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Test Specification of A1-2 Test for OECD-ATLAS Project

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1. Introduction

Fukushima accident attracted international attention to high risk multiple failures. In particular, an event that has an extremely low occurring frequency but results in high core damage frequency if it occurs needs to be re-considered from the viewpoint of the "defense in depth" concept. In order to meet the international interests in the multiple high-risk design extension conditions (DECs) raised after the Fukushima accident, KAERI (Korea Atomic Energy Research Institute) is operating an OECD/NEA project (hereafter, OECD-ATLAS project) by utilizing a thermal-hydraulic integral effect test facility, ATLAS (Advanced Thermal-hydraulic Test Loop for Accident Simulation) [1].

After the Fukushima accident, a passive safety system has received widespread attention to reinforce safety and reliability of ultimate heat removal system without any operator actions in a station blackout (SBO) transient. As one of the new safety improvement concepts to mitigate an SBO accident efficiently, a passive auxiliary feedwater system (PAFS) will be investigated in the framework of the OECD-ATLAS project to produce clearer knowledge of the actual phenomena and to provide the best guidelines for accident management. PAFS is intended to completely replace the conventional active auxiliary feedwater system of a pressurized water reactor (PWR) to cope with SBO [2].

In this study, detailed specification of the second test named as A1-2 in the OECD-ATLAS project was described. The target scenario of the A1-2 test is a prolonged SBO with asymmetric secondary cooling via a single train of PAFS attached to a SG number 2 (SG-2). PAFS cools down the secondary side of steam generator and eventually removes the decay heat from the reactor core by introducing a natural driving force mechanism; i.e., condensing, boiling, and natural circulation as shown in Fig. 1.

Table I: Test Matrix for the OECD-ATLAS Project

Topics	Tests	Remarks
A1-Prolonged SBO - Asymmetric 2^{nd} cooling - Asymmetric passive 2^{nd} cooling	1 1	Asymmetric FW supply and additional failure Asymmetric passive FW supply (ex. PAFS)
A2-SBLOCA during SBO - SBO+RCP seal failure - SBO+SGTR	1 1	Effects of leakage flow rate TISGTR
A3-TLOFW - 1ry & 2nd bleed + 1ry feed	1	With additional failure such as stuck open POSRV, ATWS, and a SGTR
A4-MBLOCA - PZR surge line break (10-inch)	1	Safety injection through cold leg (or DVI)
A5-Open items	2	Counterpart test for addressing scaling issues
Total	**8**	

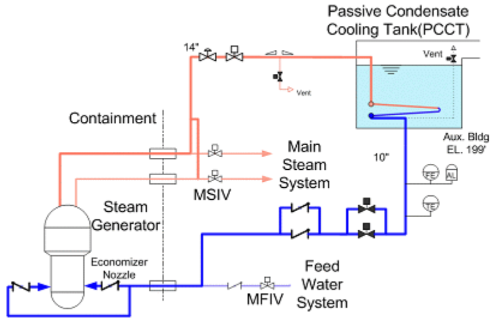

Fig. 1. Schematic concept of passive asymmetric secondary cooling

2. Test Specification of A1-2 Test

2.1 Overview of A1-2 Test

The target scenario for A1-2 test was determined to be a prolonged SBO with asymmetric secondary cooling via supply of passive auxiliary feedwater only to SG-2. In the A1-2 test, any active component such as a safety injection pump (SIP) is unavailable. However, passive components such as a pilot-operated safety relief valve (POSRV) and a main steam safety valve (MSSV) are assumed to be available. Passive auxiliary feedwater will be supplied when the secondary level of SG reaches at 25% of wide-range.

The objective of A1-2 test is to investigate the primary cool-down performance by asymmetric passive secondary cooling as an accident mitigation measure. The following items will be highlighted in the A1-2 test:

- High-pressure asymmetric single- and two-phase natural circulation
- SG heat transfer degradation during dry-out of SG
- Effects of thermal-hydraulic characteristics of auxiliary feedwater supply on primary cool-down performance
- Establishment of data base for safety analysis code validation especially focused on multi-dimensional thermal-hydraulic behaviors :
  - Condensation and instability inside the horizontal heat exchanger
  - Natural circulation and mixing phenomena inside large water pool
  - Operational performance of PAFS

2.2 Pre-test Analysis for A1-2 Test

With an aim of setting up the detailed test procedures for A1-2 test and also gaining the physical insights for a prolonged SBO transient, a pre-test analysis was performed. In the present pre-test analysis, a best-estimate safety analysis code, MARS (Multi-dimensional Analysis of Reactor Safety) [3] was used.

Based on the present pre-test analysis result, the detailed procedure for A1-2 test was determined as shown in Fig. 2. After the secondary level of SG-2 reached at 25% of wide-range, passive auxiliary feedwater was supplied to only SG-2. With an actuation of PAFS, the water level in SG-2 and high-pressure natural circulation flow in the primary loop were recovered. The dry-out in SG-1 was not observed due to the effective heat removal through SG-2. The primary system pressure was stabilized without opening of a POSRV.

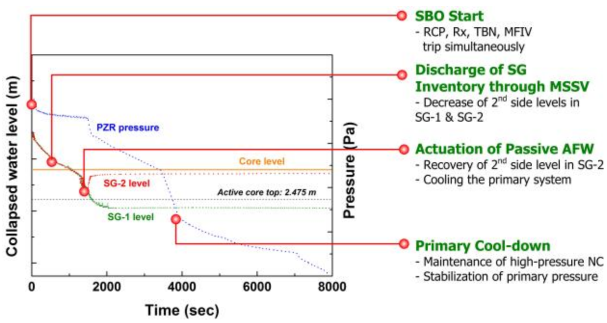

Fig. 2. Test procedure for A1-2 test

2.3 Improved Measurement of ATLAS for A1-2 test

ATLAS has own design features for simulating the multi-dimensional behavior as realistically as possible which includes an integrated down-comer of the RPV, a pertinently scale-downed primary loop and so on. Especially, thermocouples were installed to investigate multi-dimensional and asymmetric thermal-hydraulic phenomena in the primary loop and the plena of SGs, respectively. In addition to these measuring capability of ATLAS, instruments were equipped with the PAFS in order to investigate condensation heat transfer characteristics inside the heat exchanger and natural circulation and mixing phenomena inside large water pool. Figs. 3 and 4 show photograph of heat exchanger and large water pool of PAFS, respectively.

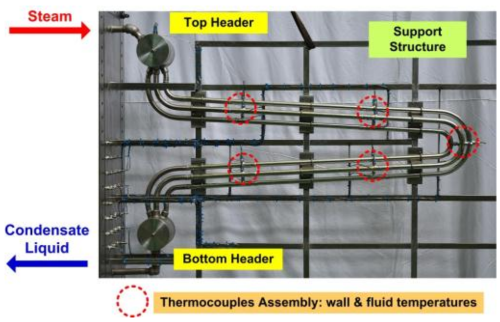

Fig. 3. Photograph of heat exchanger of PAFS

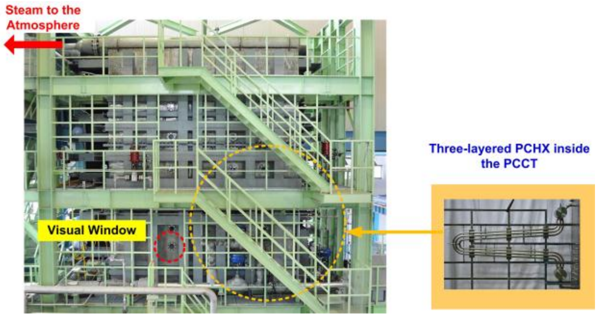

Fig. 4. Photograph of large water pool of PAFS

In the A1-1 test, with the improved measurement systems of ATLAS, the major thermal-hydraulic phenomena during a prolonged SBO transient will be precisely investigated.

3. Conclusions

A detailed specification of the first test named as A1-2 in the OECD-ATLAS project was described. The target scenario of the A1-2 test is a prolonged SBO with asymmetric secondary cooling via a single train of PAFS attached to a SG-2. The pre-test analysis using MARS code was performed with an aim of setting up the detailed test procedures for A1-2 test and also gaining the physical insights for a prolonged SBO transient. A1-2 test will contribute to produce clearer knowledge of the actual phenomena and to provide the best guidelines for accident management in case that a passive safety system is utilized for an ultimate heat removal measure to cope with SBO transient.

Acknowledgements

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