A Probability Risk Assessment for MACSTOR/KN-400 during The Air Inlet Blockage Accident

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1. Introduction

Spent fuels extracted from a reactor can be reused or be deposited to all eternity. Before they are chosen between these two ways, spent fuels are stored in the intermediate storage. The spent fuel dry storage facility is an intermediate storage using air-cooling method. In Korea, because of the current situation, spent fuels derived from continuous operation of PHWRs cannot be stored in a pool, spent fuel dry storage facility is scheduled to be built by year 2016 [1]. Therefore, the use of PSA technology for designing spent fuel intermediate storage facility needs to be developed [2]. In this study, the safety analysis for the sequence of air inlet blockage accident in spent fuel dry storage facility is analyzed.

2. Methods and Results

In this study, the safety analysis of spent fuel dry storage facility is classified in three phase. In first phase, the destruction probability of a basket and a cylinder, which are the major elements of containing radioactive substances, is modeled. In second phase, the accidents of spent fuel dry storage facility are modeled. Finally, consequence analysis through modeling circumference areas is performed. In case of spent fuel dry storage facilities, the studies up to now are only the accident modeling of spent fuel dry storage facility and are performed with only deterministic analysis. Therefore, in this study, the analysis for the accident of air inlet blockage is performed concentrating on PSA(Probability Safety Assessment).

2.1 PHASE 1

The destruction probability of a basket and a cylinder is calculated by estimating CDF(Core Damage Frequency) in Level 1 PSA using modeling a basket and a cylinder containing radioactive substances. For the accident of air inlet blockage, stress is the most important parameter in determining the destruction probability of a basket and a cylinder. Total stress generally composes of mechanical stress and thermal stress within elastic region.

$$\delta_{total} = \delta_{load} + \delta_{thermal}$$
(Eq1)

Load stress and thermal stress are represented below.[4],[5]

$$\delta_{load} = \frac{pR}{2t}$$
(Eq2)

$$\delta_{thermal} = \frac{\upsilon E \alpha q'''}{8(1-\upsilon)k} R^2 - E\alpha \left[\Delta T - \frac{q''' R^2}{4k} \right]$$
(Eq3)

Therefore, distribution of total stress has been calculated by Eq2 and Eq3 using Crystal Ball.

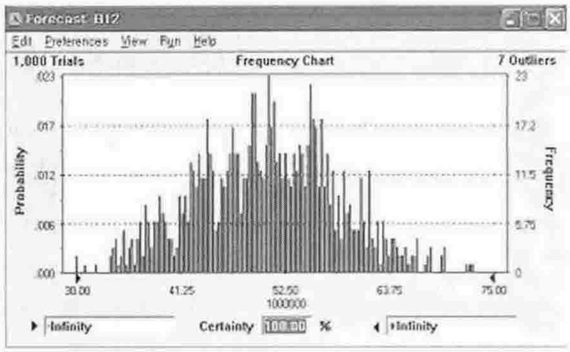

Figure 1. Frequency chart of total basket stress using Crystal ball

If 50% of yield stress is maximum allowable strength, probability that stress exceeds allowable stress using reliability physics model is represented with Eq4.[6]

$$P(Y > X) = P(Z > \frac{\mu_x - \mu_y}{\sqrt{\delta_x^2 + \delta_y^2}})$$
(Eq4)

The result of this phase is 1.4e-3 using crystal ball. In this study, the destruction probability of a basket using reliability physic model is calculated after making distribution of two types of stress considering temperature increase, which can occur in the accident of air inlet blockage. The result of this phase is 1.4e-3 using crystal ball software.

2.2 PHASE 2

Secondly, the modeling of spent fuel dry storage facility is performed. When a basic event occurs, the release probability of radioactive substances to off-site is calculated by making event tree for several elements, which effect on the accident of air inlet blockage. The heading of event tree is such as initial recovery action, degree of blockage and continuous hours.[7] Figure 2 represents event tree considered events mentioned above.

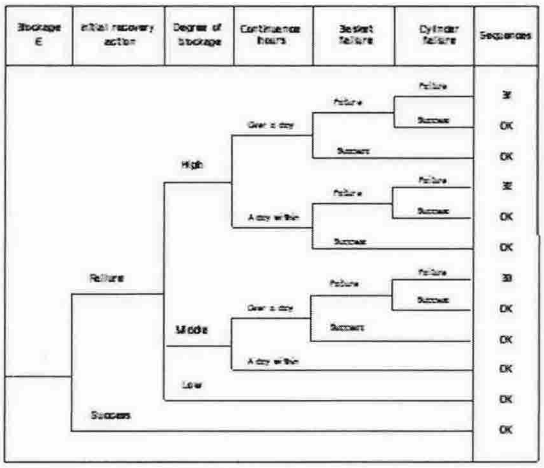

Figure 2. Event tree of air inlet blockage accident

In second phase, calculation tool is RISKMAN which is widely used in fault tree analysis and event tree analysis. In result, the radiation material release probability is 3.0556e-9. In comparison with nuclear power plant, this result is more conservative one. As a result of assessment, spent fuel dry storage facility is more safe than nuclear power plants.

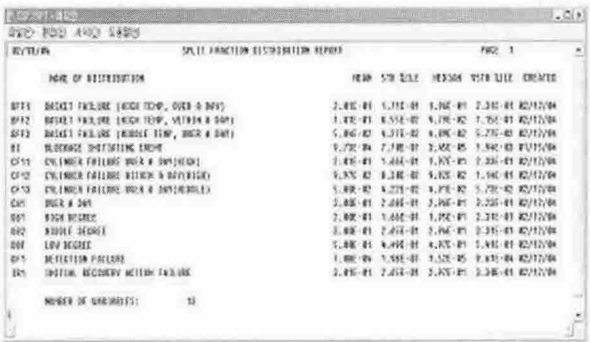

Figure 3. Calculation procedures of radioactive materials release probabilities using RISKMAN

3. Conclusion

Because of continuous accumulation of spent fuel supplied from PHWRs, additional construction of spent fuel storage facility is required. The release probability of radioactive substances from spent fuel dry storage facility is evaluated with respect to the basket failure probability in this study. Using PSA technology, the safety analysis for the sequence of air inlet blockage accident in spent fuel dry storage facility is analyzed. For further works, consequence analysis for a radioactive waste dumpsite through the use of MACCS code.

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