

## The design effectiveness of safety features of PAFS in APR1000 Level 1 PSA

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### 1. Introduction

The PSA for the standard design of the APR1000 is performed as required in the EUR Rev.E Chapter 2.17. The purpose of this design phase PSA is to demonstrate that the APR1000 design meets the probabilistic target of core damage set forth in the EUR by performing Level 1 and Level 2 PSA for all operating modes. Risk evaluations from internal and external hazards delineated in the EUR 2.17 are qualitatively or quantitatively in progress.

APR1000 has various advanced safety features including Passive Auxiliary Feedwater System (PAFS) which are very effective in the safety point of view. Therefore, this paper discusses the design effectiveness by performing the sensitivity analyses about safety features of PAFS in the design phase Level 1 PSA for internal events at power mode.

### 2. Methodology of APR1000 Level 1 PSA at power mode

This section provides an overall Level 1 PSA methodology that complies with EUR 2.1.4.3 in support of the design phase PSA. The PSA is used to ensure that the Unit satisfies the following probabilistic requirement under all operational modes including shutdown states:

EUR 2.17.1.2 says “The core damage cumulative frequency shall be less than  $10^{-5}$  per reactor year.”

The design phase Level 1 PSA for internal events at power mode is basically done based on the technical requirements of ASME/ANS RA-Sa-2009 as endorsed by U.S. NRC RG 1.200. The Level 1 internal events PSA at power mode is modeled using conventional small event tree and large (or linking) fault tree approach in terms of a set of initiating events, event sequences composed of functions or system success or failure, and logic models that describe combinations of basic events that define the possible success and failure states.

### 3. Engineered safety features of APR1000

APR1000 has various advanced engineered safety features (ESF) to provide protection in the highly unlikely events of an accidental release of radioactive

fission products for DBA and DEC-A. The main systems of ESFs are Safety Depressurization and Vent System (SDVS), In-containment Refueling Water Storage System (IWSS), Passive Auxiliary Feedwater System (PAFS) with Alternative Auxiliary Pump (AAP), Diverse Safety Features (DSF), and so on.

In particular, the PAFS provides an independent mean of passively returning condensate to the Steam Generator (SG) by using gravity force in the events where the MFWS is unavailable. The PAFS has sufficient Passive Condensation Cooling Tank (PCCT) water capacity to cooldown the RCS up to the entry condition of SCS within 24 hours. When the PAFS is unavailable, AAP supports to remove the decay heat actively through the SG.

### 4. Sensitivity analysis results for design effectiveness of PAFS in Level 1 PSA

The PAFS with AAP provides safety functions to control, mitigate, or terminate DBA and DEC-A accidents. The design effectiveness in terms of the risk is evaluated by the sensitivity analyses as Table I.

In the sensitivity case 01, AFW-MDPs (Aux. Feedwater Motor Driven Pump) remove the decay heat instead of PAFS. The PCCT water capacity is changed from 24 hours of the base case to 8 hours for the sensitivity case 02. The isolation valves of condensation line from the PCCT to the SG impact to the risk in case of no redundancy of condensation line. Therefore, sensitivity case 03 is analyzed at the condition of no redundancy of condensation line.

As a results, the total CDFs (Core Damage Frequencies) of Level 1 PSA in case of sensitivity 01, 02, and 03 are increased to 96%, 11%, and 129%, respectively. The sensitivity results of the design effectiveness in Level 1 PSA due to safety features of PAFS are summarized in Table I.

Table I: Sensitivity Cases and results for PAFS

Case No	Base	Sensitivity	CDF comparing to Base
01	Design features of PAFS - more than 24hours PCCT water capacity - Redundancy of condensation line	AFW-MDPs instead of PAFS	+96%
02		Design features of PAFS - 8hours PCCT water capacity - Redundancy of condensation line	+11%
03		Design features of PAFS - more than 24hours PCCT water capacity - No Redundancy of condensation line	+129%

### 5. Conclusion

This paper provides the design effectiveness of PAFS as APR1000 safety features for risk reduction of Level 1 PSA at power mode. The sensitivity analyses have been performed to measure the effectiveness of them. According to the results, if safety features of APR1000 PAFS such as passive system, more than 24 hours PCCT water capacity, and redundancy of condensation line are available for AOO, DBA, DEC-A during at power mode, they are very effective for risk reduction in Level 1 PSA.

By developing Level 2 PSA using the methodology defined in the EUR, it is possible to provide insights and the effectiveness of safety features to address practical elimination of severe accidents on the basis of IAEA, TECDOC-1791 and EUR Rev.E.

### REFERENCES

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