# Design and Construction of 3-Ch Cross Flow Test Facility

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## 1. Introduction

To evaluate the reactor thermal margin of APR+, reactor core flow distribution including both axial and lateral directional hydraulic resistances of fuel assemblies should be known. Test facility on reactor core flow distribution (ACOP) is being designed and constructed. ACOP will use 257 core simulators and each core simulator should have the same core flow characteristics of the PLUS-7 fuel assembly. However, data on the lateral directional hydraulic resistance of full-size fuel assemblies is rare while data on the axial resistance is currently available.

To design a core simulator which will be used at the ACOP test facility, a 3-Ch cross flow test facility is being designed and constructed with three full-size fuel assemblies. The axial and lateral directional hydraulic resistances of fuel assemblies will be measured. The test results will be applied to the design of the core simulator of the ACOP. The experimental data can also be utilized for the sub-channel analysis by upgrading the CFD model.

## 2. Description of Test Facility

The 3-Ch cross flow test facility will consist of a main tests section, three loops, upper and lower piping structures, a common header, and a makeup tank. The test section will have 3 rectangular channels and comprises 3 full-size PLUS-7 fuel assemblies. Each loop will consist of a pump, two flow meters, a heat exchanger, and piping and instruments.

### *2.1 Scaling Analysis*

The 3-Ch cross flow test facility will be operated at reduced pressure and temperature conditions. To design a test facility that simulates the hydraulic characteristics in the reactor core, geometric and dynamic flow similarities, such as aspect ratio, relative roughness, Reynolds Number, and Euler Numbers, should be considered [1]. Since the 3-Ch cross flow test facility will use full-size fuel assemblies, aspect ratio and relative roughness for the fuel assemblies are conserved.

The pressure drop caused by the relative roughness of the core is relatively small and can be ignored. The pressure drop caused by the different Reynolds Number can be ignored when the Reynolds Number in the test facility is in the fully turbulent region [2]. For the design of the 3-Ch cross flow test facility, the Euler Number is conserved so that the pressure drop through the core is conserved and the velocity of the test facility is reduced accordingly.

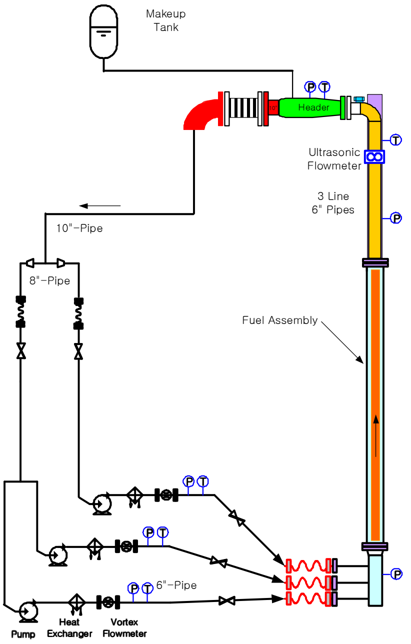


Fig. 1. Schematic diagram of the 3-Ch cross flow test facility

### *2.2 System Configuration*

The 3-Ch cross flow test facility will consist of a main test section and circulation system as shown in Fig.1. The main test section will comprise 3 full-size PLUS-7 fuel assemblies and each assembly can be separated by the movable isolation plate (Fig. 2). The isolation plates can be withdrawn to give open space for the cross flow to adjacent assemblies.

The fuel assemblies will be fixed by the upper and the lower piping structures. The lower piping structure changes a circular flow to a rectangular flow and gives a well distributed and unified flow to 3 channels. The upper piping structure changes a rectangular flow to a circular flow and also provides the space for the movable isolation plates. At the front part of the main test section, 4 windows will be provided to observe and measure the characteristics of the core flow. In addition, 42 taps for the measurements of axial and lateral differential pressures will be installed at the rear part of the main test section.

Three pumps will be provided for the circulation of water through the fuel assemblies. The pump speed is controlled by an inverter and can deliver sufficient water to a fuel assembly to cover at least 120 % of the nominal flow rate of the APR+ reactor. Heat exchangers are used to provide the desired water temperature and the common header will be installed to mix the water through the 3 different 6" pipings downstream of the main test section. In addition, the system pressure will be maintained by the makeup tank which is connected to the common header.

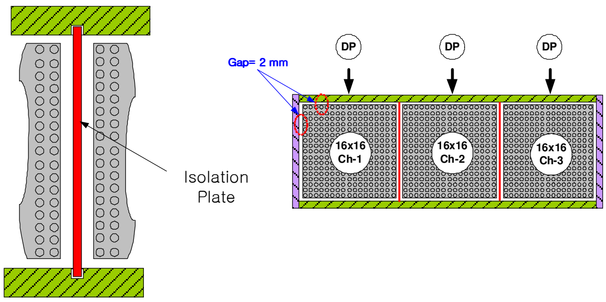


Fig. 2. Cross section of the main test section

## *2.3 Instrumentation*

Pressures, temperatures and flow rates through the loop will be measured. At the inlet of the test section, three vortex flow meters will be installed and three ultrasonic flow meters will measure the flow rates at the outlet of the test section. The cross flow distribution along the fuel assemblies will be reproduced by sectional opening of the cross flow channels with two isolation plates. The cross flow rate between two fuel assemblies can be deduced by the two measured flow rates from the vortex and ultrasonic flow meters.

Pressures at the inlet of the lower piping support and at the outlet of the upper piping support will be measured. In addition, a thermocouple will be installed at the downstream of each ultrasonic flow meter. A pressure transmitter and a thermocouple will be installed at the common header.

The tests will be performed at reduced temperature and pressure conditions with a conservation of the nominal pressure drop. CFD calculations were performed to set the measurement points and fitness, especially for differential pressures along a single fuel assembly and between two adjacent fuel assemblies. The pressure taps will be installed at the inlet and the outlet of the fuel assemblies and at center of each grid spacer.

There are 42 pressure taps at the back part of the test section for the measurement of axial and lateral differential pressures and 84 differential pressures will be measured. Twenty eight differential pressure transmitters will be installed to measure the differential pressures between axial and lateral direction (Fig. 3). 14 axial differential pressures at a single fuel assembly and 14 differential pressures between two fuel assemblies will be measured at a time. Then, by a solenoid valve system, 28 differential pressures for the next fuel assembly will be measured. In addition, characteristics of the flow near the grid spacer will be measured by the LASER system through the four windows installed at the front part of the test section.

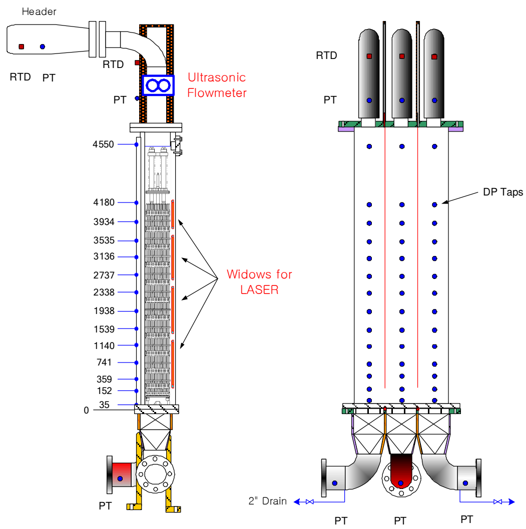


Fig. 3. Locations of the instruments

## 3. Conclusions

The 3-Ch cross flow test facility is under construction. The tests will be performed at reduced temperature and pressure conditions with a conservation of the nominal pressure drop. The tests will provide detailed differential pressure distribution in fuel assemblies. The test results will be used to design core simulators of the reactor flow distribution test facility and to evaluate the applicability of the CFD modeling method for more complicated geometries, such as a space grid and mixing vane.

## Acknowledgement

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## REFERENCES

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