsory requirements are imposed, generally, the best estimate conditions are analyzed without performing the uncertainty assessment. Instead, sufficient safety margin should be demonstrated in the analysis. The best estimate approach in analyzing design extension conditions is in accordance with the prevailing international trend. This will satisfy the intention of design extension conditions that pursue practical safety.

The regulatory agency should lead the application by assessing the impact of applying design extension conditions and discussing any technical problems with the stakeholder, based on the plans developed for implementing design extension conditions.

3.3 Document format

The IAEA Safety Standards Series No. GS-G-4.1 takes the direction that all of the safety analysis should be described in one chapter. On the other hand, USNRC Reg. Guide 1.206 requires that safety analysis based on design basis accidents be described in Chapter 15 of the safety analysis report, while the details concerning probabilistic safety assessment and severe accident analysis should be described in Chapter 19.

If the IAEA's direction is followed, some confusion may arise with the existing Chapter 15. Both regulators and licensees are familiar with the existing Chapter 15 mainly dealing with design basis accidents. It is difficult to set clearly acceptance criteria for the probabilistic safety assessment or severe accidents while the existing chapter 15 lists acceptance criteria for design basis accidents. In that respect, it would be convenient in terms of procedures to handle the probabilistic safety assessment and severe accident analysis in Chapter 19 separately from Chapter 15, as in the case of Reg. Guide 1.206. It not only accommodates the existing analysis of design basis accidents intact but also additionally requires probabilistic safety assessment and severe accident analysis.

3.4 Enhancement of domestic infrastructure

Once the design extension conditions are finalized and ready to be implemented, not only will the scope of safety analysis expand but also the contents of safety analysis report will increase qualitatively and quantitatively. As such, it is necessary to check whether the technical resource and competence to respond to such qualitative and quantitative increases.

Reg. Guide 1.206 has been reviewed and applied for USNRC design certification of APR 1400, but it is irrelevant to the domestic licensing scheme. It is not desirable to have domestic regulation that is separate and distinct from the international practice. In addition, international trends need to be actively accommodated to support the globalization of the Korean model nuclear power plants.

The related organizations should prepare in advance for the application of design extension conditions. This advance preparation requires sufficient time. Thus, it is desirable to have a grace period so as to enable the licensees to reflect design extension conditions. The date of application should be notified in advance from the regulatory side. It is necessary to induce licensees to implement design extension conditions smoothly through discussions with the regulatory agency during the grace period.

4. Conclusions

The introduction of design extension conditions is expected to be a means of systematically enhancing the safety of nuclear power plants. Yet, there exists great differences in terms of the scope of analysis and the acceptance criteria, as no uniform practices have yet been established in applying the specific requirements for design extension conditions. A careful review is required in terms of the technical basis for setting the requirements, including those pertaining to the scope of analysis and the acceptance criteria. The introduction of these new requirements to Korean nuclear power plants may cause unexpected problems. Therefore, it is desirable for the regulatory agency to systematically assess the impact of design extension conditions and to discuss the arising issues with the stakeholder, based on the plans developed for the implementation of design extension conditions.

REFERENCES

[1] IAEA Safety Standards Series No. SSR-2/1, Safety of Nuclear Power Plants: Design, Specific Safety Requirements, International Atomic Energy Agency, 2012