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An Enlargement of the Concept of "Safe Shutdown" in Korean Nuclear Energy Legislation

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1. Introduction

This year is the proudest moment of the Korean nuclear energy legislation to be 60th anniversary since it has been established in Republic of Korea. It is time to examine critically the current legislative system and to explore ways toward more advanced and innovative technologies. Reliance upon old proven technologies is easy and comport to the regulatory body, however highly elevated public demands for nuclear safety cry out for a change in the Korean nuclear energy legislation.

The concept of passive safety systems is one of the representative examples. Korean regulatory standards and guidelines for light water reactors (LWRs) [1, 2] focus mainly on active safety systems, but provisions relevant to passive safety systems are barely found. Therefore an enlargement of the regulation upon safety systems including not only active but also passive ones is very urgent and beneficial to advanced nuclear reactor designers. Especially the concept of "safe shutdown" needs to be expanded in reflection of inherent features of the passive safety systems.

In this presentation, the current regulatory position upon safe shutdown will be reviewed and some suggestions will be proposed to implant a passive safety concept in the Korean nuclear energy legislation. This paper will help readers to understand the unique features of passive safety systems and to acknowledge the differences between the conventional active safety systems and the passive ones. This presentation will also accelerate a review process of the standard design approval for SMART (System-integrated Modular Advanced ReacTor), which will be applied before the end of November this year by the Korea Hydro and Nuclear Power Co., Ltd. (KHNP) and Korea Atomic Energy Research Institute (KAERI).

2. Definition of Safe Shutdown

There is no direct statement with regard to safe shutdown in Korean nuclear energy legislation. It can be found in Korean industrial standards, KEPIC NDA[3], whose reference standard is ANSI/ANS-51.1[4].

2.1 KEPIC NDA or ANSI/ANS-51.1

Safe shutdown means a shutdown with (1) the reactivity of the reactor kept to a margin below criticality consistent with technical specifications, (2) the core decay heat being removed at a controlled rate sufficient to prevent core or reactor coolant system thermal design limits from being exceeded, (3) components and systems necessary to maintain these conditions operating within their design limits, and (4) components and systems necessary to keep doses within prescribed limits operating properly.

2.2 Notices of the NSSC

The term "safe shutdown" appears in Notices of the Nuclear Safety and Security Commission (NSSC) No. 2018-6, 2018-8 and 2018-9 [5-7]. For example, it is found in Notice No. 2018-6 as follows: The term safety function means any function that is necessary to ensure: (a) the integrity of the reactor coolant pressure boundary, (b) the capability to shut down the reactor and maintain it in a *safe shutdown* condition, or (c) the capability to prevent or mitigate the consequences of plant conditions that could result in potential off-site exposures.

2.3 Regulations on Technical Standards for Nuclear Reactor Facilities, Etc.

The term "safe shutdown" appears in Articles 14, 35, and 63 in this Regulation of the NSSC [8]. It is clear that safe shutdown temperature is never provided explicitly in the Korean nuclear energy legislation.

3. Interpretation of Safe Shutdown Condition by Korean Regulatory Body

Regulatory standards and guidelines for LWRs issued by Korea Institute of Nuclear Safety (KINS), are subordinate regulations to describe in detail or to supplement the nuclear energy legislation. Safety review guidelines for LWRs [9] is also a good reference. These subordinate regulations clearly state that safe shutdown condition is limited to cold shutdown condition.

However, this is only applicable to active safety system. The passive safety system is physically impossible to reach the cold shutdown temperature because the system uses two-phase heat transfer of evaporation and condensation. In SMART, core decay heat and sensible heat of the RCS are removed by natural circulation. Therefore, the temperature of the RCS cannot be lowered than the evaporation temperature of emergency cooldown tank (ECT) water by using the passive safety system only. This is an inherent safety feature of the passive safety system.

Therefore, it is necessary to expand the concept of safe shutdown to encompass the passive safety system as well.

4. Case Study: USA

In this section, comparisons are made to get an idea of enlargement of the concept of safe shutdown.

4.1 Regulatory Guide 1.139

This regulation [10] provides specific requirements for a residual heat removal system. The system shall be capable of bringing the reactor to a cold shutdown condition within 36 hours using only safety grade equipment. Cold shutdown condition means 200°F for a PWR and 212°F for a BWR.

4.2 Utility Requirements Document from Electronic Power Research Institute

The Electronic Power Research Institute (EPRI) insisted that cold shutdown is not needed in a passive plant to maintain the fuel and reactor coolant pressure boundary within acceptable limits. It proposed that the passive residual heat removal systems can be employed to reach a fully acceptable shutdown condition of about 420°F in 36 hours [11].

4.3 SECY-94-084

The U.S. Nuclear Regulatory Commission staff concluded that cold shutdown is not the only safe stable shutdown condition which can maintain the fuel and reactor coolant boundary within acceptable limits, and that the EPRI proposed 215.6°C (420°F) as a safe stable shutdown condition is acceptable on the basis of acceptable passive safety system performance and acceptable resolution of the regulatory treatment of non-safety systems [12].

4.4 Standard Review Plan 19.3

The U.S. Nuclear Regulatory Commission considers a “safe stable shutdown condition” for advanced passive LWRs to be a condition by which all plant conditions are stable and within regulatory limits, and the reactor coolant system pressure is stabilized and reactor coolant temperature is less than or equal to 420°F [13].

5. Conclusions

In this study, definition of safe shutdown was investigated, the Korean nuclear energy legislation was briefly reviewed, and comparison was made to that of USA. Due to the inherent features of the passive safety system, it is not possible to reach cold shutdown condition. Therefore, it is necessary to expand the concept of safe shutdown to include passive system as well as active one. As a safe shutdown temperature for passive systems, 420°F is applicable. Further study is necessary for justification on this matter.

ACKNOWLEDGEMENT

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