Containment Pressure and Distribution of Fission Products for SMART-100 under the SBLOCA with ERVC and Spray using MELCOR1.8.6

Jong-Hwa. Park[a], Sang-Ho Kim[a], Jae-Hyun Ham, Rae-Joon Park [a]
[a]*KAERI, 1045 Daeduck daero,Yuseong., Daejeon, 305-353, ejhpark3@kaeri.re.kr*

1. Introduction

This paper shows the preliminary analysis results for the effect of the backup spray system on the pressure of containment and the distribution of fission product during SBLOCA (Small Break Loss of Coolant Accident) with ERVC from SMART-100 (365 Mwt). This analysis has performed with MELCOR version 1.8.6 YV.

In case of spraying, the containment pressure continue to increase up to 1.49 bar with maximum. But thereafter the containment pressure was stabilized at near 1.475 bar. But for the case of without spraying, the containment pressure reached the 1.55 bar.

From this calculation, most of the released fission products were in LCA and were captured within the RRT and IRWST by pool scrubbing. Some of fission products are still remained within the RPV inside. Release fraction of class Cs, Te, and CsI to the environment by the revised design leak rate are in the order of minus five to ten. Consequently, overall release of fission products to the environment by the design leak rate during the SBLOCA was shown as negligible.

2. Methods and Results

2.1 Input Model of SLOCA for SMAT 100

In this study, the containment (UCA) was modeled into three control volumes regions. It is assumed that the backup spray system was installed only in the center control volume of the containment at the top side and the water source is always available [1]. The volumetric flow rate of spraying was 12.618 m^3/s (200 GPM) over the transient.

The distributions of the droplet diameter were in 1.5mm ~0.25mm. The spray water was designed to accumulate in the refueling pool. The initial temperature of the droplet was assumed as 313K and 323 K as a sensitivity test. The backup spray system starts to operate from 1 day after SAMG condition plus 30 minutes. The backup spray system continues to run up to the end of transient.

To analyze the accident sequence conservatively, it was assumed that PRHRS, PSIS are not operated during the severe accident. If these systems function, the severe accident can be delayed or even, arrested. It was assumed that CFS (cavity flooding system) is operable.

The design leak rate from the containment under the normal operation was revised based on the leak rate of 0.1 volume percent per a day. This new design leak rate corresponds to the break area of 1.72272E-6 m^2 from the UCA to the environment.

The distribution of fission product in the SMART100 was categorized into eight types as the following Table 2.1.1. The release fractions of each fission product are calculated based on their initial inventories.

Table 2.1.1 Categorized spaces for the distribution of released fission product in SMART100

Type no.	Space
1	RPV (including primary side of SG and pressurizer)
2	LCA
3	Water tanks (IRWST, RRT, CMT, and SIT)
4	UCA
5	PRHRS loop, Secondary side of SG
6	CDL, loop from SIT room to RRT
7	Turbine
8	Environment

2.2 Calculation Results on the containment pressure for SMART 100

SBLOCA occurs at 0 second with a break area equivalent to the diameter of 0.0508 m (=2 inches) on the reactor vessel wall near RCP discharge region. Therefore, the coolant in the RPV was leaked to the LCA. The backup spray was started at 98,612 seconds.

Just after the spray starts, the containment pressure was a little jumped. It was because that the temperature of the containment atmosphere was stayed in the more higher temperature than that of spray droplet. Therefore, reversely, the droplets were heated by the hot gas in the containment and some of the droplets were vaporized.

In case of spraying, the containment pressure continue to rise up to 1.49 bar with maximum. But thereafter, the containment pressure was stabilized at near 1.475 bar. But for the case of without spraying, the containment pressure reached the 1.55 bar.

The important parameter to control the containment pressure was the temperature of the spraying droplet. In this calculation, the droplet temperature of 313K was applied as the base case with comparing the case of 323K.

For the case of the droplet temperature of 323K, the containment pressure was similar to the case of without spraying. Therefore, it is necessary to reduce the droplet temperature to less than 323 K. Figure 2.2.1 shows the containment pressures depending on the operation of backup spray system and its droplet temperature.

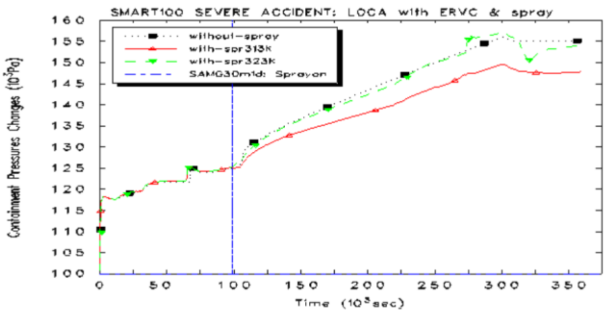

Fig. 2.2.1 Pressure of the containment (UCA)

Another parameter was the reduction of containment volume by rising of water level. The UCA was consist of 3 sub-volumes. So, the volume reduction by rising of water level from refueling pool made the hot steam uneven state in three sub volumes. The one control volume was more weighed by the expelled steam from other two sub volumes.

The pressure of this weighed sub-volume was suddenly start to increase when the refueling pool was completely filled by the spraying water. Therefore, it is necessary to set up the time period for the operation of the backup spray system.

2.3 Calculation Results on the Distribution of fission Product for SMART 100

Most of the fission product were trapped in the LCA region. It means that the CAP structure play an important role to trapping the released fission product.

The second barrier against the release of fission product was the water pools such as IRWST and RRT. The third barrier was the reactor vessel itself. The fourth barrier was the containment (UCA). But the amount of fission product release to the environment by design leak rate during the SBLOCA with ERVC and the backup spray was shown as negligible. The most of the Xe is accumulated in the UCA region. Class 2 (Cs) to 16 (CsI) fission products, water soluble and insoluble ones are accumulated in the LCA region. When the RRT pool start boil, captured fission products in the RRT are released to the UCA.

Figure 2.3.1 shows the change of CsI release fraction to the environment depending on the operation of the backup spray system.

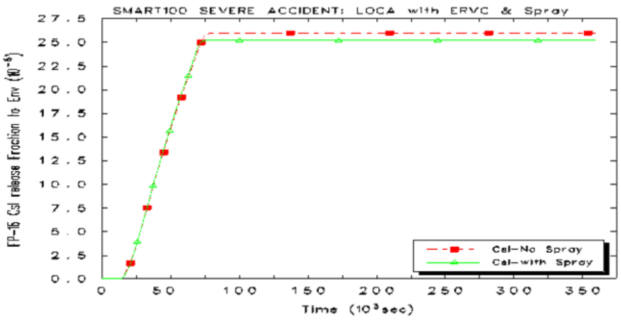

Fig. 2.3.1 CsI release fraction to environment

Table 2.2.1 shows the environmental release fractions for the representative five fission products for SBLOCA.

Table 2.3.1 Environmental Release fraction at 72 hrs (SBLOCA)

class	Type-1	Type-2	Type-3	Type-4	Type-5	Type-6	Type-7	Type-8
Cs (2)	0.22	0.459	0.112	0.261	0.0	1.7E-4	0.0	2.59E-5
Ba (3)	4.93E-3	6.0E-3	3.36E-3	2.51E-3	0.0	6.11E-7	0.0	2.05E-7
Te (5)	0.298	0.387	0.102	0.235	0.0	1.38E-4	0.0	2.35E-5
Mo (7)	2.81E-2	7.15E-2	5.8E-2	9,94E-3	0.0	1.07E-5	0.0	1.23E-7
CsI(16)	0.168	4.03E-1	0.1	0.252	0.0	1.24E-4	0.0	2.52E-5

3. Conclusions

Release fraction of class 2,5 and 16 (Cs, Te, CsI) to the environment by the design leak rate are in the order of minus five to ten, and that of class 6, 8, 9, and 10 (Ru, Ce, La, U) to the environment by the design leak are in the order of minus ten to ten or less. Consequently, the amount of fission product release to the environment during the SBLOCA was shown as negligible.

In case of spraying, the containment pressure continue to increase up to 1.49 bar with maximum. But thereafter, the pressure was stabilized at near 1.475 bar, which is below the design pressure of UCA (1.9 bar). Therefore, it was predicted that the possibility of rupture or leak by over-pressure was negligible from SBLOCA with ERVC and the backup spray system. Also it seem that a system to control the temperature for a water from the backup spray is necessary.

REFERENCES

[1] R.O. Gauntt et al., "MELCOR Computer Code Manuals vol.2: Reference Manuals Version1.8.5, COR-RM 103-106, "SNL, Albuquerque, NM 87185-0739, NUREG/CR-6119 (2000).