A Review on the Scope of Accident Management in the Accident Management Plan of Nuclear Power Plant

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1. Introduction

After the Fukushima Daiichi Nuclear Power Plant (NPP) accident, the Korean government enacted a law related to the Accident Management Plan (AMP) that comprehensively describes response strategies, organizations, and operator education and training plans for Design Extension Conditions (DEC) including Severe Accident (SA). The Nuclear Safety Act (NSA) and subordinated regulations related to the AMP promulgated on June 2015 and finally came into effect on June 2016.

This study summarizes the scope of accident management in the AMP and presents the additional works required for the selection of Postulated Initial Events (PIEs) for domestic NPP. A complete set of Design Basis Events (DBEs) and DEC is very important to design of NPP because it could be determined the scope of the mitigation systems and strategies against PIEs.

2. Scope of Accident Management

This section introduces the DBEs that have traditionally been considered for the design of domestic NPP and recently proposed DEC. All PIEs considered in the design of NPP fall within the scope of accident management. The scope of accident management is presented in the enforcement rules related to the AMP for domestic NPP [1].

2.1 Design Basis Event

When designing the NPP, deterministic and probabilistic approaches are applied to identify a comprehensive set of DBEs. In case of domestic NPPs, DBEs are traditionally classified into seven categories according to the U.S Regulatory Guide (RG) 1.70 [2] and Standard Review Plan (SRP) Chapter 15 [3]. Each postulated initiating event falls into one of the following event categories:

- Increase in heat removal by the secondary system
- Decrease in heat removal by the secondary system
- Decrease in reactor coolant system (RCS) flow rate
- Reactivity and power distribution anomaly
- Increase in RCS inventory
- Decrease in RCS inventory
- Radioactive release from a subsystem or component

In each category, there are divided into Anticipated Operational Occurrence (AOO) and Postulated Accident (PA) based on the frequency of occurrence and a total of 33 postulated initiating events have been selected and presented in DCD Chapter 15 for APR1400 [4]. However, there are no systematic selection methods or documentation for the list of DBEs presented in DCD Chapter 15. So, further work for identifying the DBEs for APR1400 is needed to determine whether the DBEs for the digital-based NPP match the list of those of RG 1.70. For example, a potential Common Cause Failure (CCF) in digital control systems could trigger initiating events which have not been considered in the analog systems.

2.2 Design Extension Condition

Recently, the Beyond Design Basis Accident (BDBA) concept has been changed to DEC in Korea. DEC concept has been introduced for the purpose to further improve the safety by enhancing the plant's capability to withstand accidents that are more severe than DBEs. According to the IAEA SSR-2/1 document [5], definition DEC concept is: postulated accident conditions that are not considered for design basis accidents, but that are considered in the design process of the facility in accordance with best estimate methodology, and for which releases of radioactive material are kept within acceptable limits. DEC could include conditions in events without significant fuel degradation and conditions with core melting.

According to the regulation related to the AMP, multiple failures with/without core melt, external hazard can be classified as DEC. The list of complex sequences presented in relevant regulations is as follows [6]:

- Anticipated Transient Without Scram (ATWS)
- Station Black Out (SBO)
- Multiple Steam Generator Tube Rupture (MSGTR)
- Total Loss of Feedwater (TLOFW)
- Interfacing System Loss of Coolant Accident (ISLOCA)
- Loss of Ultimate Heat Sink (LOUHS)
- Small Break LOCA plus Loss of Emergency Core Cooling System

- Loss of Fuel Pool Cooling

A set of complex sequences should be derived and justified as representative, based on the engineering judgement, combination of deterministic and probabilistic method. In the nuclear safety commission notice No. 2016-2 "Regulations on the scope of accident management", it states that additional complex sequences with a similar level of likelihood and impact to those that are essential to be considered should be derived through PSA [6]. However, there is no official basis document regarding additional complex sequences derived from PSA results. Therefore, further work on the identification of additional complex sequences is needed using PSA to make a complete set of DEC.

3. Results

The NSA and subordinate regulations that stipulate matters related to regulatory control of DECs came into effect on June 2016. In this paper, the scope of the accident presented in the regulation related to the AMP was reviewed. The accident management strategy for the domestic NPP has been significantly changed compared to the previous one due to the reflection of the DEC concept.

According to the AMP relevant regulations, the selection of PIEs is the starting point for designing a NPP. Therefore, systematic and complete identification for the PIEs by engineering judgement, deterministic and probabilistic method are important for effective AMP management. As a result of review for the regulations regarding the scope of accident management, it is identified that the following further works are required to make a complete set of PIEs including complex sequences.

- Find out the origin of the DBEs list
- Derive additional DBEs which have not been considered in the SAR Chapter 15 by reflecting operating experience and licensing issues etc.
- Identify additional list of complex sequences from PSA results
- Re-establish the event classification including DEC

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