Performance Test Procedure for Fuel Test Loop

Sung Ho Ahn*, Jong Min Lee, Su Ki Park, Dae Young Chi, Bong Sik Sim,
Chung Young Lee, Young Ki Kim, Kye Hong Lee
Research Reactor Engineering Division, Korea Atomic Energy Research Institute,
1045 Daedeok-daero, Yuseong-gu, Daejeon, 305-353, Korea
**Corresponding author: shahn2@kaeri.re.kr*

1. Introduction

Fuel Test Loop (FTL) is a test facility which can conduct a fuel irradiation test at HANARO [1]. The FTL simulates commercial NPPs' operating conditions such as their pressure, temperature, flow, water chemistry and neutron flux levels to conduct the irradiation test. The performance test of the FTL has been performing since April, 2007 and expected to be completed in the last half of 2009. In this paper, the performance test procedure for the FTL is introduced.

2. Performance Tests for FTL

Figure 1 shows a schematic diagram of the FTL. The FTL is composed of an OPS (Out Pile system) and an IPS (In-Pile test Section) [2][3]. The OPS is composed of a process system and I&C (Instrumentation and Control) system. The IPS is to be loaded into the IR-1 position in the HANARO core.

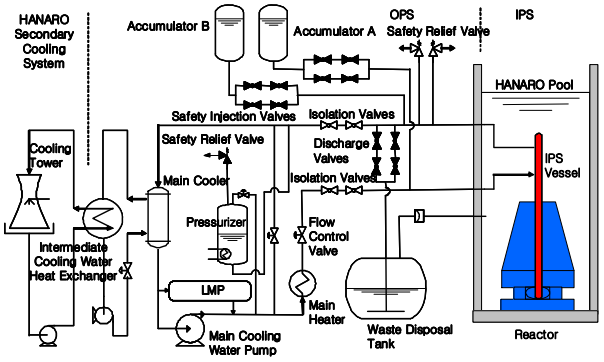

Fig. 1. Schematic diagram of the FTL.

The performance test of the FTL is performed in three stages. An individual system performance test under room temperature condition is performed in the first stage, and the integral system performance test with mock-up fuels under high temperature condition is performed in the second stage, and finally the integral system performance test with test fuels under high temperature condition is performed in the third stage.

2.1 Individual System Performance Test

The individual system performance test is performed with three sub-stages such as the function tests for electric and control devices, the performance tests for electric and control systems, and the performance tests for process systems. Table I shows the list of individual system performance test. The main purpose of the individual system performance test is to confirm the design date at room temperature.

Table I. List of individual system performance test

Stage 1	Performance tests
Function tests for electric and control devices	- Transmitters (press., diff. press.) - Switches (pressure, level) - RTDs - Detectors (dissolved oxygen, hydrogen, conductivity)
Performance tests for electric and control systems	- Electric system - Computer control system - Data acquisition system - Safety related control system
Performance tests for process systems	- Main cooling water (MCW) system - Emergency cooling water system - Penetration cooling water system - Letdown, makeup, and purification system - Intermediate cooling water system - Waste storage and transfer system - Sampling system - Radiation monitoring system - IPS inter-space gas filling and monitoring system - Miscellaneous systems

2.2 Integral System Performance Test with Mock-up Fuels

After the individual system performance test, the integral system performance is confirmed at high temperature condition with mock-up fuels. The FTL operation for passivation is performed at the first time of the integral system performance test. The purpose of the passivation is to generate a protective film on pipes. Table II shows the list of integral system performance test with mock-up fuels.

FTL operation modes are divided into LSD (Loop Shutdown), CSB1 (Cold Standby 1), CSB2 (Cold Standby 2), HSB (Hot Standby) and HOP (Hot Operation) as shown in Table III [4]. Figure 2 shows the pressure temperature diagram for FTL operation. The integral system performance test is performed at each operation modes. Table IV shows the limit criterion for the water chemistry of MCW system.

Table II. Integral system performance test (mock-up fuels)

Stage 2	Performance tests
Integral system performance test with mock-up fuels under high temperature condition	- Performance test for main heater - Performance, heat loss, and level control tests for pressurizer - Heat loss test for pressurizer - Flow measurement test for main cooling system - Vibration and thermal expansion test for MCW system - Water chemistry analysis test for MCW system - Emergency cooling water injection test - Nuclear heat measurement test - Neutron flux measurement test

Table III. FTL operation mode

Parameter	LSD	CSB1	CSB2	HSB	HOP
MCW Temp. (°C)	T<50	T<50	50≤T < 90	90≤T < 300	270≤ T
MCW pump	Off	On	On	On	On
Main heater	Off	Off	On	On	Auto
Pressurizer heater	Off	On	On	On	On
Reactor power (MW)	0	0	0	0	30

Table IV. Limit criterion of MCW chemistry

Items	Limit criterion
F^-	≤ 0.15 ppm
Cl^-	≤ 0.15 ppm
SO_4^{-2}	≤ 0.15 ppm
DO (at coolant temp ≥ 121.5°C)	≤ 0.1 ppm
pH	5.5 ~ 8.0
Conductivity	≤ 50 μS/cm

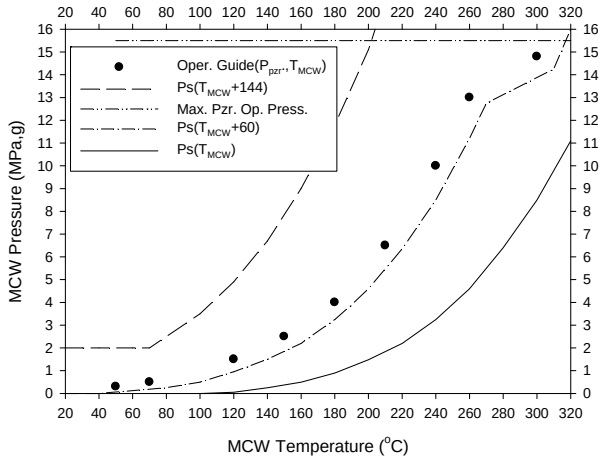

Fig. 2. Pressure-temperature diagram.

2.3 Integral System Performance Test with Test Fuels

The performance of the FTL is performed finally at the integral system performance test with test fuels as shown in Table V. The main purpose of this test is to confirm again the major parameters after the test fuels are installed, which is already performed at the integral system performance test with mock-up fuels.

Table V. Integral system performance test (test fuels)

Stage 3	Performance tests
Integral system performance test with test fuels under high temperature condition	- Reactor power increasing test - Flow measurement test for main cooling system - Water chemistry analysis test for MCW system - Neutron flux measurement test - Radiation measurement test

3. Conclusions

This paper introduced the performance test procedure for FTL in HANARO. The individual system performance test and the integral system performance with mock-up fuels are finished successfully. The integral system performance with test fuels is being performed and will be completed in the last half of 2009. After completion of the performance test, the FTL will be applied to the fuel irradiation test.

ACKNOWLEDGEMENTS

This research has been carried out as a part of the nuclear R&D program funded by the Ministry of Education Science and Technology in Korea.

REFERENCES

[1] S. H. Ahn., et. al., Fuel test loop in HANARO, Proceedings of the 2008 Water Reactor Fuel Performance Meeting (WRFPM), Oct. 19 – 22, 2008, Seoul, Korea.
[2] S. K. Park., et. al., Analyses of the small break loss-of-coolant accidents for the HANARO fuel test loop, Journal of Korea Society of Mechanical Technology, Vol.10, No. 2, p. 35-41, 2008.
[3] J. M. Lee., et. al., Thermal stress analysis on the in-pool by-pass pipe, Journal of Korea Society of Mechanical Technology, Vol.10, No. 4, p. 7-11, 2008.
[4] S. K. Park, Operation procedure for FTL start-up and shutdown, HANTAP-05-OD-ROP-OP-60, Korea Atomic Energy Research Institute, 2008.