Preliminary Analysis on Mass Release of SMART SBLOCA for Development Risk-informed Analysis Methodology

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1. Introduction

Risk-informed analysis methodology which corresponds to the technology-neutral safety assessment guideline described in NUREG-1860 is being developed. Typical accidents are chosen and the detailed scenarios for the accidents are prepared to analyze. Then the calculation is performed for the typical accidents to estimate the mass release which is necessary for estimating the radiological consequences.

2. Analysis results

2.1 Scenarios and Assumptions

A realistic calculation is performed to develop a methodology of risk-informed analysis for a design safety. Small break loss of coolant accident (SBLOCA) with 50 mm safety injection pipe break is selected as a typical accident for demonstrating the methodology. Then two different scenarios are selected for the preliminary analyses as below:

- Scenario #1

SBLOCA →Trip signal on →SIS on →Feed water off →PRHRS on

- Scenario #2

SBLOCA →Trip signal on →SIS off →PRHRS on →SCS pump on

where SIS, PRHRS and SCS denote safety injection system, passive residual heat removal system and shutdown cooling system, respectively. TASS/SMR-S code is used to analyze the various mass releases for each scenario. To provide the data for evaluation of the radiological consequences, three different values are estimated from the analyses: Total mass released to containment for 8 hours, total mass released to secondary side for 8 hours, total mass released to condenser. Among these items, total mass released to secondary side is assumed that 2 scenarios have the same value: 30 kg for initial 2 hours, 120 kg for 8 hours.

2.2 Scenario #1

Analysis of LOCA through this scenario is performed for 8 hours from the beginning of the accident. Fig. 1 shows that pressure of PZR reaches 10.26MPa at 762 seconds which is trip set point of the reactor. Feed water and main steam isolation valves are fully closed at 763 seconds by the PRHRS signal and the control rod is inserted at 763 seconds. SIS starts to operate at 806 seconds by the PZR signal with 30 seconds delay time as shown in Fig. 2.

Fig. 3 shows the total mass released to the containment for 8 hours is 476,000 kg.

The feedwater flow is reduced to 20% of nominal value when the reactor is tripped. And the PRHRS is opened and the Feedwater Isolation Valve (FIV) is closed by operator action after 30 minutes. Considering the nominal feedwater flow of 160 kg/s, total mass released to the condenser is about 156067 kg.

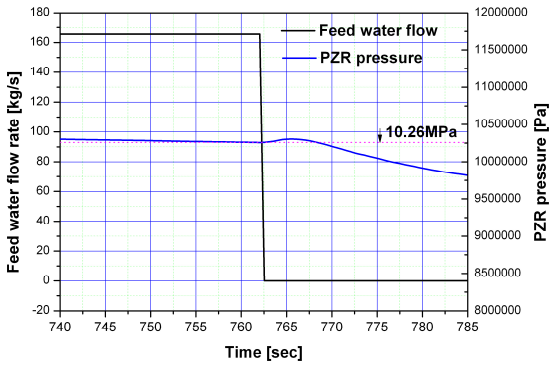

Fig. 1. PZR pressure and Feed water flow rate for scenario #1

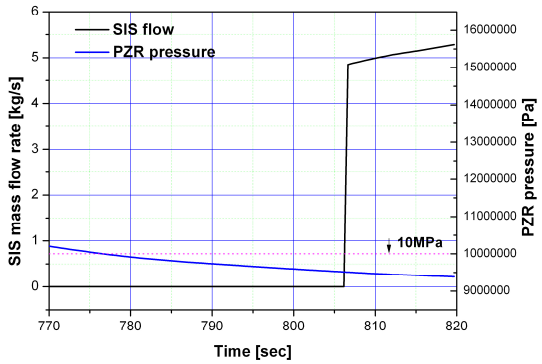

Fig. 2. PZR pressure and SIS flow rate for scenario #1

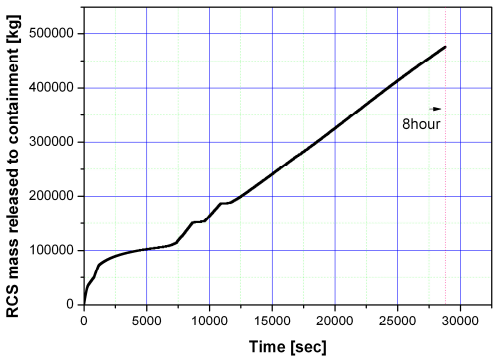

Fig. 3. Total mass released to containment for scenario #1

2.3 Scenario #2

In scenario #2, SIS does not work and Shutdown Cooling System (SCS) operates at the PZR pressure of 2.8MPa and coolant temperature of 200°C. SCS has the rated flow of 13.66 kg/s and the delay time is assumed 30 seconds.

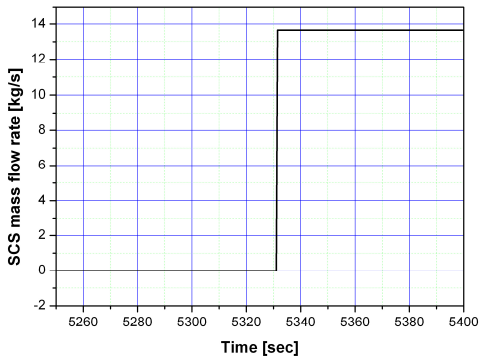

Fig. 4. SCS flow rate for scenario #2

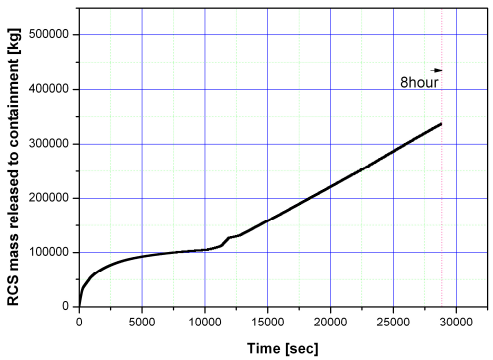

Fig. 5. Total mass released to containment scenario #2

All input data is the same as scenario #1 except SCS SCS starts to operate at 5331.5 seconds as shown in the Fig. 4. PZR pressure decreases rapidly to 0.3MPa with the transient.

Since the feed water flow stops at the same time for both scenarios, the mass flow to condenser in scenario #2 is 156067 kg, the same as that of scenario #1. Fig. 5 shows that total mass released to condenser for 8 hours is 306,390 kg.

3. Conclusion

In this study, mass release through SBLOCA of SMART was estimated as a calculation for demonstrating the risk-informed preliminary analysis. 2 scenarios were analyzed and the main difference between 2 scenarios was main cooling system: SIS was operated in scenario #1 and SCS was operated in scenario #2. The amount of the mass release from the reactor is summarized in Table I. The mass release values provide the essential information for evaluating the radiological consequences and public hazard, which describes the reactor safety quantitatively.

Table I. Mass released from the reactor system

Information	Data [kg]		
	-	Scenario #1	Scenario #2
Total mass released to containment for 8 hours	-	476,000	306,390
Total mass released to secondary side for 8 hours	0~3 hr	30.0	
	0~8 hr	120	
Total mass released to condenser	-	156067	

REFERENCES

[1] Chung. Y.J. et al, Development of risk informed deterministic safety analysis methodology, KAERI/RR-3551/2012, December 2012.
[2] Kim. S.H. et al, TASS/SMR-S code manual Vol.2, December 2011.