Containment Performance during Long-Term SBO of APR1400

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1. Introduction

In the Fukushima Accident occurred in March 11, 2011, the containment performance is very important in the long-term station blackout (SBO) situations.

For the APR1400, containment performance analyses are performed for the hypothetical long-term SBO situations.

2. Analysis of Long-Term SBO Scenarios

For the APR1400, as a typical Gen III(+) PWR in Korea, the containment performance analyses are performed for the hypothetical long-term SBO situations.

As a semi-passive decay heat removal system, steam turbine-driven auxiliary feedwater systems (TD-AFWS) are installed in the steam generator secondary side in the APR1400. The safety grade 125VDC batteries are installed in the class 1E electrical systems, which can supply for safety grade equipment for more than eight (8) hours. 125VDC batteries control the steam turbines of TDP of AFWS.

According to the service time of TD-AFWS, containment performance will be changed. In this analysis It is assumed that the TDPs are sustained to supply the water from CST to SG secondary side during 10 hours. About 20 hours after the reactor trip, the inventories of the SG secondary side and the RPV are fully emptied as shown in Fig.1 and Fig.2.

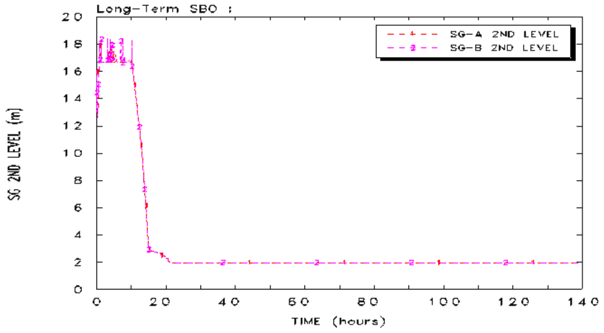

Fig.1 Water Level of SG Secondary Side

In the same time with the empty of RPV water inventory, the core melts are discharged into the reactor cavity by the failure of the ICI penetrations. The core melts discharged in to the cavity have interactions with concrete in the cavity bottom. The masses of core melts discharged into cavity are shown in Fig.3. The decay heats generated in the core and cavity and the heat rates generated or dissipated by various mechanisms are shown in Fig.4.

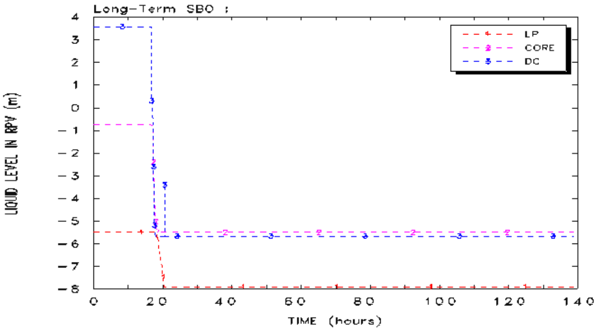

Fig.2 Water Level of RPV

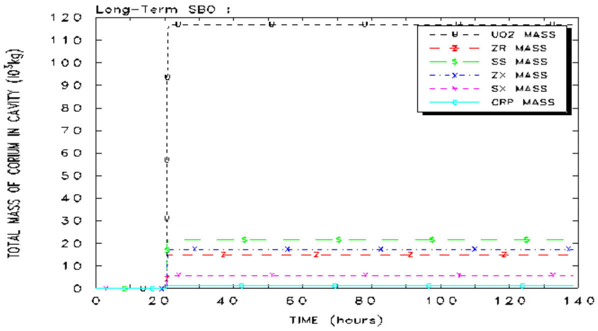

Fig.3 Mass of Core Melts Discharged into Cavity

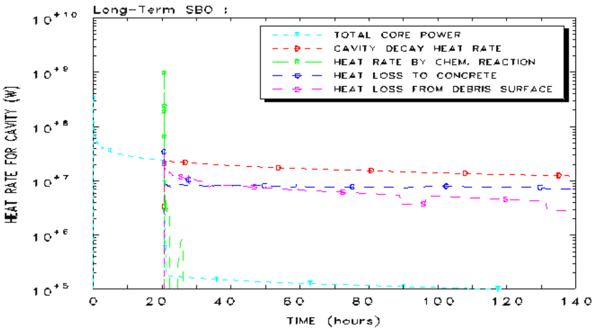

Fig.4 Various Heat Generation and Dissipation Rates in Core and Cavity

The hydrogen masses generated in the core and cavity are shown in Fig.5. Total hydrogen mass generated in the reactor core is about 750 kg, which is generated by zirconium-water reaction (MWR). MWR start to occur when the water (steam) temperature rises to above 1000K. In the cavity the hydrogen is generated from the moisture contents in the concrete. It is generated by the molten core and concrete interactions (MCCI). The other gases such as CO, CO2, H2O than H2 are also generated by the MCCI. The cumulative masses of gases produced in cavity are shown in Fig.6, which is increasing upto the time when all the concretes are consumed in the cavity.

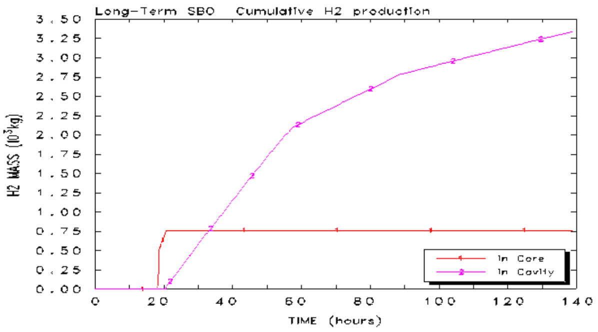

Fig.5 Cumulative Hydrogen Generation in Core and Cavity

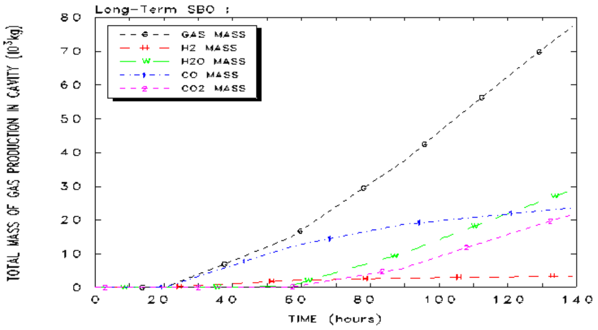

Fig.6 Cumulative Gas Production in Cavity

The changes of the radius and the altitude of the cavity are shown in Fig.7. The initial radius and the altitude (depth) of the cavity room are assumed 5m and 5m respectively. At 140 hours (about 6 days) after the reactor trip, about 3.5 meters of radius and depths of concretes are consumed.

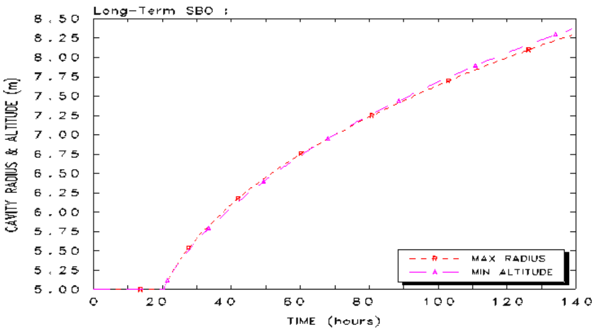

Fig.7 Change of Cavity Radius and Altitude due to MCCI

According to the amount of hydrogen, steam , and other gases generated in the core and cavity, the mole fractions of gases changed in the cavity and containment compartments. Fig.8. shows the mole fractions of hydrogen, steam and oxygen during the transients. The amount of hydrogen and and oxygen is consumed by the action of PAR (Passive autocatalytic recombiner). It is assumed that when the mole fraction of hydrogen reaches 10%, the PARs are working.

Fig.9 shows the change of the pressure of containment during the transients. At 140 hours (about 6 days) after the reactor trip, the pressure of containment reaches about 850 kPa. It would be increasing upto the time when the MCCI ceases.

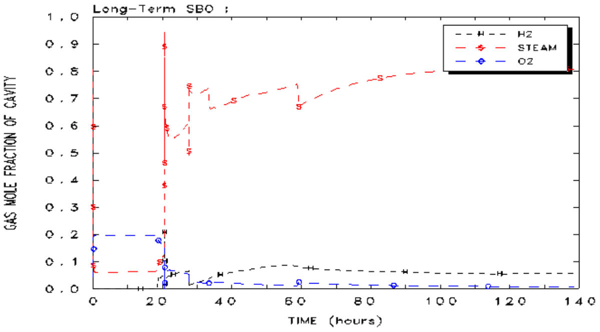

Fig.8 Mole Fractions of Gases in the Cavity

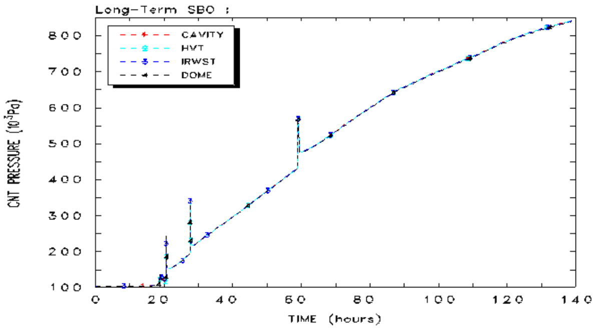

Fig.9 Containment Pressure in SBO

3. Concluding Remarks

As a sample case for the APR1400 as a representative Korean Gen III(+) NPP, the Long-Term SBO scenarios are analyzed to see the performance of containment behavior in the accident situations occurred in the Fukushima Daiichi NPP on March 11, 2011. By the installation of PARs in the APR1400, hydrogen explosion may not occur. In the long-term SBO situation more than one week duration, however, it should be considered the adoption of the severe accident dedicated emergency safety features such as the ex-vessel core catcher system or the containment filtered ventilation system (CFVS) to maintain the integrity of containment as one of long term safety improvement actions.