Sensitivity Studies on Revised PSA Model of KHNP Nuclear Power Plants

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1. Introduction

Rightly after the Fukushima accidents occurred in March 2011, each country in the world reassessed safety for their nuclear power plants. Korea also performed safety revaluation for all nuclear power plants led by Korean regulatory and elicited 49 improvement factor for plants. One of those factors is Severe Accident Management Guidelines (SAMG) development, KHNP decided to develop Low Power and Shutdown(LPSD) Probabilistic Safety Assessment (PSA) models and upgrade full power PSA models of all operating plants for enhancement of guideline quality.

In this paper we discuss about the effectiveness of post Fukushima equipment and improvements of each plant based on the results of revised full power PSA and newly developed LPSD PSA.

2. Sensitivity Analysis Results for Post Fukushima Action Items

Based on the revised PSA model, we performed sensitivity analysis for post Fukushima coping equipment. Sensitivity analysis target equipments are movable diesel generator, external injection path to RCS, Containment Filtered Vent System (CFVS) and waterproof door installation.

2.1 Movable Generator

Movable Generator is considered as coping equipment under situation of loss of offsite power and station black out due to external events such as earthquakes. Movable generator is installed every sites in Korea and can connect C-1E bus for equipment used in safety shutdown. To use this generator we need time for driver's travel and generator moving to accident occurred unit, so we consider it as alternative equipment only when AAC DG is unavailable and offsite power recovery time margin is more than 2 hours. We assumed the failure probability of Movable DG is 0.1, and human error probability is 0.1. Figure 1 shows fault tree of movable generator.

As a result, full power CDF decreased about 8% for Westinghouse type plant, 25% for OPR type plants.

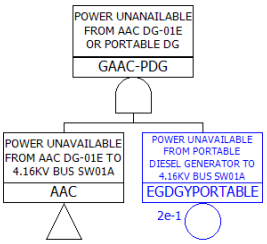

Fig. 1 Fault tree example of movable generator

2.2 External Injection Path to RCS

Next, we consider external injection path to RCS. It is only considered LPSD Level 1 PSA POS 10, 11 (Drainage operation for MID-LOOP operation, MID-LOOP operation) because movable diesel-driven pump discharge pressure is low, and it takes long time in connection and movement. We assumed the failure probability of equipment related external injection is 0.1 and HEP is 0.1. In result, CDF of POS 10, 11 decreased about 80%, overall CDF decreased 10% both Westinghouse type plant and OPR1000 type plants. Fig. 2 shows event tree of external injection.

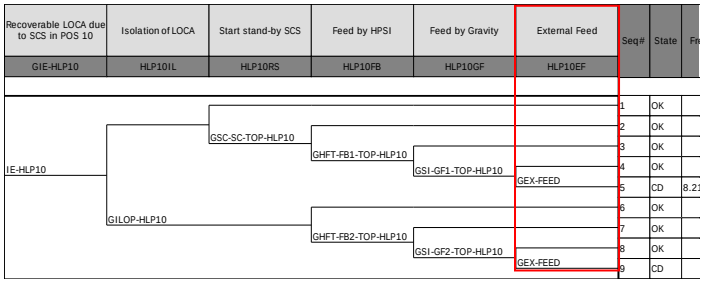

Fig. 2 Event tree of external injection

2.3 Containment Filtered Vent System (CFVS)

After Fukushima accident containment filtered vent system (CFVS) installation is scheduled in order to improve severe accident response ability. CFVS can prevent containment rupture reducing containment pressure, and filtered release steam and air containing radioactive material. We assumed the failure probability of CFVS is 1.77E-2 used in Wolsung unit 1[2]. CFVS was affected Late Containment Failure Frequency (LCF), Containment Failure Frequency (CFF) of Westinghouse type and OPR1000 type plant was reduced about 30%. But, Large Early Release Frequency (LERF) didn't change because we assumed CFVS only mitigate LCF. Fig 3, 4 and 5 show CET, DET for CFVS

#CET = [1,54]	CONTAINMENT BYPASS	CONTAINMENT ISOLATION STATUS	CFVS	MODE OF INDUCED PRIMARY SYSTEM FAILURE AT RV FAILURE
EVENTS	CONBYPASS	CONISOLAT	CFVS	RCSFAIL

Fig. 3 CET Heading for CFVS (part)

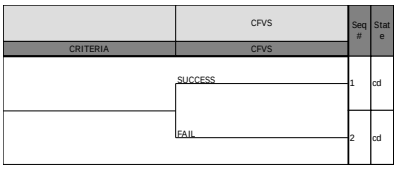

Fig. 4 DET of CFVS

	CONTAINMENT FILTERED VENT SYSTEM	FRACTION OF MASS INVOLVED IN DCH	H2 BURN OCCURRED AT/BEFORE RV RUPTURE	DEBRIS COOLED IN CAVITY
CRITERIA	CFVS	DCH-MASS	ERLY-BURN	DB-COOL

Fig. 5 Heading of CF-LATE DET (part)

2.4 Water proof Door Installation

Waterproof door installation is underway to prevent room flooding due to tsunami for the main section of the all nuclear power plants in Korea. Because OPR1000 type plants already prepared for flooding from the design stage, we only performed sensitivity analysis about waterproof door for Westinghouse type plants. We considered the propagation probability in waterproof door installed room is 0.01. We performed sensitivity analysis that Flooding propagate corridor to C-1E equipment room. If waterproof door installed that room, CDF caused by flooding was reduced about 50%.

3. Conclusions

Through sensitivity analysis based on revised PSA models we confirmed that the facilities installed or planned to installation as follow-up measures of Fukushima accident helped to enhance the safety of nuclear power plants. These results will provide various technical insights to scheduled studies which evaluate effectiveness of Fukushima post action items and develop accident management guideline. Also it will contribute to improve nuclear power plants safety

REFERENCES

[1] KHNP, “Development of Kori, Hanbit Nuclear Power Plant LPSD PSA Final Report”, Dec 2015
[2] KHNP, “Development of Wolsung, Hanul Nuclear Power Plant LPSD PSA Final Report”, Dec 2015