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Evaluation of the IRWST design load according to the change of the POSRV

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1. Introduction

The POSRVs are adopted for overpressure protection, pressure reduction, and Feed & Bleed operation in the reactor coolant system at SKN3,4 Nuclear Power Plant [1]. The operation of the POSRVs discharges the reactor coolant into the IRWST through the sparger. The previous test results according to the sparger operating condition in the PWR show that the thermo-hydraulic load is rarely influenced by air temperature, water temperature, and air volume. It is somewhat influenced by water level, and quite influenced by the valve opening time [2]. Recently, SKN3,4 Nuclear Power Plant replaces the POSRVs to reduce the valve opening time to 0.3 s. It is necessary to evaluate the effect of the reduced valve opening time, on the IRWST load. In this study, a device that has the same operating environment as that of the new valve is prepared, and an air discharge test is conducted, in collaboration with KAERI.

2. Methods and Results

2.1 Test Parameters

In the preliminary test, air temperature, air volume, and water temperature are used as variables. The pressure in the pressurizer and the water level are fixed. The valve opening time is set at 0.3 s or less. Table 1 shows the main test variables and the initial conditions used in the preliminary test.

Table 1: Test matrix (preliminary test condition)

Test ID	Air (lb)	PZR (MPa)	Air (°C)	Water (°C)	Level (m)
T-1	1.5	15.1	50	50	3.70
T-2			90		
T-3	2.5		50		
T-4			90		
T-5	3.6		50		
T-6			90		
T-7	1.5		50	80	3.76
T-8			90		

2.2 Test Facility

The test facility for this test is modified the existing device. An air chamber is added to the steam discharging pipe system, and this chamber is isolated using two valves. The air volume required in the test is obtained by pressurizing the air stored in the air chamber using the pressurizer. The air temperature is controlled using the tracer heater. During the test, two isolation valves are sequentially opened to make the steam in the pressurizer push the air through the sparger into the IRWST. In the test device, a prototype sparger used at SKN3,4 Nuclear Power Plant is installed. Fig. 1 shows the schematic diagram of the conceptual appearance.

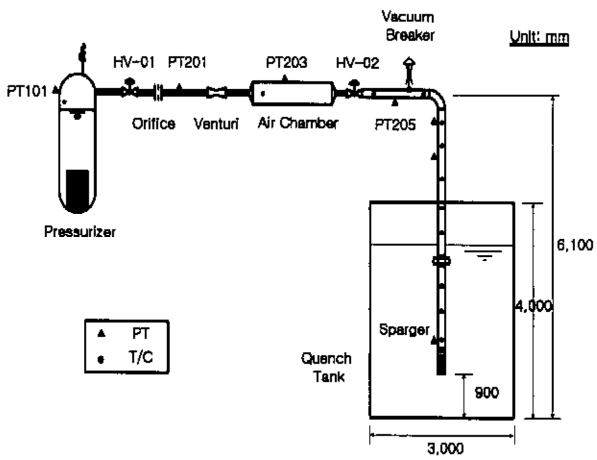

Fig. 1 Arrangement of components and instruments in the B&C Loop

2.3 Test Condition

The condition in which the load is high in the preliminary test must be found for the repeated test. When the valve opening pressure, opening time, and water level are determined, the factors that influence the load are air volume, temperature, and water level. Eight preliminary tests are conducted to select the initial values for these factors. And the conditions for the repeated test, which would be repeated according to the preliminary test results, are determined. This test is conducted twelve times resulting in a total of 20 tests. The conditions are shown in Table 2.

Table 2: Test matrix (repeated test condition)

Test parameter	Initial condition
Air mass in the discharge line	1.5 lb

Valve opening pressure	15.1 MPa
Valve opening time	Within 0.3 seconds
Air temperature in the piping	50 °C
Sparger submergence	2.8 m
IRWST pool temperature	50 °C

Fig. 2 shows the schematic diagram for the position of the dynamic pressure gauge in the IRWST and measurement points.

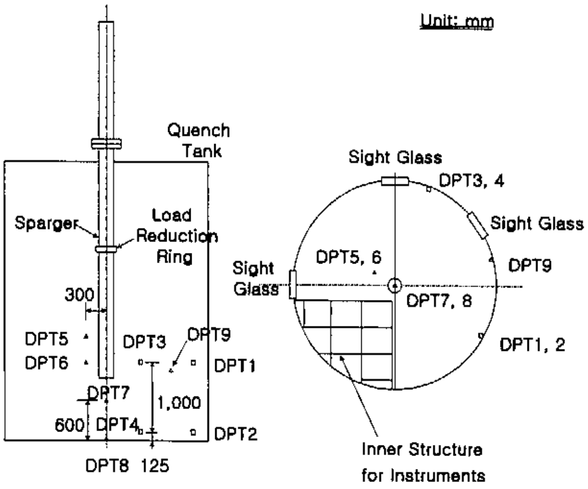

Fig. 2 Location of dynamic pressure sensors in the IRWST

2.4 Results

(1) Initial Condition Evaluation

All the results from the twelve tests are very close to the set values. Therefore, the reliability of the repeated tests can be adjudged as very high. The valve opening time is always 0.3 s or less, which corresponded to the test condition. The test results with average values less than 0.3 s can be adjudged as conservative.

A short valve opening time generally leads to an increase in the load. Fig. 3 shows the results of the relationship between valve opening time and maximum load.

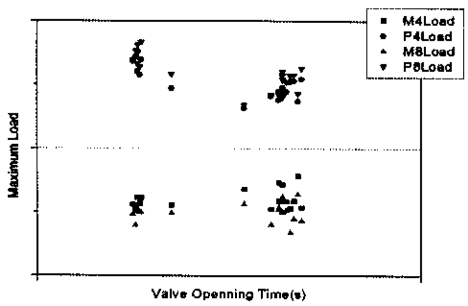

Fig. 3 Relationship with valve opening time and Maximum Load

(2) Load distribution in the IRWST

Fig. 4 shows the maximum and minimum loads of the pressure wave measured at the wall and bottom of the IRWST. The load is highest at the bottom, and lowest at the side injection hole of the sparger.

The reason seems that the distance from sparger to bottom is more closer than that from sparger to wall of IRWST. The average load at the bottom of the IRWST is less than the half of the design pressure.

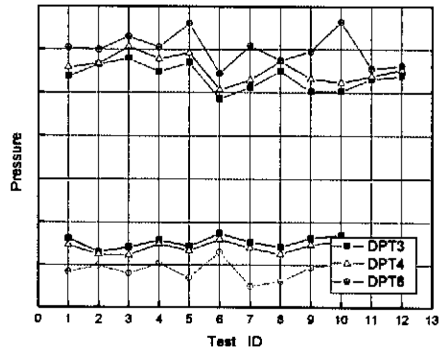

Fig. 4 Results for dynamic pressure distribution (DPT3, DPT4, DPT8)

3. Conclusions

As a result of this study, the effects of the air volume, air temperature, water level and water temperature on the IRWST load are generally found to be insignificant [3]. When the valve opening time is reduced, the load tends to increase. But the increased value of the load is still much smaller than that of design pressure. The repeated test results are statistically processed including errors to compare them with the load values that are applied to the design. The comparison of the conservatively calculated repeated test results with the load value applied to the SKN3,4 IRWST shows that the design margin is sufficient.

REFERENCES

[1] KHNP, Preliminary Safety Analysis Report, 2008

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