Sensitivity of Sump Water Temperature to Containment Integrity

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1. Introduction

In the large break loss of coolant accident (LOCA), containment air temperature would be a maximum for the malfunction of spray system and local air cooler. If accompanied the malfunction of heat exchanger or pump in the time of low pressure safety injection, of emergency core cooling system (ECCS), it will be one of the aggravating factors to the integrity of core and containment.

This paper is focused on the containment behavior analysis in the above described cases using GOTHIC-IST (generation of thermal-hydraulic information for containments, industry standard toolset) [1]. GOTHIC-IST version 7.2a is an integrated, general purpose thermal-hydraulics software package for design, licensing, safety and operating analysis of nuclear power plant containments and other confinement buildings.

2. Methods and Results

The accident case is assumed to be 35% break of reactor inlet header (RIH) of Wolsong Nuclear Power Plant-1(NPP-1). In the view of reactor safety and dose analysis for Wolsong NPP-1, the most limiting accident is 35% RIH break [2].

2.1 GOTHIC Model (KHNP, 2008)

Lumped nodalization of 15 control volumes and 74 flow paths for PP analysis are modeled.

All assumptions of input data for GOTHIC model are verified by the analysis report of Wolsong NPP-1 containment [3]. One of the purposes of containment analysis is to be found out the maximum peak pressure (PP) to verify the integrity of containment under the design bases accidents.

2.2 Assumed sump water temperature

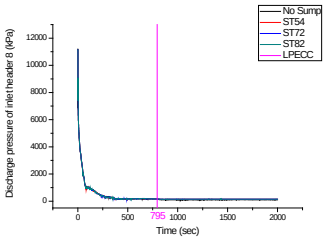
The sump water temperatures for sensitivity study on containment integrity are selected as the following 4 cases.

(1) Malfunction of ECC pump case (No Sump)
(2) 54ºC calculated roughly using water volume and temperature of each water sources, which are D2O in one coolant circuit and H2O for spray, high pressure injection from the high pressure tank and medium pressure injection from the dousing tank (ST54) [3]
(3) 72ºC case to meet available net positive suction head ($NPSH_A$), 20ft (ST72) [3]
(4) 82ºC estimated case at low pressure ECC injection time in 35% RIH break with malfunction of spray system and local air coolers (ST82) [4]

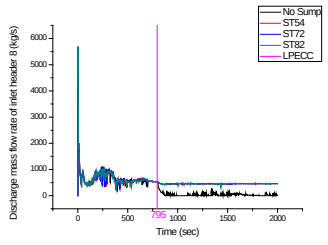
In the normal operation, the sump water is cooled to about 48.9 ºC by the ECCS heat exchanger, where the heat transfer coefficient is 3,670W/m^2/ºC for used heat exchanger and 4,920W/m^2/ºC for new one [2]. However, it is assumed to be the malfunction of heat exchanger in this paper and the estimated sump water temperature is maintained.

2.3 Discharged energy data

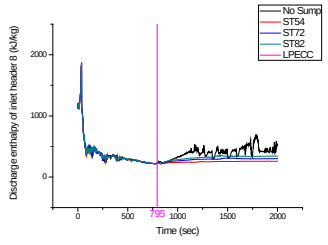
Figure 1 shows time-dependent discharge data for the selected cases.



(a) pressure



(b) mass flow rate



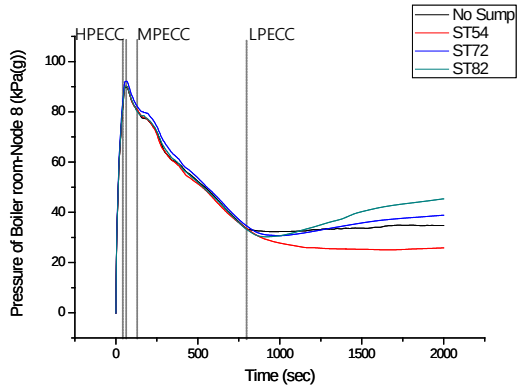
(c) enthalpy

Fig. 1. Time-dependent behavior for various sump water conditions

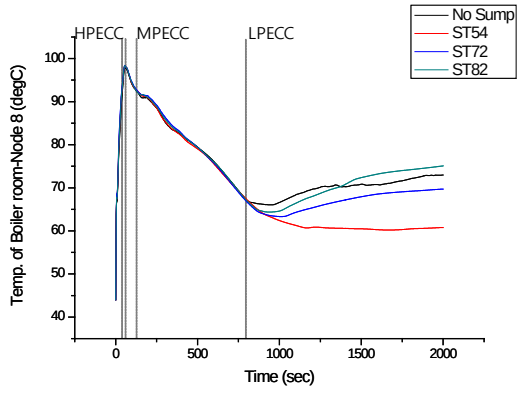
As shown in figure 1, all cases of the discharge mass flow rate from broken header of primary heat transport system (PHTS) and its pressure are decreasing at the low pressure ECC (LPECC) injection time, 795 seconds, in case of malfunction of ECC pump. However, discharge enthalpy for a failure of LPECC injection is higher than other cases. In case of normal injection of ECC but malfunction of heat exchanger, high sump water results in high discharge enthalpy.

2.4 Sensitivity of sump water temperature to containment integrity

Figure 2 shows the comparison of containment pressure and temperature among various sump water temperatures. A pressure gauge is assumed to be installed at boiler room below dousing tank.



(a) Pressure



(b) Temperature

Fig. 2. Time-dependent behavior of boiler room pressure and temperature for various sump water conditions

Although the time of high pressure ECC (HPECC) injection is 35.5 seconds, containment pressure and temperature start to decrease at the time of actual re-charging in break position, 58 seconds. At the time LPECC, 795 seconds, behavior is different among various sump water temperatures. Early LPECC stage, containment temperature and pressure are higher in case of malfunction of ECC pump than in 82ºC estimated case. However, the sump water temperature is high, the containment temperature and pressure are high as a function of time. It would be resulted from the influence of high temperature steam discharge from broken RIH.

3. Conclusions

In this study, we perform the sensitivity the sump water temperature to containment integrity.

For 35% RIH break accident with the malfunction of spray system, local air coolers, ECC pump and heat exchanger, the peak pressure at boiler room do not exceed the design pressure 124kPa(g) of the containment [5] and containment integrity is secured.

ACKNOWLEDGEMENT

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