The Results of the Emergency Water Core Injection Flow Rate Test in HANARO

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1. Introduction

When the water level of a reactor pool descends to an extremely low level due to a loss of reactor pool water accident in HANARO, a multi-purpose research reactor of a 30 MWth, the emergency water stored in the emergency cooling water storage tank should be injected to the core of HANARO by a gravity force. It is impossible to periodically measure an injection flow rate under an emergency condition because the reactor pool maintains a normal water level for a cooling of the core during a reactor operation.

Last year, the reactor pool water was temporarily transferred to the storage tank. And the water level descended to EL 77.5 m, 0.4 m above the extremely low level to install the in-pile section of a Fuel Test Loop project in the reactor core [1]. When the water was re-transferred into the reactor pool, an emergency water injection test was conducted. This paper describes the results of the test including the test methods, results and conclusions.

2. Test methods

The emergency water supply system (EWSS) of HANARO is composed of an emergency water storage tank, four injection valves, a reactor sump, two sump pumps, two loops for a reactor core injection and a reactor sump injection, piping and instruments as shown in fig. 1. When the reactor operates normally, the EWSS is under a standby condition to supply the emergency

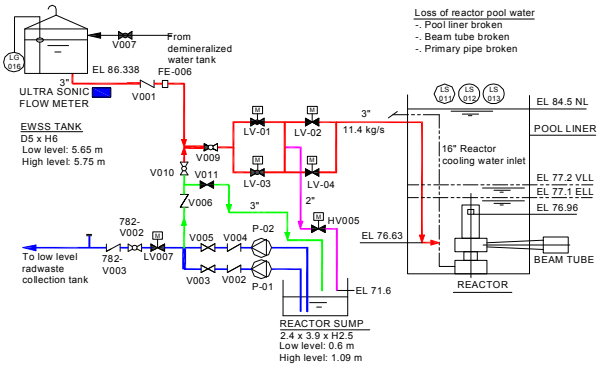

Figure 1 Schematic diagram of EWSS

Table 1 Test conditions compared with the system design requirements

Description	Design condition		Test condition
Water level of RX pool, EL, m	Extremely low	77.1	77.5
	Very low	77.2	
Water level of emergency water storage tank, EL, m	Low level	92	91.6
	High	92.1	
Core injection flow rate, kg/s	11.4		–
Internal section area of injection pipe, 3", sch. 40S, m²	-		4.77E-03

water for a cooling of the reactor core during a loss of reactor pool water when a beam tube, a liner plate or a primary cooling water pipe line is broken [2].

When the water level descents to an extremely low level, two of the three level switches (LS-014/015/016) are actuated, four injection valves (LV-001, 002, 003 and 004) are opened and the emergency water is injected to the core through the flow control valve (V009), the system flow meter (FE-002), the injection valves and the 16" reactor cooling water inlet line as shown in fig. 1. The injection flow rate should be maintained above a design injection flow rate. When the water level returns to a very low level, two of the three level switches are actuated, four injection valves are closed and the emergency supply is stopped.

When the core injection flow rate test is conducted, the test conditions are listed in table 1 to estimate the injection flow rate. According to combing the injection valves, there are a minimum of three emergency water injection methods as follows;

Case 1: When an injection loop fails due to a mechanical damage, the flow passes through the injection valves, V001 and V002 or V003 and V004

Case 2: When an injection valve of each loop fails, the flow passes through the injection valves V001 and V004 or V003 and V002

Case 3: When each injection loop is normally operated, the flow passes through the injection valves V001, V002, V003 and V004.

The injection flow measurements were made five times of five second injection intervals for every one turn of the control valve open. At the same time, the water level of the storage tank was measured with the same method.

3. Test results and considerations

For each additional flow control valve turn, figure 2 indicates the injection flow rates of each case which were measured by the system flow meter (Case-FE) and the ultra sonic flow meter (Case-US) and the water levels of the storage tank measured by the level indicator (LG-016). As shown in the figure, the injection flow rate measured by the system flow meter is higher than that measured by the ultra sonic flow meter. It is considered that an air pocket remaining in the measuring device is not vented.

For a conservative approach, we took the flow rates measured by the ultra sonic flow meter for a review of the injection flow rate. Between them measured by the ultra sonic flow meter that of case 2 is the least because of considerable local friction losses for bypassing a failed

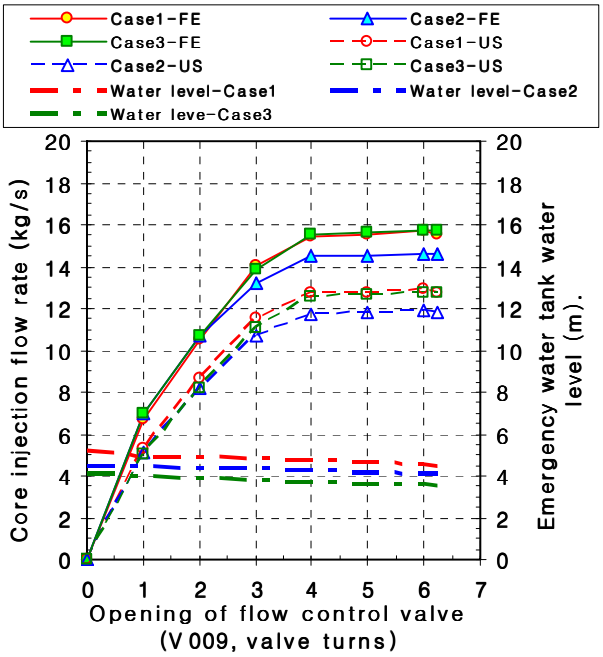

Figure 2 Test results of core injection flow rate per the water level variation of the emergency water supply tank

valve of each injection loop. The flow control valve is set at 3.5 turns to a partially open position for maintaining the design injection flow rate of 11.4 kg/s [3]. From the figure, it was confirmed through the measurement that the flow rate measured by the ultra sonic flow meter indicates 11.46 kg/s, a little high than the required design flow rate. At that time, the water level of the emergency water storage tank indicates about 4.3 m from the tank bottom. Thus, despite that the water level of the emergency water storage tank is about 1.3 m below the low water level of the storage tank, it is possible that the control valve can maintain the design injection flow rate.

After the field measurement, an injection flow rate was recalculated under the design conditions of an extremely low water level of the reactor pool for compensating for a level difference under the flow injection test. After the compensation, the injection flow rate of case 2-UL, the lowest flow rate is about 12 kg/s when the control valve is set at 3.5 turns of the control valve to a partially open position.

4. Conclusions

As for the results, it was confirmed through the test results that the injection flow rate was maintained above the design injection flow rate by setting the flow control valve at 3.5 turns to a partially open position. It was possible to maintain the design injection flow rate when the emergency water storage tank is filled with water above 4.3 m from the tank bottom, 1.3 m below the low water level of the storage tank. After compensating for a level difference between a water level of the storage tank during the test and the low water level of the tank, the injection flow rate is about 12 kg/s when the control valve is set at 3.5 turns of the control valve to a partially open position.

References

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