Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2012

A Preliminary Study on Level 1 PSA of SFR-600 Conceptual Design

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1. Introduction

KALIMER-600 is under design with defense in depth concept with active, passive, and inherent safety features. In this paper, a level 1 internal PSA results for the SFR-600 are described. There was a previous work [1] for the preliminary Level-1 PSA for the SFR-600. However, since several design and data has been changed, a new level-1 internal PSA was performed, and this paper discusses the results.

2. Preliminary Level-1 PSA Models and Results

Accident scenarios which lead to the core damage should be identified for the development of a Level-1 PSA model. As a design change of KALIMER-600, the active decay heat removal system in intermediate loop, called IRACS(Intermediate Reactor Auxiliary Cooling System), was removed, and instead, 2 x 50% passive PDRC(Passive Decay Heat removal Circuit), and 2 x 50% active PDRC is installed in reactor vessel. The KALIMER-600 has also inherent reactivity feedback effects such as Doppler, sodium void, core axial expansion, control rod axial expansion, and core radial expansion, etc.

The following 10 initiating events are considered; General Transient(GTRN), Reactivity Insertion, Loss of Primary Flow, Loss of Intermediate Flow, Loss of Secondary Flow, Loss of Electrical Power, Sodium water Reaction in Steam Generator, Large Secondary Side Break(LSSB), PDRC Unavailable, and Reactor Vessel Rupture. Fig. 1 shows the GTRN event tree. Although it would be impossible that the reactivity suddenly increases due to the LSSB in SFR, LSSB event tree was conservatively developed as in LWR.

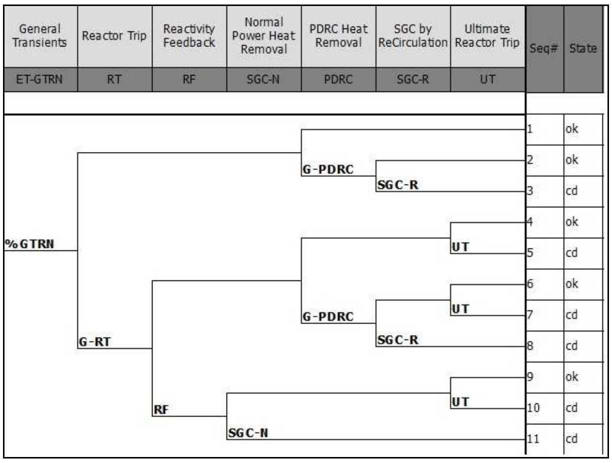

Fig. 1. An Example of Level 1 System Event Tree of General Transient Accident for SFR-600

The fault trees for PDRC, Electric Power System and Reactor Trip System are made using the conceptual design information. Reliability data for the initiating event frequencies and component failure rates are quoted from the available sources for the fast reactor design report such as PRISM and current light water reactor PSA reports. If the initiating events and components, the reliability data cannot be obtained from the available sources, most of them are assumed based on the current generation LWR experience and practices.

Table 1 shows initiating events frequencies and relative core damage frequencies contributions for SFR-600.

Table 1: Initiating Events Frequencies and Relative Core Damage Frequencies Contributions for SFR-600

Initiating Event	IE. Freq/yr.	CDF(%)
General Transients	1.0e+0	13.76
Vessel Leak	1.0e-6	0.00
Loss of Normal Electrical Power	4.0e-2	6.03
Loss of Primary Flow	3.0e-1	4.13
Loss of Intermediate Flow	3.0e-1	35.1
Loss of Secondary Flow (Main Feed)	2.0e-1	23.4
PDRC Unavailable	3.0e-3	8.05
Reactivity Insertion Accident	2.0e-2	0.27
Large Secondary Side Break	1.0e-3	0.12
Sodium Water Reaction in SG	3.0e-2	9.1
Total		100

3. Sensitivity Study on the Design Alternatives

KALIMER-600 is in the design stage where various configurations are under consideration now. Table 2 shows the results (increasing ratio of CDF to base case) of the various design alternatives on the safety systems. Case 1), 2), 3) shows the importance of PDRC damper. CDF is highly dependent of the failure probability of Damper. In case 4), if operator can manually open the damper when damper fails, CDF can be reduced to 0.15 times of the base model. Even though there are several PDRCs for the decay heat removal, PDRC could fail. If PDRC fails, a recirculation pump should be used. Case 5) shows the increased CDF when the recirculation pump is not used. The base case assumes that there are two independent groups of the RPS and there are two gas turbine generators to support the safety grade electric power system.

4. Conclusions

In conclusion, we identified that the current design features on the safety systems are the most acceptable in terms of risk as well as cost. The reliability of PDRC Damper is very important. Further detailed design for the recirculation pump is required.

Acknowledgement

This research was supported by "The Mid-& Long Term Nuclear R&D Program" of MEST (Ministry of Education, Science and Technology), Korea.

REFERENCES

[1] T.W.Kim et al, 'Sensitivity Analyses of Core Damage Frequency on the Design Alternatives for SFR-600 Conceptual Design', *Transactions of the KNS Spring Meeting, Pyeongchang, Korea, May 27-28, 2010*

Table 2. Sensitivity study results of the various design alternatives on the safety systems

Cases	Assumptions	CDF Increasing Ratio
1) Use of Pneumatic Damper, (Damper failure Prob. = 1e-3)	- No Manual Operation of Damper	42.6
2) Use of Highly Reliable Passive Damper, (Damper failure Prob. = 1e-4)	- No Manual Operation of Damper	4.8
3) Use of Highly Reliable Passive Damper, (Damper failure Prob. = 1e-5)	- Base Model - Damper open by gravity when electricity is removed - No manual operation of damper	1
4) Use of Highly Reliable Passive Damper, (Damper failure Prob. = 1e-5)	- Add Manual Operation of Damper - Operator error 0.1	0.15
5) No Use of Recirculation Pump for Decay Heat Removal	- No Manual Operation of Damper	3.15