Development of Methodology for Evaluation of Chemical Effects on Sump Screen Performance Testing

Young Wook CHUNG [a*], Jae Seon CHO [a], Byung Il KWON [a], Hee Kwon KU [a], Yu Jung CHOI [b], Hyeong Taek KIM [b]
[a]*FNC Technology Co., LTD.*
Seoul National University Bldg. #135-301 Gwanakro 599, Gwanak-gu, Seoul, 151-742 Korea
[b]*Korea Hydro & Nuclear Power Co., LTD.*
[*]*Corresponding author: viper61@fnctech.com*

1. Introduction

The PWR containment buildings are designed to facilitate core cooling in the event of a LOCA. The cooling process requires water discharged from the break and containment spray to be collected in a sump for recirculation by the Emergency Core Cooling System (ECCS) and Containment Spray System (CSS). The containment sump contains one or more screens to protect the components of the ECCS and CSS from fibrous and particulate debris generated by the break and could form a debris bed on the screen that would collect chemical precipitates.

Since the containment materials will dissolve or corrode when exposed to the reactor coolant and spray solutions and cause various chemical reactions occurring within the post-LOCA environment, it is very difficult to predict the effects of precipitated material on head loss.

New experimental methodology to predict the type and quantity of chemical precipitates has been developed to evaluate the chemical effects on containment sump performance testing.

2. Testing Methods and Instrumentations

The test method consists of two different tests – chemical precipitate generation test and head loss test for evaluation of the chemical effect. The first test was developed to estimate the type and quantity of chemical debris, and the head loss test performed to evaluate the chemical effects by the chemical precipitates according to the results of the first test.

2.1. Chemical precipitate generation test

To generate the plant-specific chemical precipitation as if in post-LOCA environment, the actual chemical condition of the recirculation sump during post-LOCA should be simulated in experiment reactor.

Fig. 1 shows the P&ID of reactor and other instrumentation of the chemical precipitate generation test. This facility consists of reactor(R-101), agitator and reactor cooling coil in the reactor head, auxiliary recirculation loop for measuring pH and electrical conductivity, chemical reagent introduction module, and pressurization module which enable to keep the pressure in the reactor higher than saturation vapor pressure. To protect the pH and electrical conductivity sensors and prevent thermal shock, heat condenser and pre-heater were instrumented in auxiliary recirculation loop.

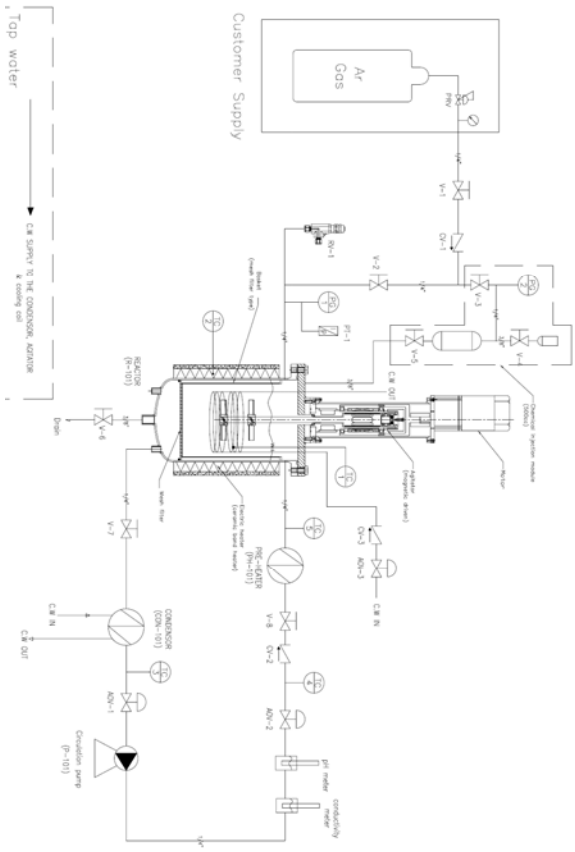

Fig. 1. P&ID of chemical precipitate generation facility

The plant-specific containment materials introduced in the reactor to simulate the post-LOCA condition were glass fibers, concrete blocks, aluminum specimens, and chemical reagent – boric acid, spray additives or buffering chemicals (sodium hydroxide, Tri-Sodium Phosphate (TSP), or others). The inside temperature of the reactor was controlled by heater and cooling coil to simulate the plant-specific temperature profile of the recirculation sump.

According to the test matrix, different time duration were applied for each test and the maximum were 30 days required time duration for recirculation mode of the ECCS. For example, 1, 3, 5, 10, 20, and 30 days time duration were applied to each test for one type of

plant test. After the time duration, each test was terminated and the reactor was opened to collect the chemical precipitate generated in the reactor for the time duration.

The qualitative and quantitative analyses were performed for collected precipitates and the precipitation generation database was established according to the each analysis result.

2.2. Head loss test for evaluating chemical effects

Fig. 2 is the P&ID of the head loss test facility to evaluate the chemical effects. This facility consists of head loss test section and recirculation loop. The test screen was located in the test section and the debris bed could form on the screen. The differential pressure meter and thermocouples were instrumented in the test section to measure the head loss across the test screen and temperature. Centrifugal pump and two heaters were instrumented for recirculation and heating of the recirculation loop and the flow were controlled by pump inverter and butterfly valve in the recirculation loop. .

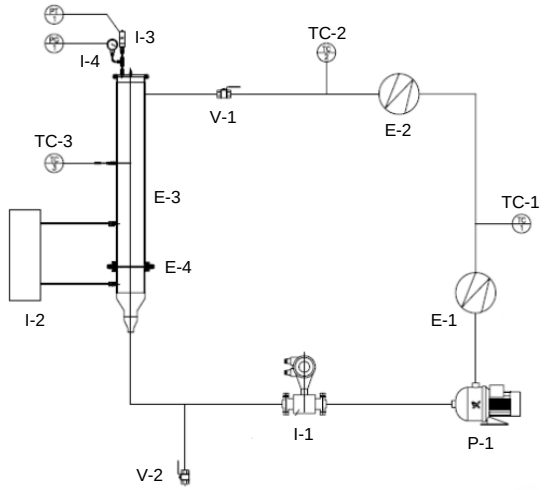

Fig. 2 P&ID of Head loss test facility to evaluate chemical effects.

According to the chemical precipitation generation database, the materials introduced into the test section were determined for each type of plant test. Through the comparison of the test results without chemical precipitates, the chemical effects on head loss in recirculation sump screen could be evaluated.

3. Conclusion

For predicting chemical effects on sump screen performance testing, new experimental methodology conducting two different types of serial tests were developed.

Fig. 3 shows the diagram for this test methodology. Each chemical precipitate test result were collected to establish the database, and this database could be the input of the head loss test.

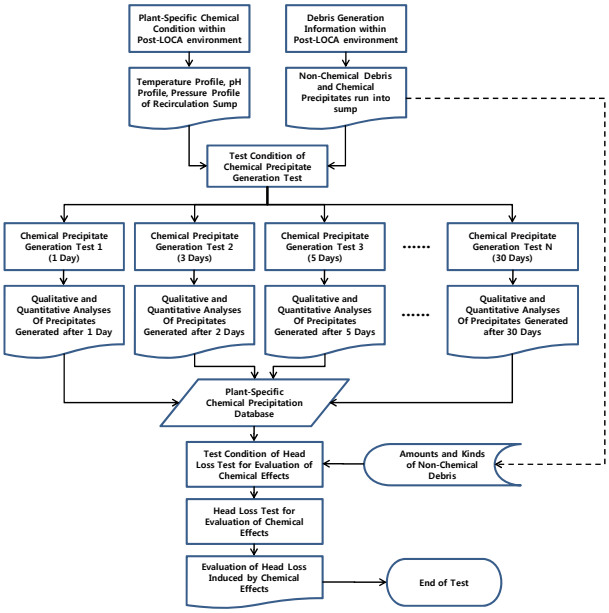

Fig. 3 Diagram of chemical effects evaluation methodology

REFERENCES

[1] Regulatory Guide 1.82, Revision 3, “Water Sources for Long Term Recirculation Cooling Following a Loss-Of-Coolant Accident Sump Performance Evaluation Methodology” U.S. Nuclear Regulatory Commission, November 2003.
[2] NEI 04-07, “PWR Sump Performance Evaluation Methodology,” May 2004.
[3] WCAP-16530-NP, Revision 0, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191", Westinghouse, February 2006
[4] WCAP-16785-NP, Revision 0, “Evaluation of Additional Inputs to the WCAP-16530-NP Chemical Model”, Westinghouse, May 2007