

Design and Pre-Test Scoping Analysis for a Large Scale PAFS Test Facility

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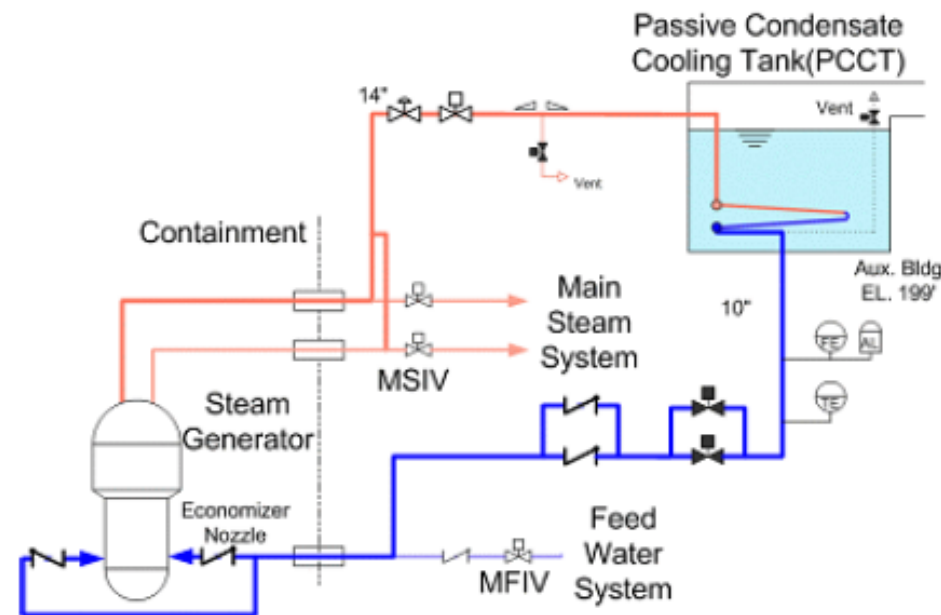
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1. Introduction

□ Passive Auxiliary Feedwater System (PAFS)

- One of the evolutionary safety systems adopted in APR+
 - removes the decay heat by a natural circulation in the steam generator secondary system
 - consists of PCHX (Passive Condensation Heat Exchanger), a return-line, and PCCT (Passive Condensation Cooling Tank)



Schematic diagram of PAFS in APR+
(J. Cheon, 2010)

1. Introduction

□ Previous experimental works for PAFS

Test facility	Major specifications	Remark
PASCAL	- Volume scale: 1/240, length scale: 1/1 - No. of PCHX tubes: 1	Completed
ATLAS-PAFS	- Volume scale: 1/330, length scale: 1/2 - No. of PCHX tubes: 3	Completed

- Previous experimental results confirmed that the PAFS satisfies the cooling requirement and operational performance during the anticipated transient and accident conditions

2. LAPLACE Test Facility

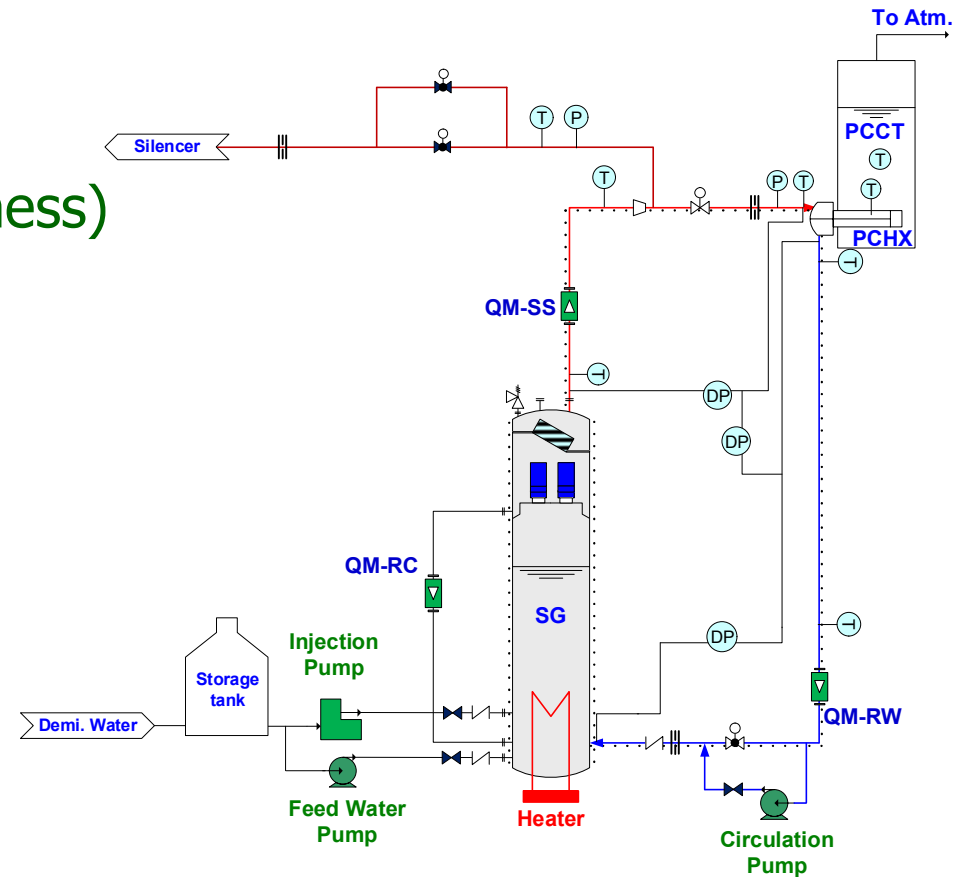
□ New experimental program with a more large scale

● Objectives

- to investigate an effect of scale ratio on the cooling performance, and
- to observe more detailed boiling phenomena on the PCHX tube bundle surface

□ LAPLACE test facility

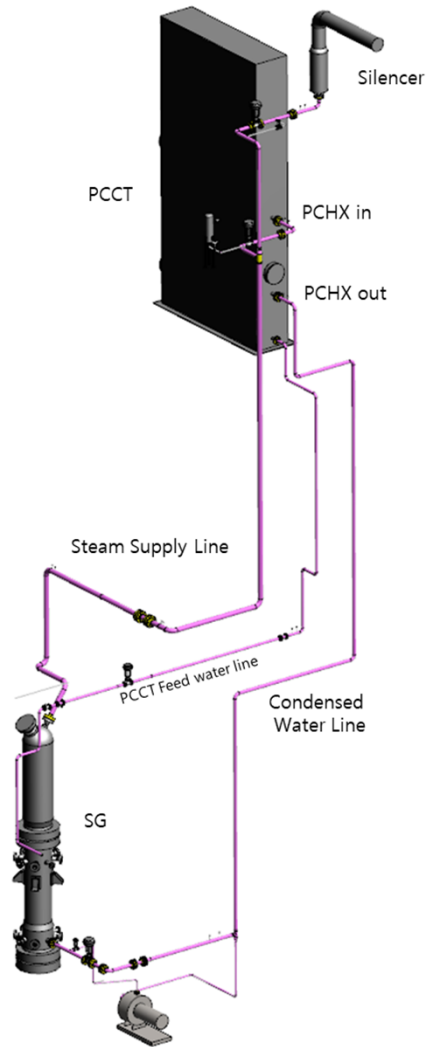
- LAPLACE (Large Scale PAFS Loop for Assessment of Condensation Effectiveness)
- Volume scale = 1/16
- length scale = 1/1
- No. of PCHF tubes = 15



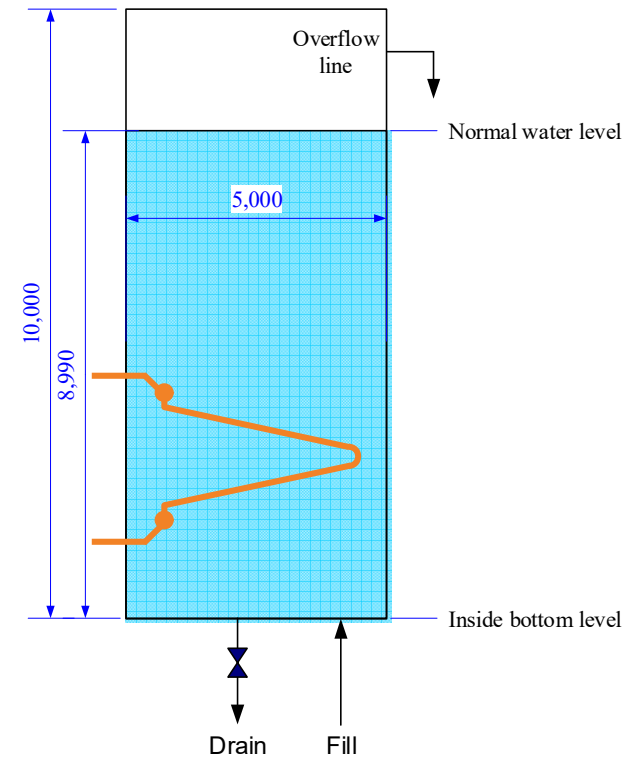
Simplified schematic diagram

2. LAPLACE Test Facility

□ Isometric view and PCCT of the LAPALCE test facility



Isometric view



Passive condensation cooling tank

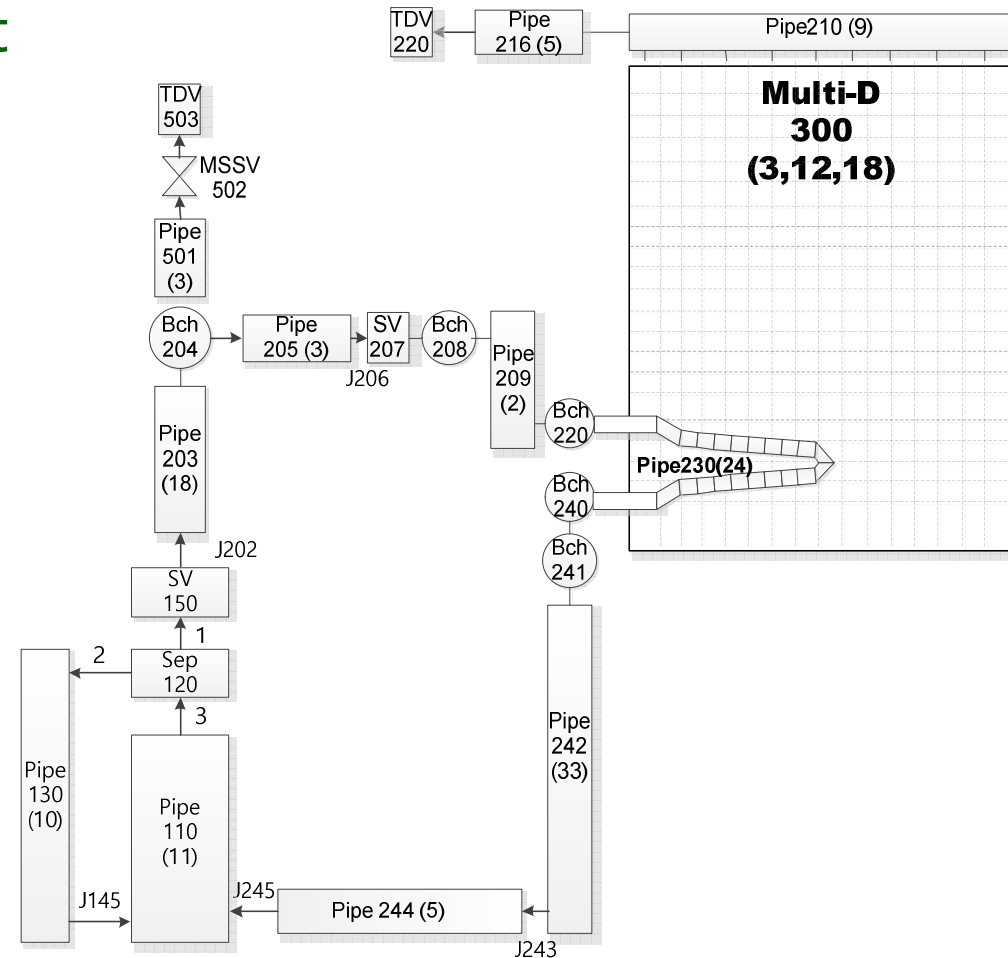
3. MARS-KS Calculation

Objectives of pre-test calculation with MARS-KS

- Investigation of the condensation heat transfer at the heat exchanger in the LAPLACE facility
- Evaluation of the natural convection behavior in the loop

MARS-KS calculation model for the LAPLACE facility

- One-dimensional components : SG, PCHX, SS/RW pipeline
- MULTID component : PCCT

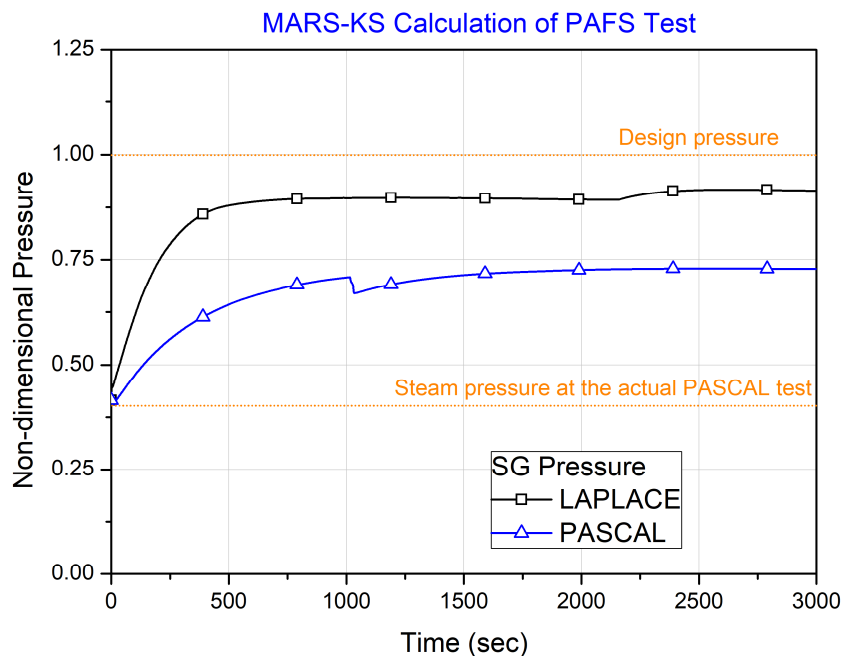


MARS-KS nodalization of LAPLACE facility

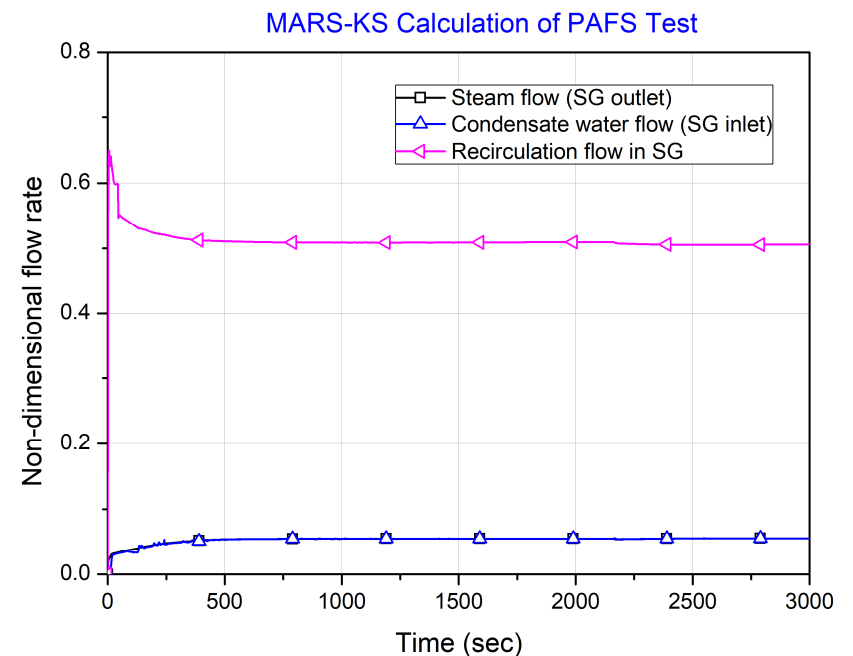
3. MARS-KS Calculation

□ Pre-test calculation result for the scaled full power with 8.1 MW

- Steam pressure was converged under the design pressure of the PAFS, which proved a sufficient capability of the current PCHX design.
- Difference between the LAPLACE and the PASCAL (A single tube test facility) was attributed to the boiling heat transfer and the natural convection flow in the PCCT.
- Stable behavior of natural convection was observed in the loop.



Steam pressure in the MARS-KS calculation



Natural convection flow in the MARS-KS calculation

4. Conclusions

□ Conclusions

● New experimental program

- LAPLACE test facility with the volume scale of 1/16 for the PAFS of APR+
- To investigate an effect of scale ratio on the cooling performance and to observe more detailed boiling phenomena
- The LAPLACE test facility is now being constructed for the new experimental program.

● Preliminary scoping analysis using MARS-KS system analysis code

- The current PCHX design has a sufficient cooling capability to remove the decay heat during an accident condition.
- The condensation model of the MARS-KS code showed a conservative prediction for the heat removal capability of the PAFS.

References

☐ References

- [1] J. Cheon et al., The Development of a Passive Auxiliary Feedwater System in APR+, ICAPP2010, San Diego, USA, 2010.
- [2] K.-H. Kang et al., Separate and Integral Effect Tests for Validation of Cooling and Operational Performance of the APR+ Passive Auxiliary Feedwater System, Nucl. Eng. Tech., Vol. 44, No. 6, pp. 597-610, 2012.

ACKNOWLEDGEMENT

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경청해 주셔서 감사합니다.

LAPLACE

Large Scale **P**AFS **L**oop for **A**ssessment of
Condensation **E**ffectiveness