Analysis of SBLOCA and SBO Scenarios for SMART Level-1 PSA

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1. Introduction

A Korean-designed small reactor, called 'SMART' (**S**ystem integrated **M**odular **A**dvanced **R**eac**T**or), is under development at the Korea Atomic Energy Research Institute (KAERI). SMART is an integral type pressurized water reactor under design now in Korea. SMART contains a pressurizer, reactor coolant pumps(RCPs), and steam generator cassettes(S/Gs) in a single reactor vessel [1]. As a Risk-Informed Design Approach a Level-1 Probabilistic Safety Analysis (PSA) is performed for SMART. In performing the Level-1 PSA (Analysis of Core Damage Frequency), accident sequence analyses are needed for identifying the systems response behaviors and human actions behaviors. For the accident sequence analysis for SMART, MIDAS/SMR code is used.

For the accident sequence analysis the initiating event types are to be identified first. The initiating event types are identified as LOCA group and Transient group by reviewing SMART design.

In the design of SMART, LBLOCA possibilities are eliminated by designing the pipings of which the size is less than 2 inches.

A passive residual heat removal system (PRHRS) is adopted in secondary side instead of Auxiliary Feed Water System (AFWS) which is used in commercial NPP.

2. Analysis of SBLOCA Scenarios

To define the success criteria for SIS the above SBLOCA accidents are analyzed with increasing the number of available trains of SIS from zero to one, two, three, and four. For all of the above SBLOCA scenarios, one train of SIS is enough to makeup the RCS coolant inventory which is lost by the break.

In the LOCA groups, the following SBLOCA initiators are identified and analyzed with MELCOR 1.8.5 code.

- 70mm ID CRDM nozzles in the top of pressurizer
- 50mm ID SIS nozzles bellow the RCP pump

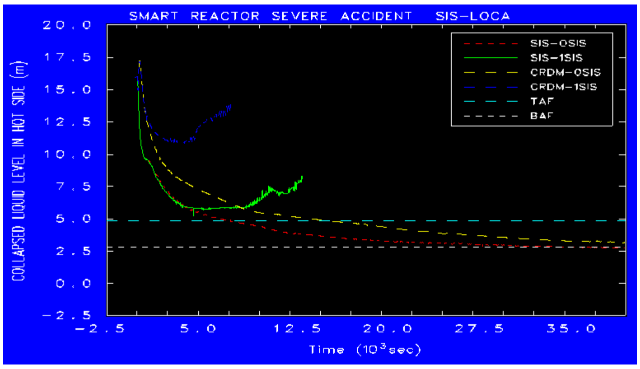

Fig.1. RPV Water Level in SIS and CRDM LOCA (zero and one train of SIS)

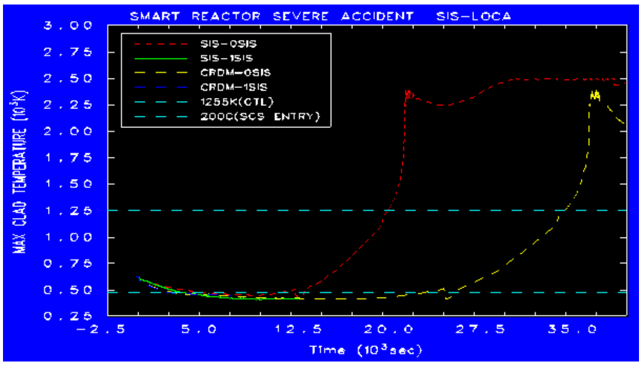

Fig.2. Peak Clad Temperature in SIS and CRDM LOCA (zero and one train of SIS)

Even for more severe (bigger break sise) accidents than the above SBLOCA scenarios such as the RCP ejection accident, the steam header rupture accident, and the feed header rupture accident, one train of SIS is identified to be enough to makeup the RCS coolant inventory which is lost by the break. However, conservatively the criterion of two trains out of four SIS trains is used in the event tree modeling.

For the feed and bleed sequences after the failure of the secondary heat removal in the transient event groups, inventory makeup by the one train out of four SIS trains and the bleed operation by one train out of two SDS valves are identified to be successful recovery operation.

3. Analysis of SBO Scenarios

To define the success criteria for PRHRS the station blackout (SBO) accidents are analyzed with increasing the number of available trains of PRHRS from zero to one, two, three, and four. The core decay heat is removed by the two trains of PRHRS in about 33 hours, where the design requirement is 36 hours.

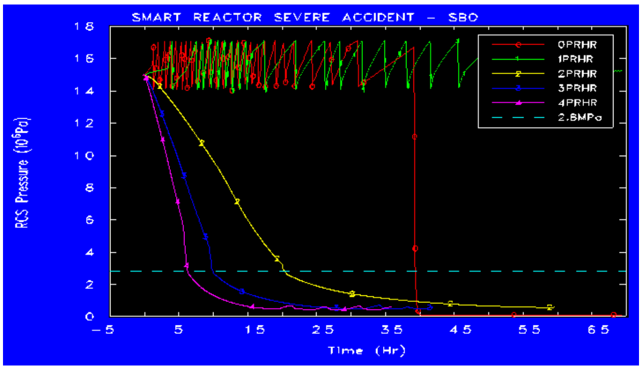

Fig.3 RPV Pressure in SBO (0 to 5 PRHRS)

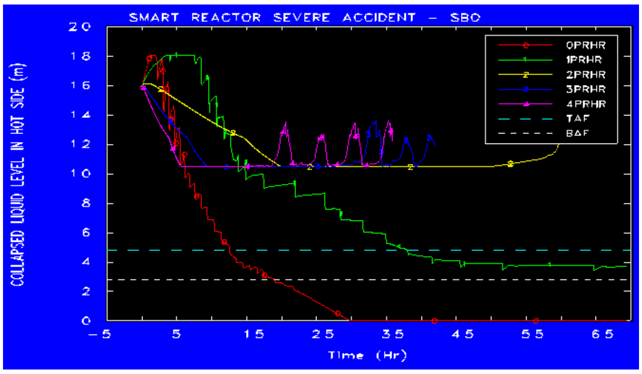

Fig.4 RPV Water Level in SBO (0 to 5 PRHRS)

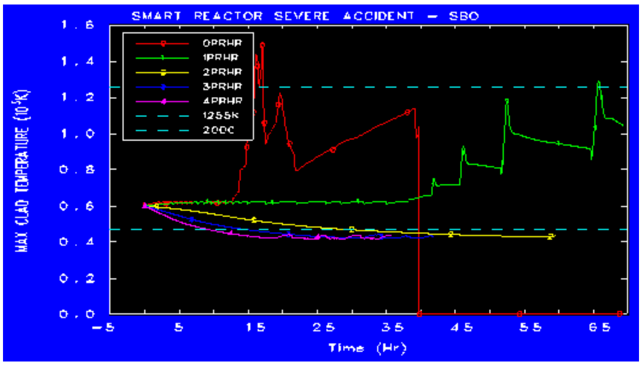

Fig.5 Peak Clad Temperature in SBO (0 to 5 PRHRS)

4. Concluding Remarks

The high RCS (Reactor Coolant System) pressure sequence of a SBO (Station Blackout) and the low RCS pressure sequences of various locations Small break LOCAs (SBLOCA) for SMART were analyzed in order to obtain the success criteria for each accident scenario. The two inches inner diameter small break LOCA accidents are analyzed according to the locations of break from the highest possible elevations to the lowest elevations such as the pressurizer safety valve stuck open LOCA, the safety injection line break, the steam generator steam header break and the steam generator feed header break. One out of four safety injection system (SIS) trains is enough for makeup of reactor coolant inventories released from the break. In the station blackout (SBO) scenario, availability of two out of four trains of secondary side Passive Residual Heat Removal Systems (PRHRS) is enough to remove the decay heat generated from the core. The core decay heat is removed by the two trains of PRHRS in about 33 hours, where the design requirement is 36 hours. These results are used for the construction of Level-1 PSA and the estimation of Core Damage Frequency (DCF) of SMART Design.

REFERENCES

1. SMART Reactor System Description, KAERI, 2010
2. SMART Standard Safety Analysis Report, KAERI, 2011