Preliminary Probabilistic Safety Assessment for SMART

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1. Introduction

The SMART(System-integrated Modular Advanced ReacTor) Pre-project Engineering joint project is performing with Korea and Kingdom of Saudi Arabia. As a part of this project, the preliminary PSA was performed. The SMART is the integral type of a pressurized water reactor with a nominal thermal power is 365 megawatt thermal power, which contains core, reactor coolant pumps, steam generators and pressurizer within a single reactor pressure vessel. The inner diameter of all pipes of the primary system less than 2 inches because of SMART design features, so the large break LOCA(Loss of Coolant Accident) could be eliminated. The SAMRT passive safety systems are designed to cool the RCS(Reactor Coolant System) below the safe shutdown condition temperature within 36hrs and to keep the core undamaged for 72hrs without any corrective actions by operators at postulated design basis accident. These SMART passive safety systems use only natural forces such as gravity and natural circulation to achieve their safety function except the valves arrangement for passive system operation. The active power for valve operation is supplied from station battery system and the active support systems(ac power, diesels, HVAC, forced cooling) are not required. After 72hrs, some active systems(refilling the passive safety system water tank, back-up diesel for battery charge) are required to maintain the passive system operation for long-term. The active support system are designed as the RTNSS(Regulatory Treatment of Non Safety Systems) requirements to ensure their reliability. The PSA is performing to confirm the safety level and to find the vulnerability for SMART plant which is performing. In this paper, the results of preliminary level-1 internal events PSA at power operation are presented.

2. SMART PSA

In PSA is a quantitative assessment that provides measures of overall risk to the public that result from a range of faults. The SMART PSA scope is comprised risk from internal events, internal fire events, and internal flooding events. The seismic margin analysis also would be performed separately.

2.1 Selection of Initiating Events for SMART PSA

For the SMART PSA, the list of preliminary candidates for initiating events has been identified based in three methods such as the heat balance fault tree, PWR experiences and FMEA of SMART specific design. The candidate events were grouped based on plant response to the final initiating event and the required mitigating system responses and presented Table 1

Table 1 List of Final Initiating Event for SMART

Loss of Coolant Accident
01. Small break LOCA
02. Excessive LOCA
03. Steam Generator Tube Rupture
04. Interfacing System LOCA
Transients
05. Large Secondary Side Breaks
06. Loss of Feedwater Transient
07. Loss of Offsite Power
08. General Transient
09. Total Loss Component Cooling Water Train
10. Loss of a 4.16KV AC Bus
11. Loss of a 125V DC Bus A
12. Loss of a 125V DC Bus B
13. Anticipated Transient Without Scram

2.2 Accident Sequence Analysis(Event Tree)

The event tree is constructed for 10 initiating events category except for three initiating events that could direct core damage. Each event tree describes accident scenarios for a given initiating event and facilitates the identification of failure or success of mitigating systems associated with various consequences of accidents for SMART. The thermal hydraulic analysis for decide accident scenario and success criteria for mitigation system were also performed. Two representative event trees are presented in Figure 1 and 2.

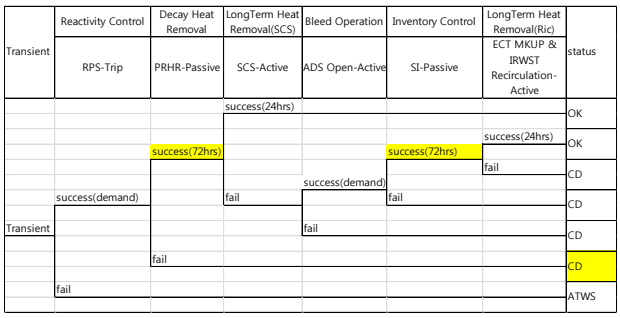

Fig. 1 Typical Event Tree for Transient Initiating Event

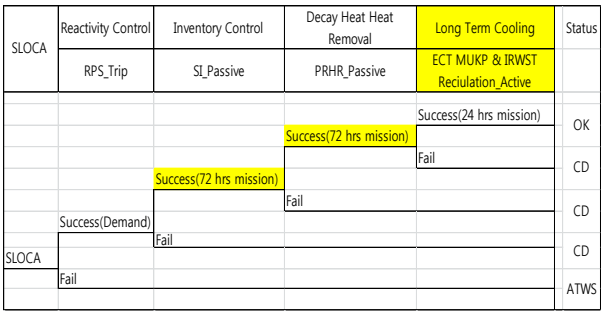

Fig. 2 Typical Event Tree for LOCA

2.3 *System Analysis(Fault Tree)*

The system analysis in SMART PSA is performed using system fault trees which are a deductive approach to identify the relationships between an undesired system event and the subsystem failure events that may contribute to its occurrence. In this study, system fault trees are developed for both front-line passive safety systems and its support systems. And, the fault trees for some active systems(refilling the passive system water tank, back-up diesel generator for long term cooling support and etc.) are also developed. Two mission times are considered such as 72 hours for passive safety system based on design concept and 24 hours for active system based on basic PSA approach. The HRA(Human Reliability Analysis) and data analysis also performed for fault tree development.

2.4 Accident Sequence Quantification

The Event Tree/Fault Tree linking approach(One-top Model) was developed and the total CDF is estimated as the sum of the frequencies of the individual event tree sequences resulting in core damage. The results of core damage frequency is presents Table 2 & Fig. 3

Table 2 Main Cutset for SMART PSA

1	%GTRN	RPRDWRIN	#GIE-GTRN-10	
2	%GTRN	CCOPH-SCS	PRMPK2D-PP01/02	#GIE-GTRN-03
3	%SGTR	GFS-CMTAS	#GIE-SGTR-12	
4	%SGTR	GFS-SITAS	#GIE-SGTR-12	
5	%LOCCWA	PRMPK2D-PP01/02	#GIE-LOCCW-2	
6	%LOKVA	PRMPK2D-PP01/02	#GIE-LOKV-03	
7	%LOFW	RPRDWRIN	#GIE-LOFW-10	
8	%EXLOCA	#GIE-EXLOCA-1		
9	%GTRN	CCOPH-SCS	PRMPW2D-PP01/02	#GIE-GTRN-03
10	%SGTR	SIMPW2D-PP01/02	#GIE-SGTR-02	

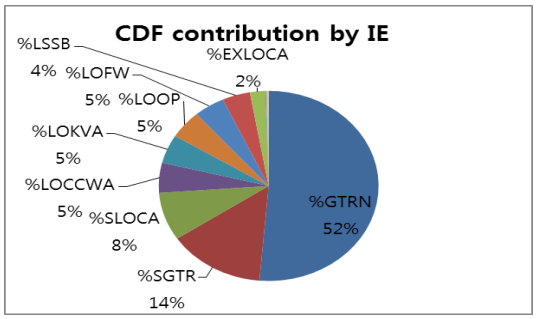

Fig. 3 CDF contribution by IE for SMART PSA

The quantification results shows that no vulnerable point in SMART design but some detailed analysis is needed to reduce uncertainty and conservatism of SMART PSA such as ATWS(Anticipated Transient Without SCRAM) analysis and passive safety system reliability analysis.

3. Conclusions

The preliminary PSA for SMART was performed to confirm the safety and to find the vulnerability for SMART plant. Ten event trees were developed and quantification was performed for 10 initiating events category. The quantification results shows that no vulnerable point in SMART design but some detailed analysis is needed to reduce uncertainty and conservatism such as ATWS(Anticipated Transient Without SCRAM) and passive safety system reliability analysis.

ACKNOWLEDGMENTS

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