Evaluation on the Simulation Capability of SPACE code with respect to System Pressurization

Eun Ju Lee*, Chan Eok Park, Min Soo Park, Jae Young Huh and Gyu Cheon Lee
KEPCO Engineering & Construction Company, Inc. Daedukdaero-989 113, Yuseong-gu, Daejeon, 34057
**Corresponding author ejlee@kepco-enc.com*

1. Introduction

Detailed thermal hydraulic analyses for loss of condenser vacuum (LOCV) with loss of off-site power for the Shin-Kori units 3 and 4 (SKN 3&4) were performed using the Safety and Performance Analysis CodE for nuclear power plants (SPACE) to evaluate the simulation capability of the system pressurization events. Several nodalization schemes for the components such pressurizer, reactor vessel and steam generator, have been tested to find out an optimized node for non-LOCA analysis. The sensitivity study was performed with various combinations of system parameters such as core inlet temperature, core coolant flow, pressurizer pressure/level, and so on, to find out the limiting initial conditions. The calculation results were compared with those of CESEC code which is the current licensing system code for non-LOCA.

2. Methods and Results

In this section, the analysis methodology using SPACE code and the results are described.

2.1 Identification of Event and Cause

A LOCV may occur due to the failure of the circulating water system to supply cooling water, failure of the main condenser evacuation system to remove noncondensible gases, or excessive in-leakage of air. Immediate cessation of feedwater flow is assumed after the event occurs, and the turbine is also assumed to trip immediately coincident with the cause for LOCV.

2.2 Nodalization

Several nodalization of reactor vessel, pressurizer, and steam generators, have been tested to find out an optimized node for non-LOCA analysis. Reactor vessel in the sensitivity study was considered with the number of core node, downcomer node and channel. Pressurizer and steam generator were considered with the number of node. The analysis results show that the reactor with axial six (6) nodes core, two (2) channels and two (2) nodes downcomer, pressurizer with seven (7) nodes, and steam generator with four (4) nodes downcomer, two (2) nodes evaporator, two(2) nodes preheater and twelve (12) nodes U-tube are reasonable. Based on the sensitivity results, the optimum nodalization scheme depicted in Figure 1 is derived for APR1400 non-LOCA analysis.

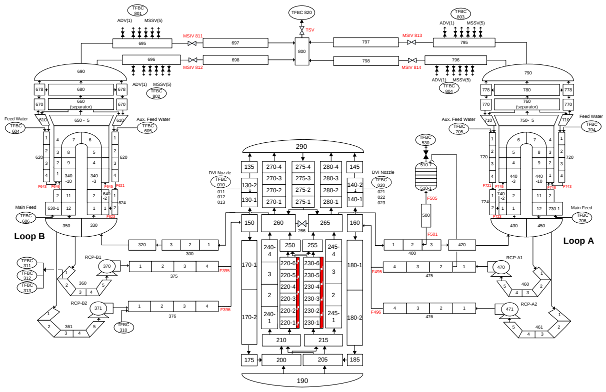

Fig. 1. Non-LOCA Nodalization for APR1400

2.3 Input Parameters and Initial Condition

The major initial condition parameters are core inlet temperature, core coolant flow rate, pressurizer pressure and level, and steam generator level. The sensitivity study was performed with various combinations among limiting conditions of operation (LCO) to find out the limiting initial conditions. It results in the similar initial conditions compared with those of CESEC.

Each initial parameter initialization is performed as following: The initial steam generator level, pressurizer pressure and pressurizer level are initialized through control systems, such as pressurizer level control system (PLCS) and feed water control system (FWCS). The reactor coolant flow rate is initialized by controlling the geometric K-factor in reactor coolant system. The core inlet temperature is also initialized by controlling the secondary pressure.

2.4 Results

Table I provides the results of LOCV using CESEC and SPACE code with limiting initial conditions. The limiting initial conditions are similar to each other. However, the RCS peak pressure is 2,742 psia with CESEC code and 2,731 psia with SPACE code. SPACE code is expected to show a slightly lower peak pressure than that of CESEC since SPACE considers the steam line volume of the secondary system. If the steam line volume of secondary system is not considered, the pressure and temperature of secondary system would be rapidly increased, and it would cause the primary system pressurization. Consequently, the steam line volume of secondary system plays a role in buffering effect of primary system pressurization. Dynamic behavior is presented in Figures 2~5.

Table I: Analysis results with limiting initial conditions

Parameter	CESEC	SPACE
Core Power	Max.	Max.
Core Inlet Coolant Temp.	Min.	Min.
Core Flow	100%	Min.
Pressurizer Pressure	Min.	Min.
Pressurizer Water Level	Min.	Min.
SG Water Level, %WR	65.0	66.0
LOOP delay, sec	6.0	7.0
RCS Peak Pressure, kg/cm^{2}A (psia)	192.8(2,742)	191.9(2,731)

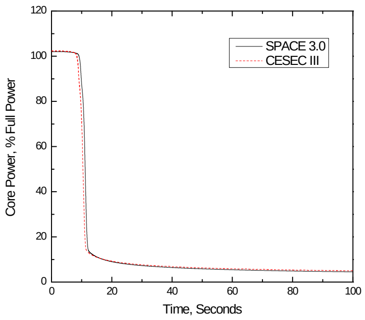

Fig. 2. Core Power

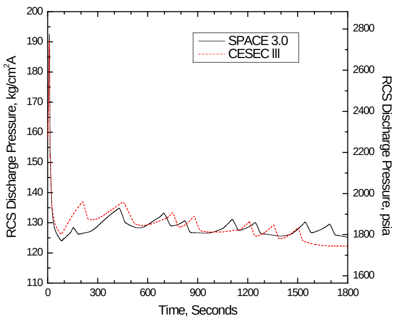

Fig. 3. RCS Pressure

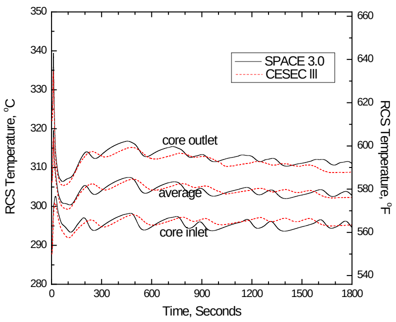

Fig. 4. RCS Temperature

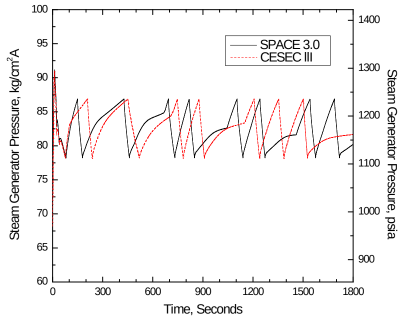

Fig. 5. SG Pressure

The analysis with same initial conditions was also performed. The RCS peak pressure is evaluated to be 2,742 psia, and 2,724 psia, respectively, for CESEC, and SPACE code.

3. Conclusions

LOCV with a loss of offsite power with some delay after turbine trip is calculated using the SPACE code. The analysis results show a good agreement with those of SKN 3&4 FSAR calculated by the CESEC code. This study shows that the SPACE code has sufficient capability to simulate the non-LOCA events resulting in the RCS pressurization with a reasonable conservatism

Acknowledgment

This work was supported by the Nuclear Research & Development of the Korea Institute of Energy Technology and Planning (KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy.

(No. 20161510101840)

REFERENCES

[1] Topical Report for the Non-LOCA Safety Analysis Methodology for Typical APR1400 with the SPACE code(Rev.4), KEPCO-ENC, KEPCO-KNF, KHNP, 2016.
[2] SPACE 3.0 User Manual, 2016
[3] E. J Lee, Analysis of a Loss of Condenser Vacuum Event using the SPACE code, Korean Nuclear Society Fall Meeting, 2011.
[4] SKN 3&4 FSAR, KHNP, 2011.