Performance Verification Tests for the APR1400 Fluidic Device

I.-C. Chu, N. H. Choi, C. H. Chung, B. H. Cho, C.-H. Song
Korea Atomic Energy Research Institute, 150 Dukjin-dong Yusong-gu Daejon 305-353 Korea, chuic@kaeri.re.kr

1. Introduction

Emergency core cooling system of APR1400 adopted a new design concept of a passive flow controller, called "Fluidic Device", which is installed inside the safety injection tank.

Throughout the previous R&D project, a prototypical test facility, called VAPER, had been constructed to evaluate the flow controlling performance of full scale fluidic device[1, 2], and the design specification of fluidic deivce that satisfied the APR1400 standard design requirement was developed[3].

The main objectives of the present study are to verify the performance of APR1400 fluidic device using VAPER and to conform the repeatability of the fluidic device performance.

2. Experiments

2.1 Fluidic Device and VAPER

As a wholly passive component with no moving part, fluidic device controls the discharge flowrate in accordance with the strength of vorticity inside the fluidic device. ECC water can be more effectively utilized via APR1400 fluidic device, that is, the same high ECC injection rate with conventional SIT is achieved at early stage of LBLOCA and prolonged low ECC injection rate is provided during reflood stage.

Detailed design and working principle of the APR1400 Fluidic Device are provided in [3].

VAPER (Valve Performance Evaluation test Rig) consists of full scale SIT, prototype fluidic device, water reservoir with capacity of 97m^3, air compression system upto 50 bar, data acquisition and control system, and associated utilities.

SIT has an inner diameter of 2.74m, a height of 11.95m, and a volume of 68.13m^3, in addition it has the same geometrical size with APR1400 SIT.

2.2 Quality Assurance Program

The achieve the highest quality of the experimental results, a quality assurance program for fluidic device tests has been developed by adopting the requirements relevant to R&D project from the quality assurance requirements of ASME NQA-1[4]. Every procedure of experiment has been carried out under the control of the quality assurance program.

3. Results

A total of 4 repeatability tests were carried out at reference test condition and one reduced pressure test (FD-5) was performed to enhance the reliability of the K-factor of the fluidic device. Test-1 denotes the test previously performed to develop design specification. A summary of the test results is provided in table 1.

Table 1. Summary of test results

Test ID	Peak Flow (kg/s)	Total Duration (sec)	VAPER FD K factor (high/low flow):	APR1400 ECCS K factor
Test -1	1000	165	~18.8/159.7	17.7/105.6
FD -1	1040	160	**~16.2/156.3**	**16.1/103.5**
FD -2	1010	160	**~15.6/159.8**	**15.7/105.7**
FD -3	1005	165	**~16.2/159.2**	**16.1/105.3**
FD -4	1005	165	**~15.7/162.6**	**15.8/107.4**
FD -5	780	210	**~15.2/169.4**	**15.5/111.7**

3.1 SIT and Stand Pipe water level

Figure 1 shows the water level inside SIT and stand pipe measured by differential pressure transmitter. The slope of SIT water level is decreased at turndown point, which agrees well with the turndown point indicated by stand pipe level measurement.

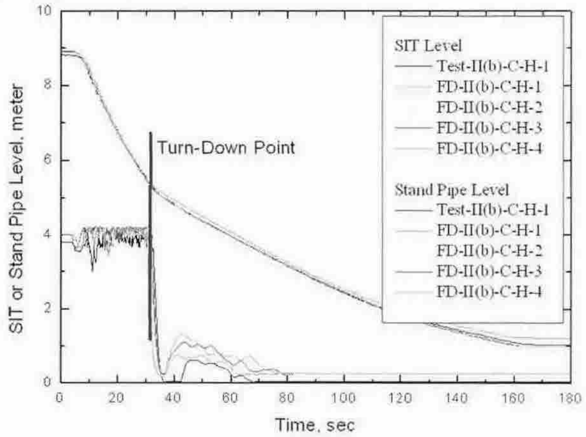

Figure 1. SIT and Stand Pipe water level

3.2 ECC water discharge flow rate

The discharge flow rate is deduced from the decrease rate of the SIT water level. As can be seen in Fig. 1, the SIT water level decreases almost linearly. Therefore the water level decrease rate can be approximated to the first order differentiation without causing a significant error.

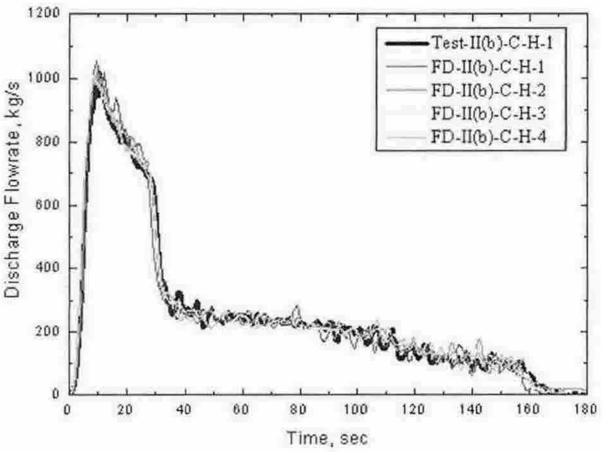

Figure 2. ECC water discharge flow rate

3.3 Fluidic Device K-Factor

Figure 3 shows the K factor of fluidic device obtained in the VAPER facility. However, the diameter of discharge piping in actual plant is slightly different with that of VAPER. Table 1 shows the K factor of APR1400 ECC piping system (fluidic device K factor + piping K factor), taking the difference into account. As can be seen in Table 1, the K factors of APR1400 are almost similar with the design goal of Shin-Kori 3 & 4 (K factor of 17 at high flow rate, 100 at low flow rate)

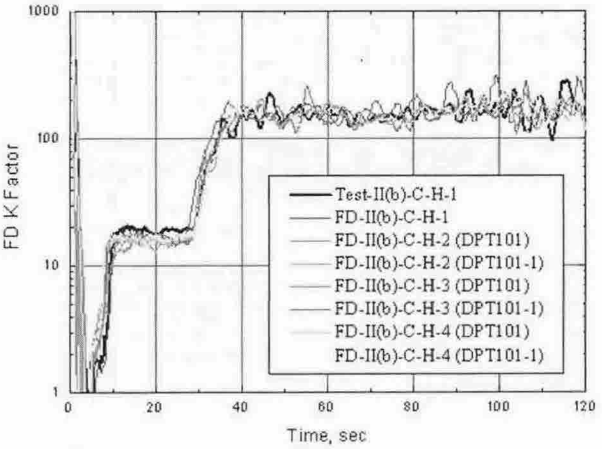

Figure 3. K factor of fluidic device

3.4 Air Discharge

About 100 seconds after the initiation of ECC injection, water level in the stand pipe is depleted. Thereafter, the air inside the top of SIT can flow out from the SIT. Figure 4 shows air discharge mass flow rate. Applying ideal gas law, the discharge flow rate is evaluated from measured air temperature, pressure, and volume.

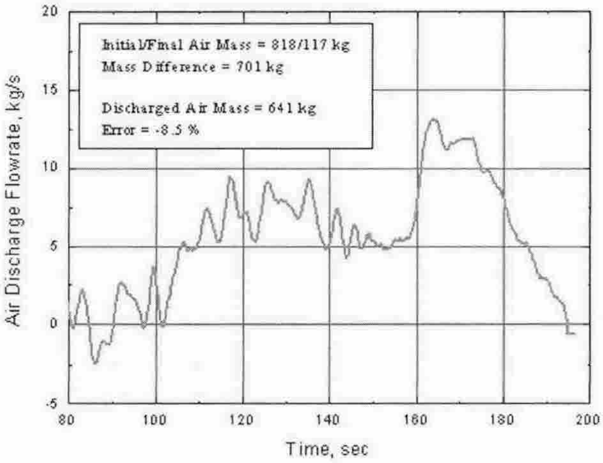

Figure 4. Air discharge flow rate (FD-2 test)

3. Conclusion

Throughout the present experiments, the performance of APR1400 fluidic device was verified and the repeatability of major performance-related parameters was conformed.

The peak ECC water discharge flow rate was about 1,000 kg/s, and total discharge duration was about 165 sec.

The K factors of APR1400 ECC piping system were about 16 for high flow rate and 105 for low flow rate, which are almost same with the design goal.

REFERENCES

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