# Conceptual Design of Passive Containment Cooling System Based on APR+

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## 1. Introduction

The accident of Fukushima nuclear power plants has proved the importance of preparing extended station blackout (SBO). Korea is developing Advanced Power Reactor Plus (APR+) with Passive Auxiliary Feedwater System (PAFS). PAFS is expected to work well under extended SBO, but is vulnerable to extended SBO coupled with loss of coolant accident (LOCA). Various reactors have been developed, such as AP1000, ESBWR, and KERENA, with passive containment cooling systems (PCCSs) dealing with the accident scenario of SBO with LOCA [1-3]. The performance of the PCCSs is already or almost validated. Though PCCS is well adopted into BWRs, there has been no success in PWRs with concrete containment. In this paper, we suggest a new PCCS based on APR+ and represent scoping analysis results.

## 2. Description on new PCCS

The schematic diagram of our PCCS is displayed in Fig. 1. The space inside containment is divided into three chambers: inner chamber, PCCS chamber, and outer chamber. When a pipe is broken, released steam is accumulated inside the inner chamber and then transported into the PCCS chamber. The PCCS chamber contains external heat exchangers (HXs) and in-tube heat exchangers (HXs), which use PCCT water as an ultimate heat sink. One merit of our PCCS is that we can use in-tube HXs and PCCS for both PAFS and PCCS lowering construction and maintenance cost. Through the HXs, condensate is stored inside the condensate holdup tank (CHT) and then is injected into reactor vessel (RV) by gravity. The outer chamber makes a convective flow via pressure difference between the PCCS chamber and outer chamber and draws non-condensable gas from the PCCS chamber to increase the heat transfer rate of HXs. During the transport process, the gas passes through the in-containment refueling water storage tank (IRWST). The IRWST plays an important role of trapping radioactive materials.

## 3. Scoping analysis results

A simple calculation code is developed solving mass and energy balance equations to get the history of containment pressure.

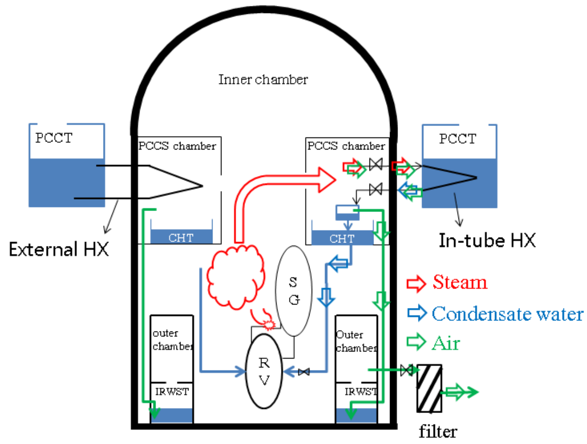


Fig. 1 Schematic diagram of suggested PCCS

For a one chamber case, the calculated pressure matched with the theoretical value. The decay heat curve came from APR+ data. The HX heat transfer models came from heat and mass transfer analogy for in-tube HXs, and Dehbi's correlation for external HXs. These HX models used in code were verified by reproduction of previously published data. To meet the design pressure of 0.52MPa, the required number of external HXs (D=0.05m, L=8m) to be installed is obtained as a function of outer chamber volume fraction in Table 1. The air mass fraction inside the containment is given in Fig. 2. When the outer chamber volume fraction is increased, larger mass of air can be transported to the outer chamber thereby easing condensation through HXs. The result proved the importance of increasing outer chamber volume.

Table I: Required number of HXs for PCCS

| Outer chamber volume | Required number of HXs |
|---|---|
| No chamber | 900 |
| 10% containment V | 440 |
| 20% containment V | 260 |
| 40% containment V | 0 |

## 3. Conclusions

The Fukushima accident proved the importance of treating extended SBO. To deal with extended SBO with LOCA scenario, the PCCS based on APR+ is suggested and evaluated roughly for the first time as a PWR with concrete containment.

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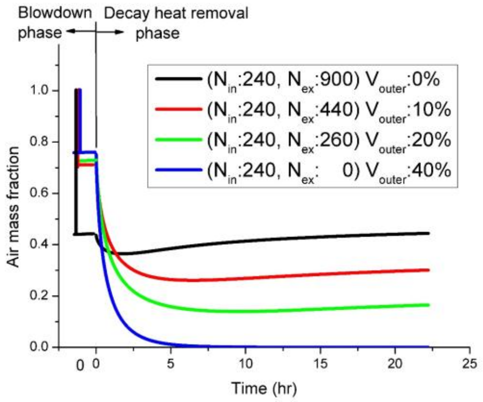


Fig. 2 Air mass fraction inside the containment after LBLOCA

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