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External Probability Safety Assessment Framework

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Considering the climate change, a new analysis is needed for external events related to natural disasters on nuclear power plants. In the case of extreme natural disasters such as tsunamis and earthquakes, the consequences of accidents will be very serious. After screening and analysing the natural disasters affecting the nuclear power plant, the nuclear power plant structure and components affected by the selected natural disasters are derived through the nuclear power plant walkdown. After the failure mode and effect analysis of the derived component is performed, the initial event analysis is performed by referring to the internal event PSA(Probabilistic Safety Assessment Framework). It is necessary to analyse the accident scenario according to each initiating event. In addition, hazard and fragility analysis is performed on the screening component.

Keywords: Probabilistic Safety Assessment Framework, Extreme External Event, Risk Assessment, Natural Hazard

1. Introduction

It is expected that there will be changes in the safety assessment for natural disasters in nuclear power due to the impact of climate change. In particular, the Korea Climate Change Assessment Report predicts that temperature, precipitation, typhoons, seawater temperature, and sea level will increase. The average temperature is increasing by about 1.8℃ from 1912 to 2017, and the average precipitation is increasing by 11.6mm per decade from 1912 to 2017. Sea temperature is rising by 0.024℃ per year from 1984 to 2013, and sea level rose by 2.9mm per year from 1989 to 2017.

As the frequency of natural disasters and accidents are expected to increase due to climate change, studies on the safety analysis of nuclear power plants have recently been conducted abroad. Safety evaluation of extreme natural disasters in nuclear power plants and development of safety improvement technology using the results are required, and a systematic and quantitative evaluation method for analysis of natural disasters is required. Accordingly, we present a methodology to analyse possible extreme natural disaster scenarios, evaluate the safety of nuclear power plants, and derive safety improvement measures.

2. External Probability Safety Assessment

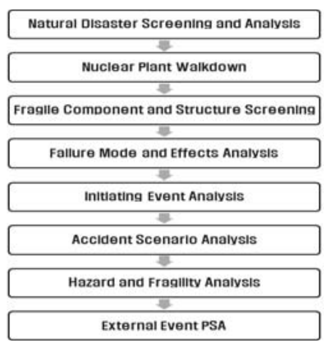

Fig. 1. External Probability Safety Assessment

Fig.1 is a framework for evaluating the probabilistic safety of power plants against natural disasters. An evaluation was conducted on the site for Shin-Gori Units 1 and 2 in Korea, and an analysis was conducted on natural disasters related to high wind.

2.1. *Natural Disaster Screening and Analysis*

In the case of extreme natural disasters, the frequency of occurrence is low, but analysis is necessary because the impact on power plants will be very large, and the frequency of occurrence of natural disasters is predicted to increase according to climate change. In this study, an analysis of high winds was conducted.

2.2. *Nuclear Plant Walkdown*

In this step, Structures, Systems and Components (SSC) affected by high winds are derived using site visits and drawings. The survey includes up to 1km from the power plant area, and most of the buildings outside the nuclear power plant are targeted.

Fig. 2. Shin-Gori Site information

2.3. *Fragile SSC Screening*

In this study, SSC selection is carried out through walkdown and case analysis of external events. A total of 22 external events caused by high winds in Korea were analyzed, and the systems likely to be damaged by high winds include the component cooling water system, circulation water system, and off-site power system.

2.4. *Failure Mode and Effects Analysis*

The failure mode of the SSC, which is vulnerable to high winds, must be evaluated, and the failure mode and effect analysis of the derived devices is performed by referring to the internal event data.

2.5. *Initiating Event Analysis*

The initial event analysis is performed by referring to the external event case analysis and the internal event data. Accidents affected by high winds include Loss of Offsite Power (LOOP), Station Black Out (SBO), and Loss of Component Cooling Water (LOCCW).

2.6. *Accident Scenario Analysis*

Accident scenarios were derived by considering SSC vulnerable to high winds. It was analyzed by assuming that the component would be damaged if the structure was damaged. Fig. 3 is the high wind accident scenario used in this study.

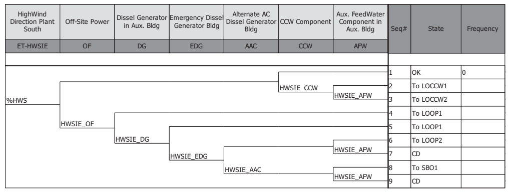

Fig. 3. High Wind Accident Scenario

2.7. *Hazard and Fragility Analysis*

The hazard of strong wind was derived using the data of the Korea Meteorological Administration, and the fragility of strong wind was assumed by referring to the fragility of earthquake.

2.8. *External Event PSA*

The Core Damage Frequency (CDF) was derived using the accident scenario of high winds, the degree of disaster, and the degree of vulnerability. For existing equipment failure rates, internal event PSA was referenced. Results such as the table below were derived.

Table 1. High Wind CDF

	LOCCW	LOOP	SBO	Total
CDF	8.99E-11	9.75E-09	2.79E-08	3.78E-08

3. Result

In this study, the high wind risk evaluation for the Korean nuclear power plant site was conducted according to the external event framework as shown in Figure 1. As shown in Figure 2, in the case of SSC affected by high wind, most of the buildings outside were affected. Such as Auxiliary building, Off-Site Power, Diesel Generator building, CCW Heatexcahnger structure, CW Intake structure. In the case of high wind CDF, it was derived as 3.78E-8/yr. Depending on climate change, analysis of other external events is also needed.

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