Assessment of TRACE Code for GE Level Swell Test to Review Industrial Code

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1. Introduction

Korea Institute of Nuclear Safety(KINS) has reviewed the industrial code for safety analysis of nuclear power plant, in which TRACE and MARS-KS codes are being used to support the understanding of specific phenomena and code prediction. For this aspect, the TRACE code was assessed for the GE Level Swell Experiment.

General Electric (GE) performed a series of experiments to investigate thermal-hydraulic phenomena such as critical flow, void distribution, and liquid-vapor mixture swell during blowdown conditions. These GE Level swell experiments are frequently simulated to verify safety analysis codes as a separate effect test.

TRACE code calculations with version 5.0 patch 4 for GE Level Swell experiment 1004-3 have been performed to assess the applicability of the TRACE code for verification of industrial code.

2. GE Level Swell

2.1 Small Vessel Test 1004-3 Facility

The GE Level swell experiments were conducted as part of the qualification task plan for reflood and refill test program. The small vessel was made of 1 ft (0.3048 m) diameter and 14 ft (4.267 m) height, schedule 80 pipe. It was instrumented with differential pressure (ΔP), pressure (P) gauges and thermocouples located along the vessel. The vessel discharge was guided to a suppression tank via 0.375 in. blowdown pipe, which included an orifice mounted near the vessel. The pressure vessel was filled with saturated water and steam with water reaching up to the axial level of 10.4 ft. Pressure is 1011 psia in the vessel. The small vessel schematic is shown in Fig. 1.

2.2 Simulation of Test 1004-3

The TRACE nodalizations of the small vessels are shown in Fig. 2. It consists of 2 PIPES and BREAK components to describe the pressure vessel, blowdown pipe with orifice, and suppression pool, respectively. The vessel was modeled using 13 and 26 fluid cells with TRACE. Initial condition of Test 1004-3 is presented in Table I. These values are from early version of RELAP5 assessment report except orifice.

The blowdown pipe was simulated by two ways in which the pipe was installed with 0.007 m diameter orifice and without orifice.

Table I: Initial condition of TRACE calculations

Parameters	TRACE
Vessel Diameter	0.28895 m
Vessel height	3.9624 m
Outlet Diameter	0.009236 m
Orifice Diameter	0.007 m
Pressure	6.971 MPa
Water Level	3.07848 m

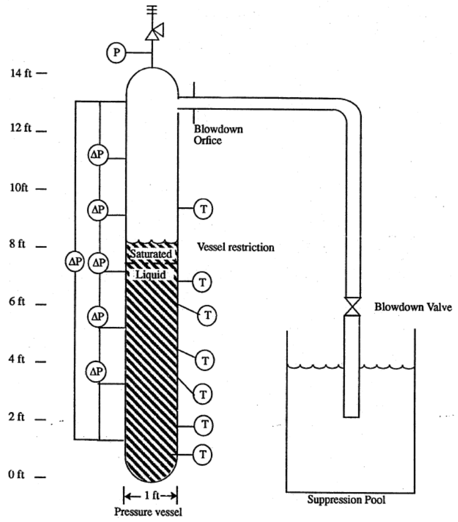

Fig. 1. Schematic of the experimental facility

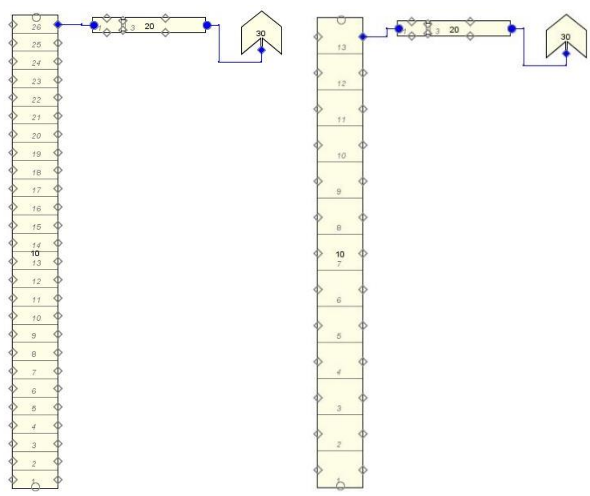

Fig. 2. Nodalization of TRACE

As soon as a calculation was started, a blowdown was initiated subsequently and choking was occurred at blowdown pipe.

The pressure vessel had been modeled using 26 cells at assessment reports of RELAP5 and SPACE Code. Through the sensitivity study of the nodalization, however, TRACE shows that the results using 13 cells and 26 cells are same.

3. Results and Discussion

Fig. 3 illustrates the comparison between the pressure of experiment and codes which are is measured at the top of the pressure vessel. RELAP calculation shows a good agreement with the experiment although the blowdown pipe was simply described as a single junction in the same way as the RELAP assessment manual. SPACE predicted slightly lower pressure than the experiment and other codes. TRACE with orifice is well fitted with experiment results on the same level with RELAP. To get this best results for pressure, the orifice was included. Without orifice, however, TRACE underestimate the pressure than SPACE.

Fig. 4 and 5 show a comparison between the calculated and measured void fractions along the axial level. The calculated void profile of TRACE is in a good agreement with the measured data. As shown in Fig. 5, void fraction of TRACE without orifice is better agreement with the experiment data than TRACE including orifice at 100 sec. At the later part of the transient, the void fraction trends are more different between the codes. In the topical report of the SPACE code, however, the result for void fraction was shown only at 10 sec which is too early time of the transient to judge the accuracy of the SPACE code. For this reason, it is need to check the void fraction of SPACE after 60 sec which is appeared lower pressure than the results of experiment and other codes.

4. Conclusion

An Assessment analysis of the TRACE version 5.0 patch 4 code was carried out for GE Level Swell experiments 1004-3 by comparison purpose with SPACE. Overall, TRACE predicted the pressure and axial void fractions at different times reasonably well for 1004-3 blowdown test, while SPACE tends to underestimate the pressure. It was also found that results of void fraction distribution should be compared at different time to discuss the accuracy of the SPACE code against this test.

ACKNOWLEDGEMENTS

This work was supported by the Nuclear Safety Research Program through the Korea Radiation Safety Foundation(KORSAFe) and the Nuclear Safety and Security Commission(NSSC), Republic of Korea (Grant No. 1305002)

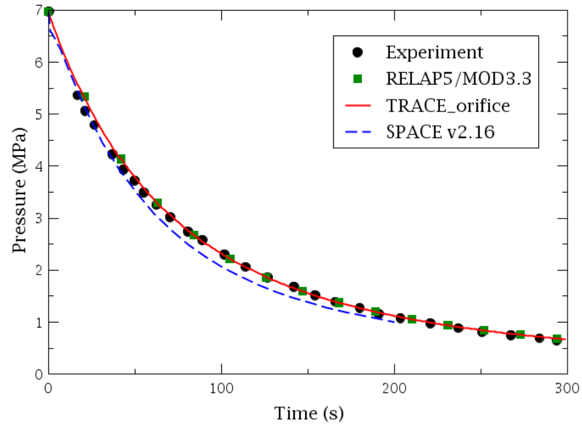

Fig. 3. Time-dependent pressure of the test 1004-3

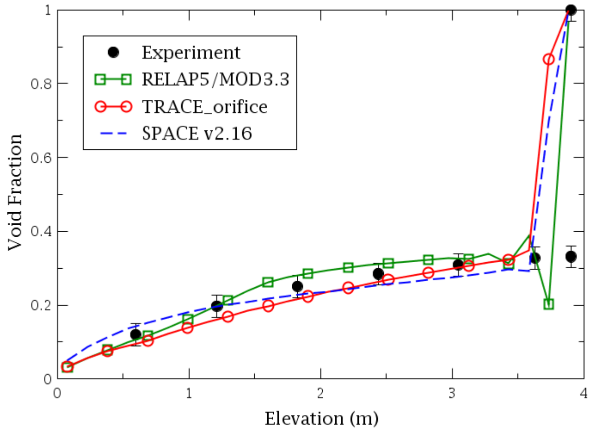

Fig. 4. Axial void fraction at 10 sec.

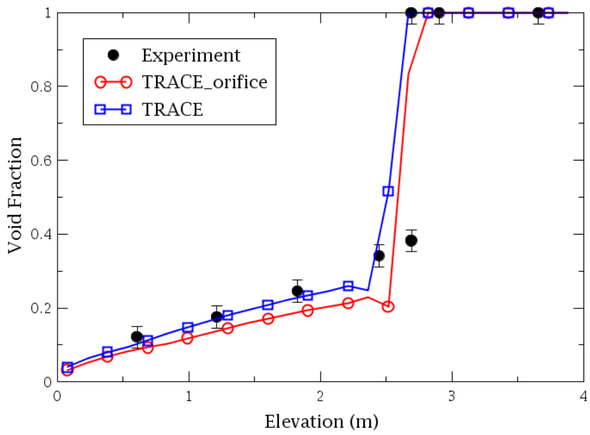

Fig. 5. Axial void fraction at 100 sec.

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