The Development of the Code Safety Valve Test Facility

Chang Hyun KIM, Young Ae KIM, and Jong Woon PARK
Korea Hydro & Nuclear Power Co., Ltd., 25-1, Jang-Dong, Yuseong-Gu, Daejeon, 305-343, chkim@khnp.co.kr

1. Introduction

The Pressurizer Safety Valves (PSV) in Pressurized Water Reactors (PWRs) are required to provide the overpressure protection for the Reactor Coolant System (RCS) during the overpressure transients. According to the ASME OM code, all safety valves should be tested every 5 years with the acceptance tolerance of 1%. If one valve failed to meet this criterion, other two additional valves should be tested and if these valves don't meet the requirement, all valves should be tested. These frequent tests may make the valves decrepit and become a cause of leak. Therefore, increase of the acceptance tolerance is vital for the safe operation of the plant. In the United States, the acceptance tolerances are enlarged up to about 3% in most plants. This requires re-analysis of relevant accidents in FSAR. Also, the technical background data for the valve pop-up characteristics and the loop seal dynamics (if the plant has the loop seal in the upstream of PSV) are needed for the new safety analysis.

Korea Hydro and Nuclear Power Company (KHNP) plans to build the PSV test facility for the purpose of providing the background data. This paper describes the preliminary design of the facility and studies on the system dynamics using GOTHIC-7.2a code[1] to verify the pressure vessel capacities and to find the best operating condition.

2. Design of PSV Test Facility

A schematic diagram of the PSV test facility is shown in Fig.1. The test facility is designed to test the pop-up and lifting characteristics of the safety valves. The facility is able to test all types of PSVs including loop seals of the Westinghouse type plants. The facility consists of the accumulator, test vessel, pressure relief tank (PRT), loop seals, two boilers, safety valves, pumps, pipes, and so on. The accumulator includes the heater to assist boiler. The pressure of test vessel is controlled by the control valve installed between the accumulator and the test vessel.

The design pressure and temperature are 230 kg/cm^2 (22.56 MPa) and 400 ^{o}C, respectively. The operating pressure and temperature are assumed as 210 kg/cm^2 (20.59 MPa) and 370 ^{o}C, respectively. The volume of accumulator and the PRT is 10 m^3 and the volume of test vessel is 3 m^3. The thickness of the tank is determined in accordance with the ASME code Sec. III. The two loop seals will be made by the same size as in the Kori 3,4 and the average value of the Kori 1,2. The Crosby safety valve (HP-BP-86, 6M6) will be tested. Its set pressure is 2,485 pisg (174.7 kg/cm^2) and rated relieving temperature is 650 ^{o}F (343 ^{o}C). The discharged capacity is 380,000 lbm/hr (47.88 kg/s) [2].

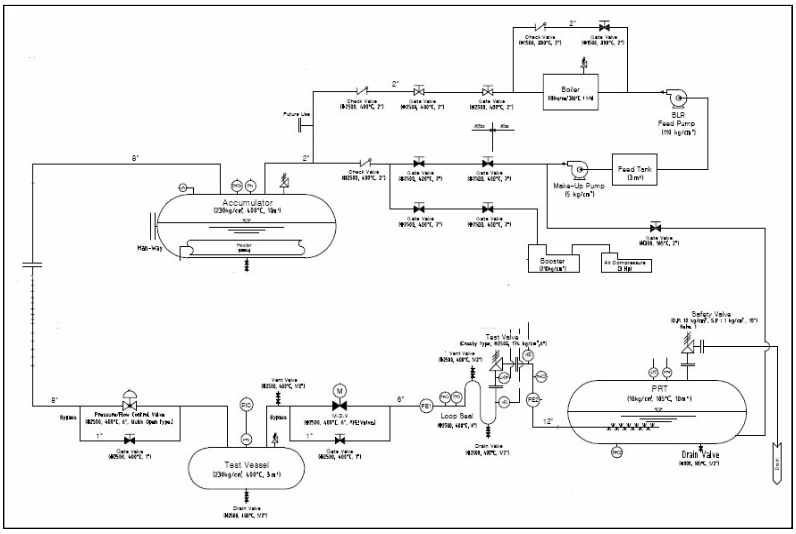

Fig.1 Schematic Diagram of the KHNP PSV Test Facility

3. Results and Discussion

The calculation of the valve opening time and the reseating time are performed using GOTHIC-7.2a code to verify the capacities of the pressure vessel and to find the best operating condition. Opening time is defined as the time from the starting transient to the time of valve opening; the reseating time is the time from valve opening to the valve closing. The GOTHIC (**G**eneration of **T**hermal-**H**ydraulic **I**nformation for **C**ontainments)[1] code is an integrated, general purpose thermal-hydraulics software package for design, licensing, safety and operating analysis of nuclear power plant equipments, pipes and containments.

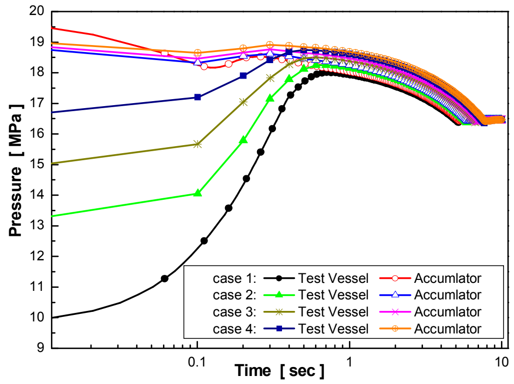

Fig.2 Pressure transient behavior of the accumulator and the test vessel with various initial pressure of the test vessel.

The transient behavior of the accumulator and the test vessel is simulated and shown in Fig.2 for the various initial pressure of the test vessel. The accumulator supplies higher pressure steam to the test vessel. The operating condition of the accumulator for all cases is assumed as the saturated condition at the pressure and temperature of 200 kg/cm^2 (19.61 MPa) and 364.6 ^{o}C, respectively. The pressure of test vessel was assumed variable from 100 to 160 kg/cm^2 (9.8 to 15.7 MPa) with the intervals of 20 kg/cm^2 (1.96 MPa). The discharged flow through the PSV is assumed as its maximum capacity, 380,000 lb/hr (47.88 kg/s) [2]. The control of the valve between the accumulator and the test vessel is not modeled in the present study.

Table 1. Time of opening and reseating the valve according to the test vessel pressure

Pressure of Test Vessel [kg/cm^2]	Opening time [sec]	Reseating time [sec]
100 (9.8 MPa)	0.39	5.24
120 (11.8 MPa)	0.40	5.9
140 (13.7 MPa)	0.30	6.7
160 (15.7 MPa)	0.10	7.7

The time of opening and reseating of the valve is shown in Table 1. The time zero means the full opening of the 8 inch control valve and the starting transient of the accumulator and the test vessel.

The accumulator pressure initially undergoes a sudden pressure drop to fill the lower pressure steam volume of the test vessel except for the case of the test vessel pressure of 160 kg/cm^2 (15.7 MPa). As the initial pressure of the test vessel is higher, the valve opening time is shorter and the valve reseating time increases. In all cases, the pressure vessel design capacities are adequate to open the PSVs. As shown in Table 1 and Fig.3, the valve reseating time is ranging from 4.85 sec to 7.6 sec. These times are sufficient to test the overall dynamics of the PSV and loop seals. However, the valve opening time is so short that the hydraulic load by steam from the accumulator to the test vessel should be very high and the data resolution will not be good. Therefore, the valve between the accumulator and the test vessel should be controlled and further detail modeled to adjust the opening time of the PSV.

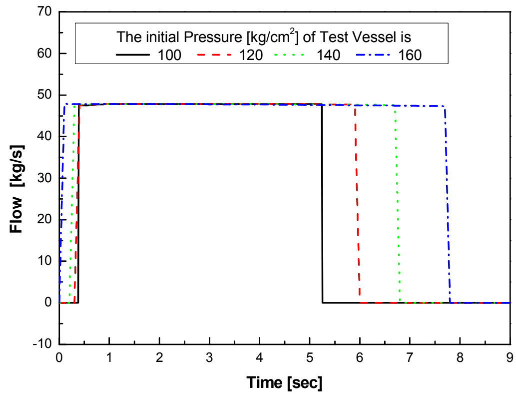

Fig.3 Comparison of the PSV discharge flow with the initial pressure of the test vessel.

4. Conclusions

A KHNP PSV test facility is designed and will be constructed to provide the background data for the safety analysis to enlarge the acceptance tolerance of PSVs. The design is introduced and the studies are presented on the valve set point arrival time and the valve reseating time using GOTHIC-7.2a code to verify the capacities and to find the best operating condition. It is found that the pressure vessel design capacities are adequate and the reseating time is sufficient to model the overall overpressure transient. The opening time is too short for the resolution and need to be adjusted by the control valve installed between the accumulator and the test vessel. This will be further evaluated in the near future.

Acknowledgment

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REFERENCES

[1] Numerical Applications Inc., GOTHIC Containment Analysis Package, Technical Manuals, 2006.
[2] KHNP, KORI Unit1, Final Safety Analysis Report, Chapter 6, Table 5.1-1.