Transactions of the Korean Nuclear Society Spring Meeting
Gwangju, Korea, May 30-31, 2013

Performance Analysis on Passive Emergency Core Cooling System(P-ECCS)

Soon Il Chung [a*], Soon Joon Hong [a], Doo Yong Lee [a], Sang Hee Kang [b], Han Gon Kim [b]
[a]*FNC Tech., SNU 135-308, Daehak-Dong, Kwanak-Gu, Seoul, 151-742, S. Korea*
[b]*Korea Hydro & Nuclear Power Co., Ltd. 1312, Yuseong-daero, Yuseong-Gu, Daejeon, 305-343, S. Korea*
[*]*Corresponding author: soonil@fnctech.com*

1. INTRODUCTION

Overseas Advanced Reactors is strengthened passive tendency of the safety system prepare to SBO. Passive safety system possible the long term cooling of core at SBO accident without operator action. So domestic nuclear industry issue necessity for development of key technologies for design of passive safety system. It is necessary to develop the original technology for the improved technology, economics, and safety features. For this purpose, a Passive Emergency Core Cooling System (P-ECCS) was adopted as an improved safety design concept of APR+; and then there have been many efforts to develop the P-ECCS.

The design concept of P-ECCS is shown in Fig. 1. When LOCA occurs or SBO, the P-ECCS can remove the residual heat in the core and then prevent the core damage.

P-ECCS has design feature that is applied high pressure accident and SBO. The main purposes of this study are: 1) to develop the RELAP5 input model, 2) to analyze the performance of applying the P-ECCS model into the RCS input model.

In this paper, as a representative case, SLOCA was analyzed.

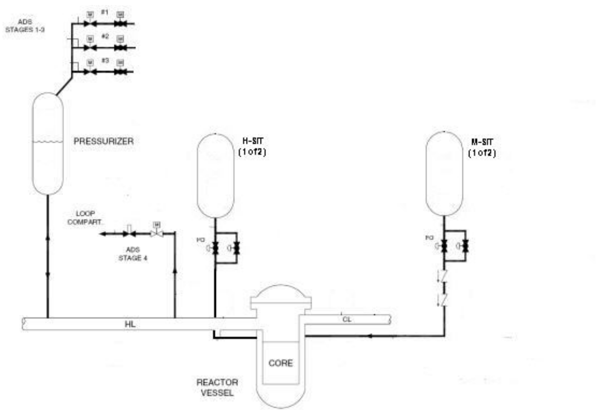

Fig. 1 Outline of P-ECCS

2. RELAP5 Modeling

Nodalization for P-ECCS is shown in Fig. 2. This PECCS model is applied into the APR+ model and used for the performance analysis.

P-ECCS consists of SIT(H-SIT/M-SIT) and Automatic Depressurization System(ADS).

SIT is High pressure SIT(H-SIT) conception and it is applied Medium pressure SIT(M-SIT) in the existing plants. M-SIT is operated at 4MPa and H-SIT is operated 10MPa. SIT is injected in primary system, so remove the residual heat in the core.

For using the passive safety system, system such as ADS is reflected in system. When accident occurs, ADS perform functions which suddenly depressurize primary system for passive safety injection. ADS consists of four valves : ADV#1, ADV#2, ADV#3, ADV#4. ADV#1~#3 is installed in above pressurizer and ADV#4 is installed hot leg.

Performance standard which must confirm through the performance analysis is following.

1) confirm that it is possible reduce pressure below the IRWST injection pressure(about 2bar) for long term cooling.

2) Not exceed the Peak Cladding Temperature(PCT) setpoint(1477K) before reached the IRWST injection pressure.

3) Retain the time for injecting the IRWST

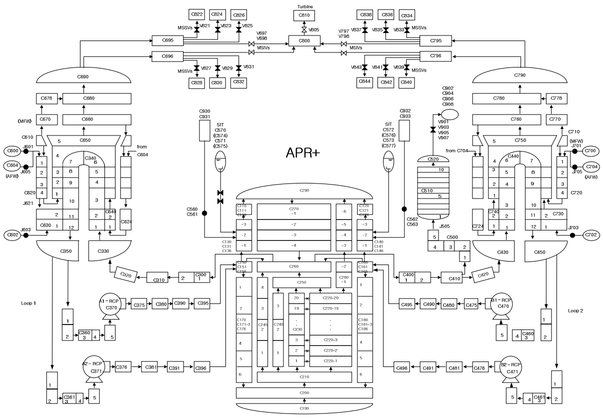

Fig. 2 P-ECCS nodalization

3. Performance Analysis and result

In this section performance analysis of Passive Emergency Core Cooling System is described.

Break size is 0.01ft^2. It is very small break size corresponding SLOCA and if depressurization is possible at IRWST injection pressure, depressurization is possible for break area which is bigger than 0.01ft^2.

Assumed basic input model is following.

1) 2 H-SIT model (Pressure 10MPa, liquid volume : 52.6m^3)
2)) 2 H-SIT model (Pressure 4MPa, liquid volume : 52.6m^3)
3) ADV model

ADV	Effective area (m^2)	Open signal
ADV#1	0.00225685	Pressurizer <9MPa
ADV#2	0.00225685	ADV#1 + 70sec
ADV#3	0.00225685	ADV#1 + 120sec

4) RCP stop/ MFW isolation/ MSIV isolation
5) H-SIT and M-SIT N2 is not isolated.
6) Using the choking model in Pressurzier surgeline

For the analysis performance, Sensitivity variable is selected and shown in table 1.

Table 1. Sensitivity variable

Title	Variable
liquid volume of SIT	(1) 52.6127 m^3 (2) 52.6127 m^3 X 1.5 (3) 52.6127 m^3 X 2.0
effective area of ADV#4	(1) 0.04965725 m^2 (2) 0.0993145 m^2 (3) 0.198629 m^2 (4) 0.397258 m^2
setpoint of ADV#4	(1) 1.7m (2) 1.8m
PAFS	(1) off (2) on

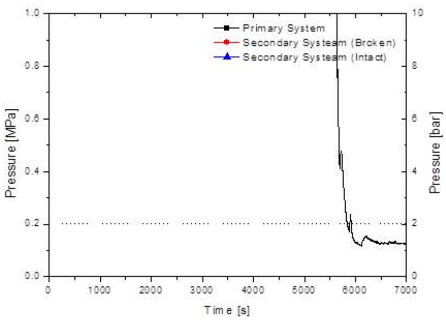

Fig. 3 Core Pressure

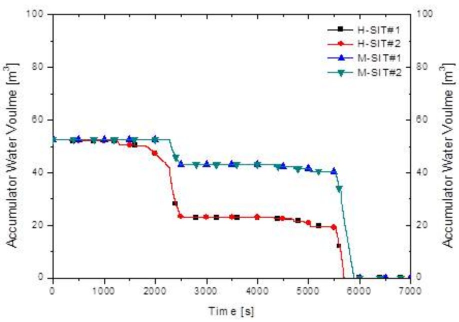

Fig. 4 Inventory of SIT

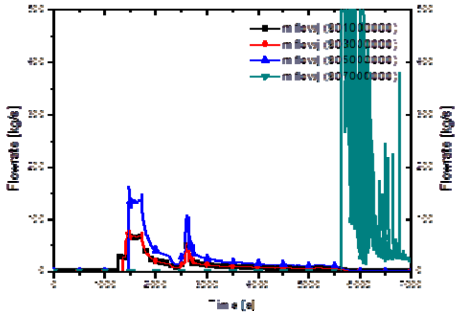

Fig. 5 Flowrate of ADV

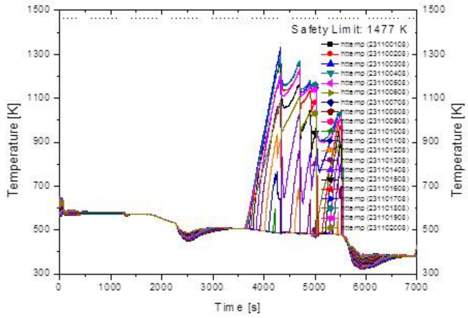

Fig. 6 Cladding temperature

Results of analysis are shown Fig. 3,4,5. This case is reduced pressure below the IRWST injection pressure(about 2bar) and then prevent the core damage(Fig. 3,6). Because SIT inventory is exhausted(Fig. 4) and release the many steam into the ADV#4(Fig. 5). However, if ADV#4 not opened or ADV#4 area is less than 0.0993145m^2 , pressure is not depressurized below the IRWST injection pressure.

4. CONCLUSION

In this study, the performance analysis for P-ECCS was carried out by using the RELAP5 code. From the simulation results, when LOCA occurs, the P-ECCS can remove the residual heat in the core and then prevent the core damage. However, to adopt passive safety design concept of APR+, P-ECCS is required to additional sensitivity analysis such as other accidents and various variable.

REFERENCES

[1] KHNP "Report of Technical Evaluation for Passive Safety Features " , S07NJ06-R-TR-007, 2008
[2] IAEA, 2009, Passive Safety Systems and Natural Circulation in Water Cooled Nuclear Power Plants, IAEA-TECDOC-1624.