# Establishing and Testing an Integrated LOCA Experiment Setup

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## 1. Introduction

Safety standards of nuclear power plants and related industries have been intensely revised after the severe accident in Fukushima. Regulatory bodies are going to establish the Design Extended Condition (DEC) rules to secure safety even in beyond Design-Based Accident (DBA) situations.

KAERI have been developing estimation and evaluation technologies to support new regulations. As a part of the plan, we are working to improve the SPACE code systems to cover the DEC scenarios. An integrated Loss-of-Coolant Accident (LOCA) experiment have been built to aid the code verification.

Goal of the experiment setup is to simulate a complete LOCA process, including steady-state boiling, blowdown, ballooning, burst, and reflooding with a single zircaloy fuel rod.

## 2. Methods and Results

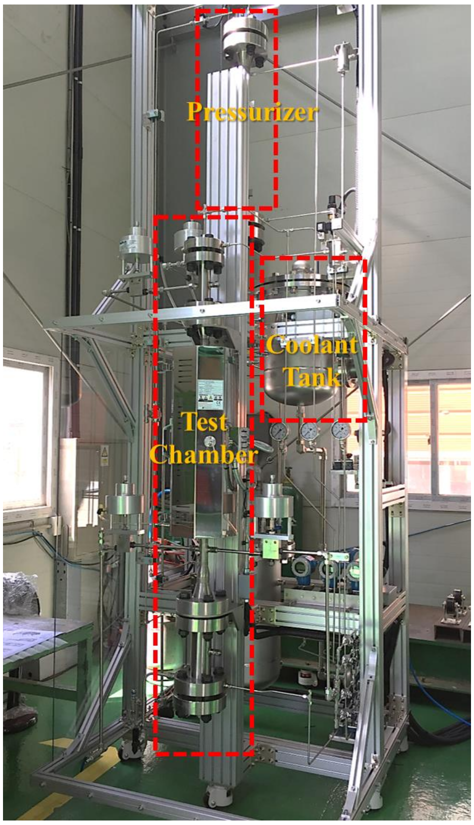


Fig. 1. Overall hardware structure of the experiment setup.

Overall hardware structure of the setup is shown in Fig.1. and is consist of test chamber, pressurizer, reflood tank, and blowdown tank. The test chamber is a pressurized container which simulates the core of nuclear power plant and designed to contain coolant and environmental gas over 15 MPa pressure. Fuel rod assembly, zircaloy cladding and electric heater inside, is placed inside the chamber. Pressurizer is connected on top of the test chamber for buffering the pressure. Coolant tank is a container for water, which simulates Safety Injection Tank (SIT). Blowdown tank is a reservoir for exhausted coolant and also a buffer for transient high-pressure jet from the test chamber.

### *2.1 Test Process*

Series of test procedures were carried out to verify capability of the experiment setup in ~5 MPa pressurized environment. The test chamber was filled with DI water as a coolant and pressurized with Ar gas. Then the coolant was heated using auxiliary furnace heater surrounding the test chamber.

After monitoring spontaneous coolant circulation inside the test chamber due to heating, pressurized He gas was filled inside the fuel rod and electric power was supplied to rod heater, and then coolant was discharged to initiate the blowdown process.

Temperature of cladding surface abruptly went to ~800 ℃ in about 3 minutes and finally the cladding has burst open with ~ 6 MPa rod internal pressure. Then electric power to the heater rod was cut and reflood process was started.

The test chamber was fully filled with saturated water and fuel rod was quenched into ~100 ℃ within 5 minutes and the test was complete. Result of the test run is shown in Fig.2.

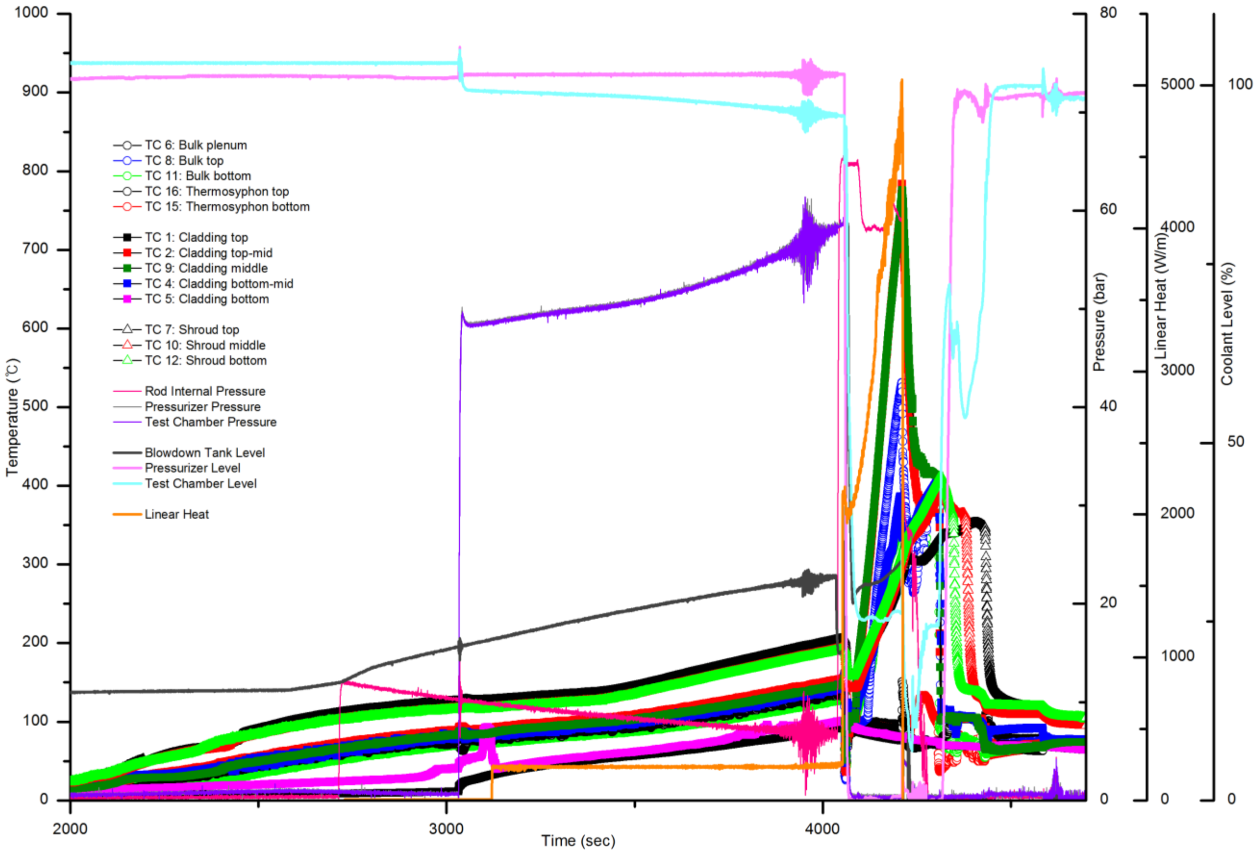


Fig. 2. Overall experimental data expressed in one figure. The chamber was pressurized at ~3000 sec and blowdown was initiated at ~4000 sec. Cladding was burst open at ~4200 sec and then cooled down by coolant reflooding.

### *2.2 Axial Temperature distribution and Temperature Ramp*

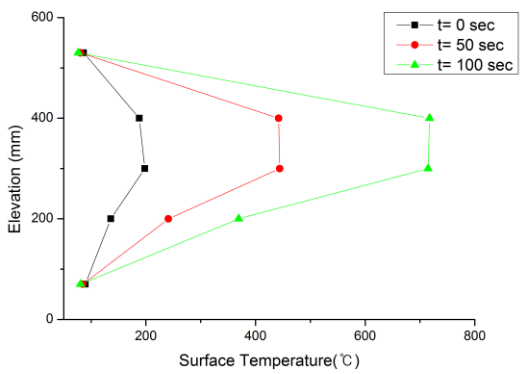


Fig. 3. Axial temperature distribution evolution of the heater rod starting from shortly after the blowdown (t=0), at the middle of the ramp (t=50), and about ten seconds before the burst (t=100).

Axial temperature distribution during the ballooning process is shown in Fig.3. based on thermocouples attached on the zircaloy cladding. At shortly after the blowdown, temperature was low and temperature deviation was small because coolants in the test chamber was not yet emptied. After blowdown, temperature around the center was abruptly increased and eventually reached about 800 ℃ at the burst. Average temperature ramp was about 5 ℃/sec in the test.

### *2.3 Cladding Ballooning and Burst*

Fig. 4. Deformed zircaloy cladding, retrieved after the test.

Zircaloy cladding was deformed as a consequence of the LOCA simulation test sequence as shown in Fig.4. Circumferential elongation of the cladding was about 90 %. Length of the crevice was about 7 mm.

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## 3. Conclusions

We have established a single rod, integrated LOCA experiment setup and now on test run to confirm the performance of the facility. In the test run, we have confirmed operation in pressurized environment up to about 6 MPa. The zircaloy cladding was ballooned and eventually burst as a result of coolant blowdown and internal heating. We are going to continue further test runs to fully confirm the capability of the setup.

### 3. Acknowledgements

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### REFERENCES

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