

Conceptual design and mock-up testing for development of a multi-segment capsule

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JMTR alternative irradiation project is currently underway. "Multi-segment capsule" is a candidate of the next irradiation.

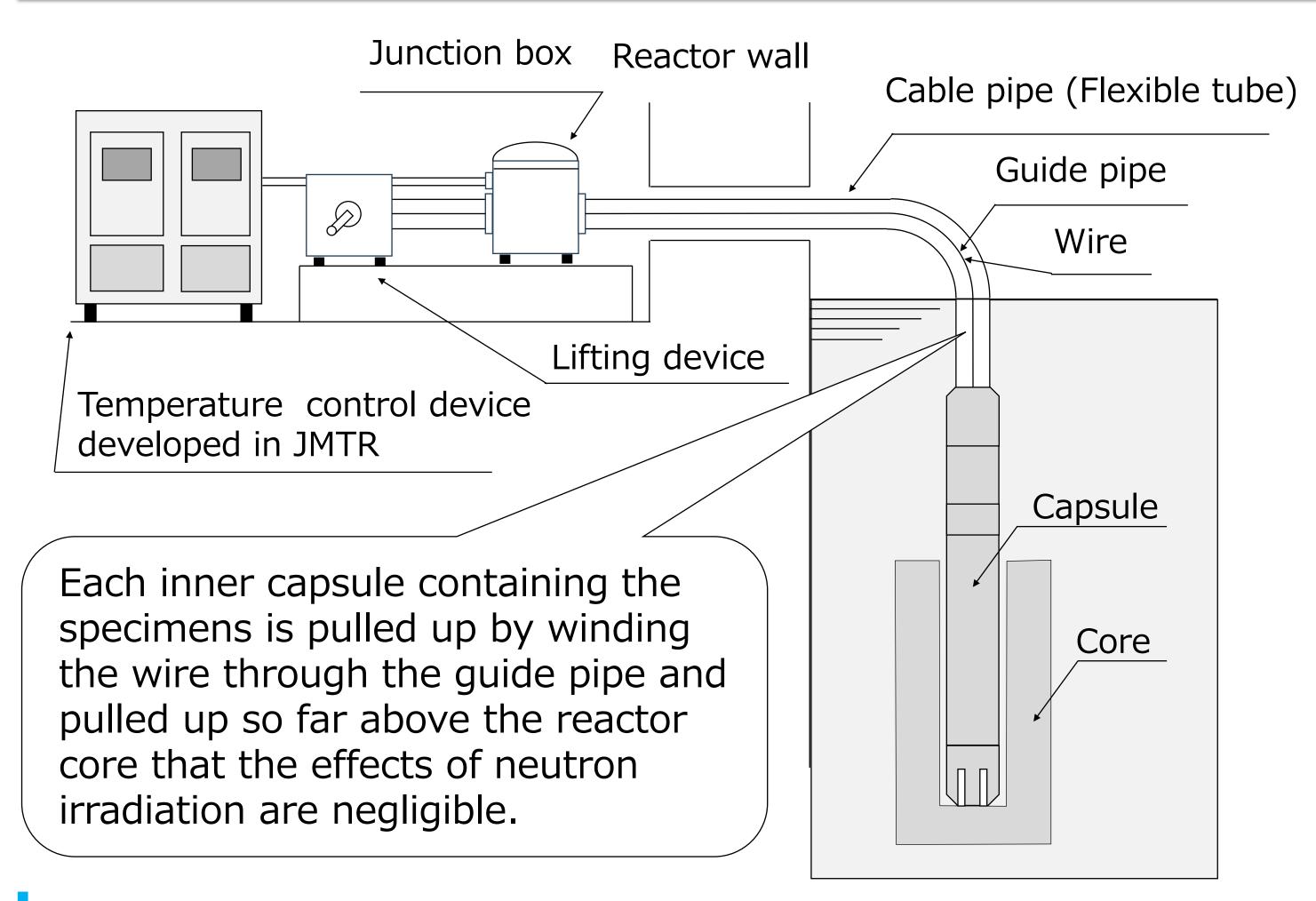
2. Conceptual design

2.1 Test system by multi-segment capsule

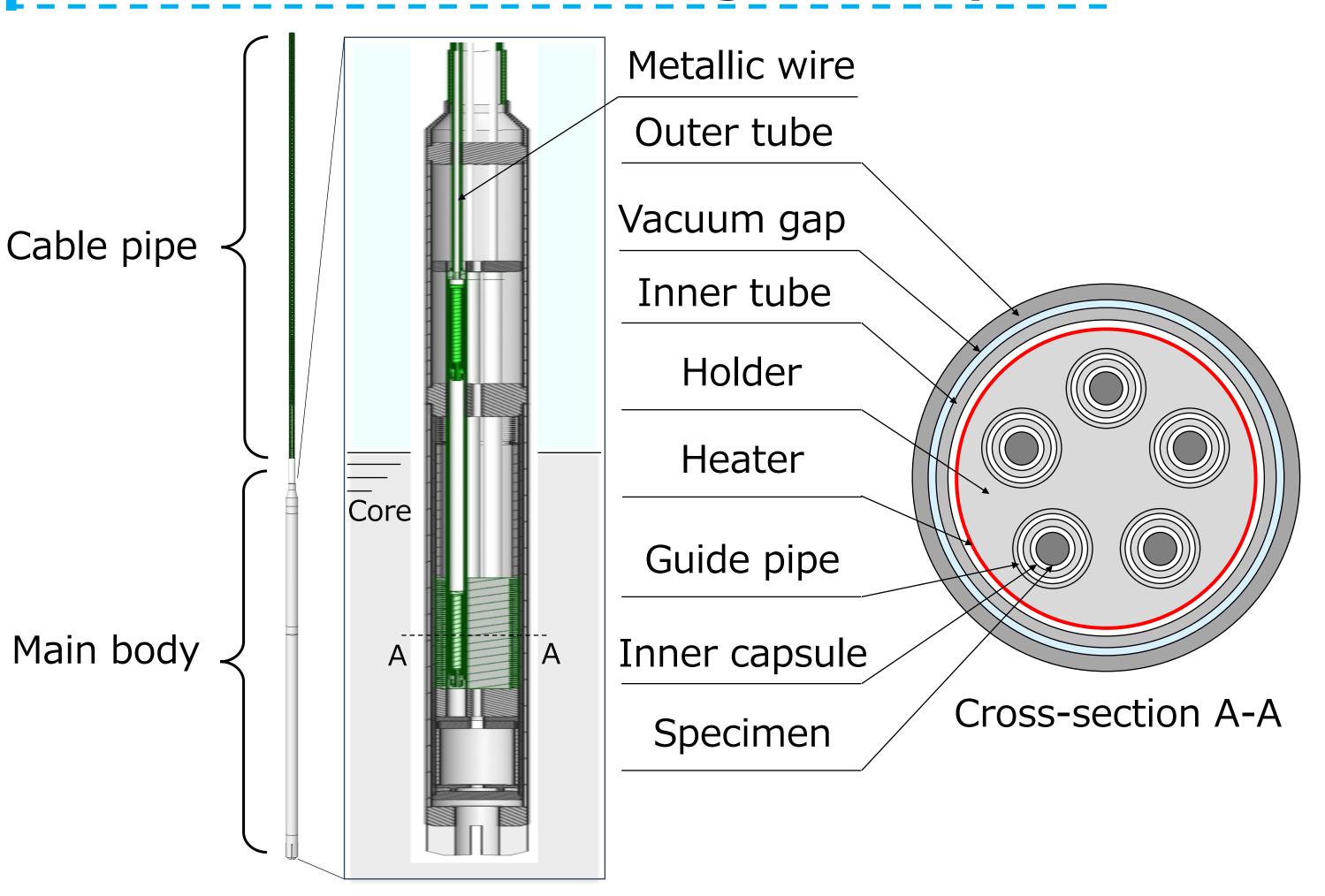
Reproducible testing often requires varying only a single condition while maintaining all others unchanged.

The multi-segment capsule enables the acquisition of irradiation data at multiple neutron fluence within a single irradiation with same flux, spectrum, and temperature.

A similar capsule was previously developed at JMTR and served as a reference for this conceptual design study on the premise that it conduct in MARIA reactor.



2.2 Structure of multi-segment capsule



5 segments

Double tube configuration

Φ 8 mm

251 mm²

Heater and vacuum control

This structure ensures to vary neutron fluences for up to five conditions in a single irradiation test.

Number of inner capsule

Structure

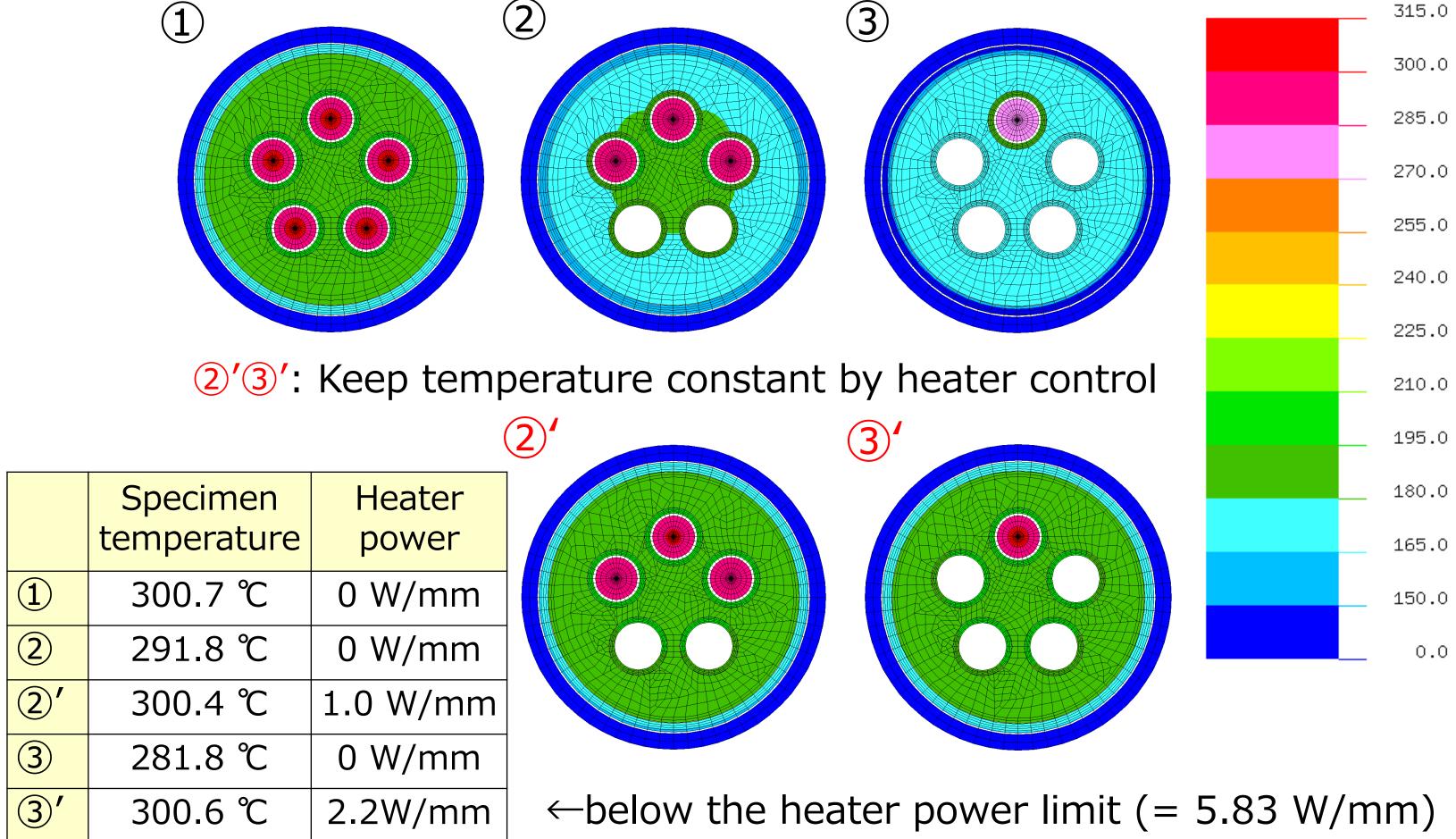
Specimen diameter

Total cross-section of specimens

Temp. control method

2.3. Thermal evaluation

Fluctuations in temperature during irradiation can cause unexpected changes in the properties of samples. Evaluated the thermal response of inner capsule withdrawn on temperature to ensure stable irradiation conditions in MARIA reactor.



Temperature compensation with heaters using the temperature control device can offset the effect of inner capsule withdrawal on temperature.

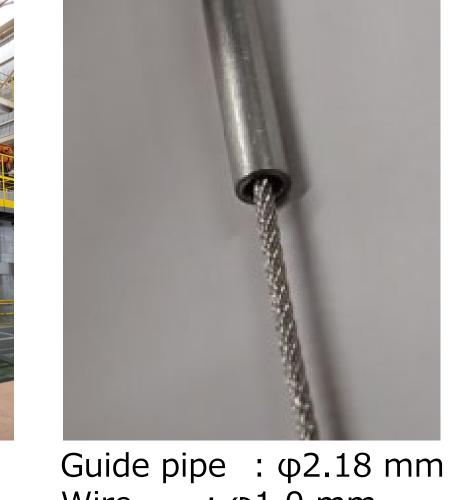
3. Mock-up test

Cable pipe design change from straight pipe to flexible tube is required for application. Flexible routing is possible, but increased sliding resistance of wire is a concern.

Repeated 90° bending tests on flexible cable pipes at a minimum bending radius of 1.0 m revealed that the maximum allowable number of bending is 4.



Test facility



: φ1.0 mm

Simulating the routing of the cable pipe in MARIA reactor

Result	Wire	Guide pipe
	Outer diameter	Inner diameter
X	Ф 1.5 mm	Φ 4.35 mm
X	Ф 1.5 mm	Ф 2.18 mm
V	Ф 1.0 mm	Ф 2.18 mm
	7	

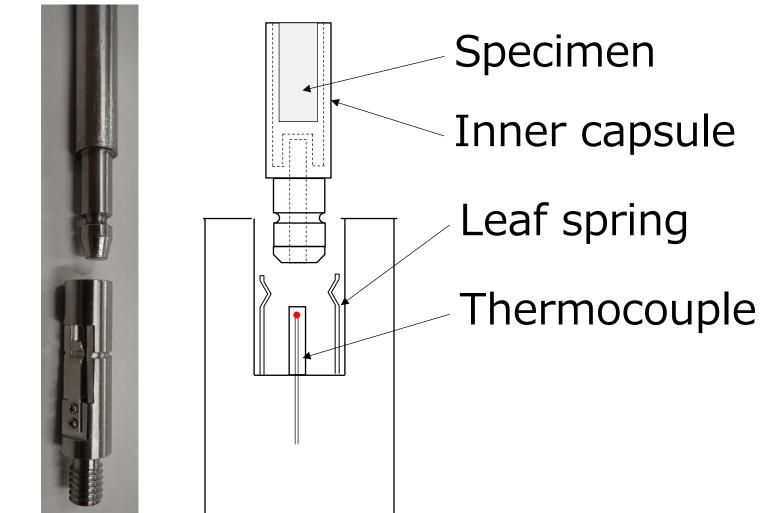
Below the safety allowable level (Sliding resistance < 100 N)

A mock-up test simulating the wire arrangement in the MARIA reactor confirmed successful withdrawal using a guide pipe with an inner diameter of 2.18 mm or less, in combination with a Φ 1.0 mm wire.

4. Examination of retention mechanisms

Concerns about dislodgement during air transportation

Inner capsule retention mechanism



Leaf-spring clamp

The inner capsule is secured by a leaf spring engaged in a groove, and it is released when the withdrawal force exceeds a certain threshold. This simple, radiation-resistant design avoids contact with thermocouple junctions.

This can prevent dislodgement due to air transportation to Poland.

5. Conclusions

The conceptual design of multi-segment capsule was completed, with mock-up tests confirming resolution of concerns about pulling-up.