The Result and Risk Insight of Probabilistic Safety Assessment for Advanced Power Reactor Plus

H. R. Moon [a*], S.H. Kang [a], H.G. Kim [a]
KHNP, Central Research Institute, Yuseong-daero 1312-70, Yuseong-Gu, Daejeon, Korea, 305-343
[*]Corresponding author: moonn@khnp.co.kr

1. Introduction

The application of standard design approval for advanced power reactor plus (APR+) was submitted at December, 2011.

The major design characteristic of APR+ is that it is designed using N+2 concept. APR+ emergency power system has four EDGs and is designed with four-train that is electrically and mechanically completely independent.

Another design feature is passive auxiliary feedwater system (PAFS), completely substitute active auxiliary feedwater system [1]. This system can supply cooling water using natural forces such as gravity.

The goal of this paper is to optimize the design for APR+ using analyzing the result of probabilistic safety assessment (PSA) for APR+. As the result of PSA, risk insight is analyzed through the sensitivity analysis of CDF.

For reducing CDF and unavailability, item for design optimization is applied for APR+.

2. Probabilistic Safety Assessment

In case of full power internal events, core damage frequency (CDF)'s goal for the APR+ standard design is less than 1.0E-6/yr. The safety goal of CDF for APR+ is achieved.

Adopting of advanced safety features like four-train safety system and PAFS, the risk of APR+ is significantly reduced [2].

2.1 Results

The evaluated CDF induced by internal events during full power is under 1.0E-6/yr. Among the initial events, dominate CDF is 4 events: the partial loss of components water (24%), small LOCA (19%), loss of offsite power (15%), and station backout(12%). The total CDF of those four events accounts for approximately 70% of the total CDF. The relative contribution (percent of total) of the various internal events to the total CDF is illustrated in Fig. 1

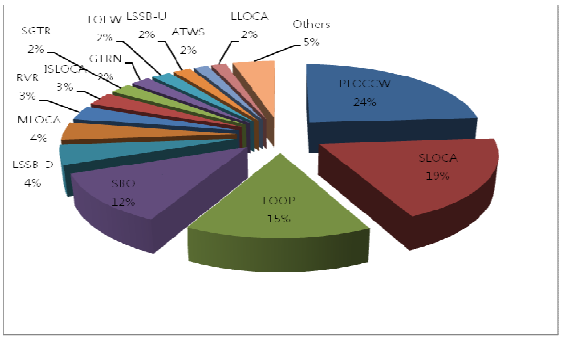

Fig. 1. Contributions to CDF

2.2 Risk Insight

As the result of PSA for APR+, the risk insight is analyzed as followings.

- Supplement for the PAFS, if the PAFS is unavailable
- Supplement for N_2 charging, considering the specification of standstill seal for reactor coolant pump (RCP)
- Supplement for PCCT charging, considering re-filling the raw-water to PCCT for long-term coping process
- Design optimization and modification for reducing common cause failure(CCF) and unavailability of components or equipments

2.3 Sensitivity Analysis and Design Improvement

In Table I, CDF is compared to base and reference case for APR+. In case of adopting motor driven aux. pump to backup PAFS, if the PAFS is unavailable (Case 1), CDF of APR+ is reduced to 23.8% than base case.

Case 2 is removed the check valve for reducing CCF and unavailability for PAFS. The unavailability and CDF is reduced to 69.5% and 6%.

Table I: Comparison of core damage frequency to base and alternative case for APR+

Case	Design feature	Improving rate of CDF for alternative case
1	Supplement for PAFS adding motor driven aux. pump	-23.8%
2	Reducing CCF	-6%

3. Conclusions

Consequently, the CDF of APR+ was evaluated to be less than 1.0E-6/yr. Through the sensitivity analysis of CDF based on the result of PSA, the risk insight was analyzed and the design was applied and optimized for APR+

REFERENCES

[1] KHNP Central Research Institute, Evaluation Report on the Safety Analysis for the APR+ Development, 2011.
[2] H. R. Moon, B. L. Park, Y. S. Park, "Sensitivity Analysis for Using Gas Turbine Generator to Provide Alternate Alternating Current in APR+", Trans. of the KSME(A), Vol. 36, No. 1, pp. 101-102, 2012.
[3] KHNP Central Research Institute, APR+ Probabilistic Safety Assessment Technical Report, Vol. I, 2011.