IAEA-CN-226-79

Demonstration Test Program for Long–term Dry Storage of PWR Spent Fuel

17 June 2015

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5. Summary

1. Background

- ***Mutsu interim spent fuel storage facility in Japan*** is preparing for the **maximum 50-year storage** of spent fuels in dry metal casks for both transportation and storage.

- To reduce risk of radiation exposure to workers and waste materials, the facility has **no hot cell**. It is required that ***the spent fuels stored will be confirmed for their integrity indirectly by monitoring cask*** during storage, and also will be transported after the storage ***without opening the cask lid.***

Lots of demonstrations & experiences in overseas

Lots of fuel cladding integrity investigations in Japan

Dry storage experiences of BWR fuels in Japan

Long-term storage test in domestic research facility to accumulate knowledge and experience on **"long-term integrity of PWR spent fuels"** during dry storage.

To make assurance doubly sure on safety of transportation after storage.

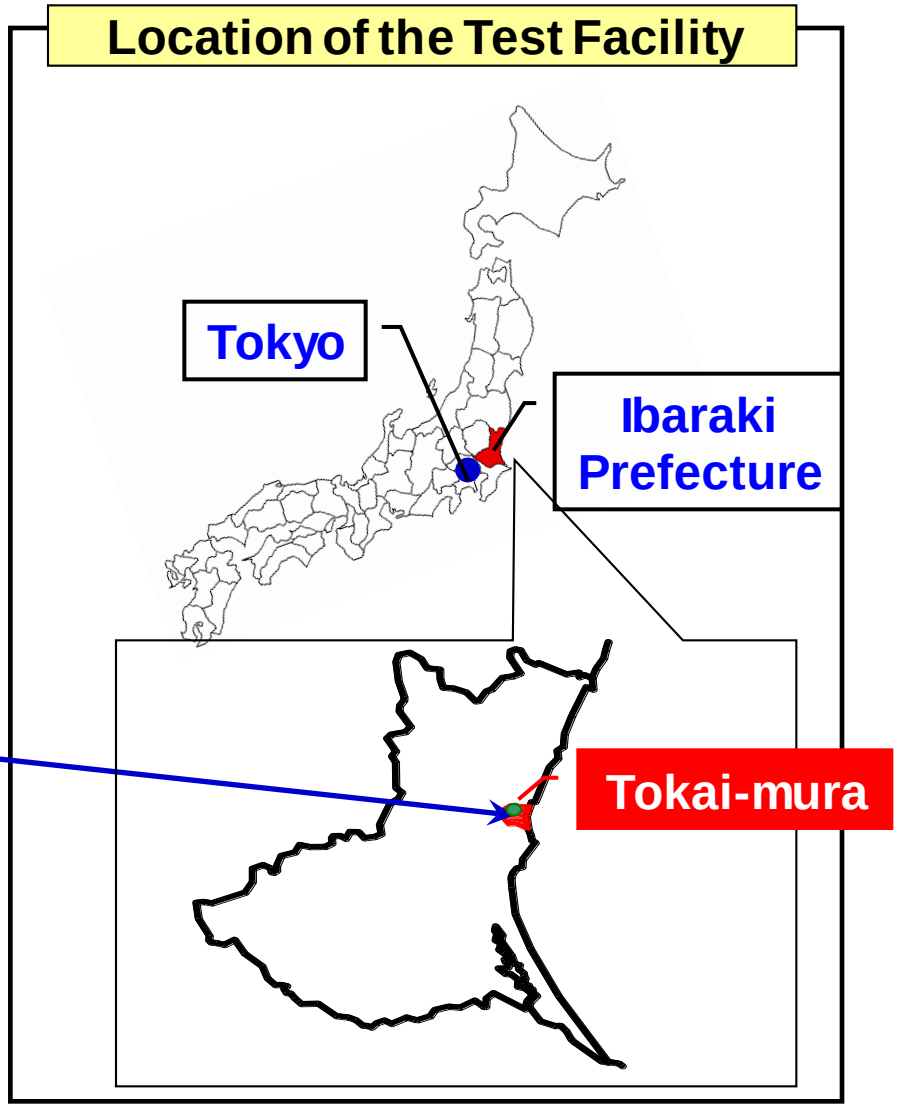
2. Demonstration Test Program (1/4)

Organization

Utilities(Customer)
-The Japan Atomic Power Company
-The Kansai Electric Power Co. ,Inc.
-Kyushu Electric Power Co. ,Inc.

Contractor
-Mitsubishi Heavy Industries Ltd. (MHI)

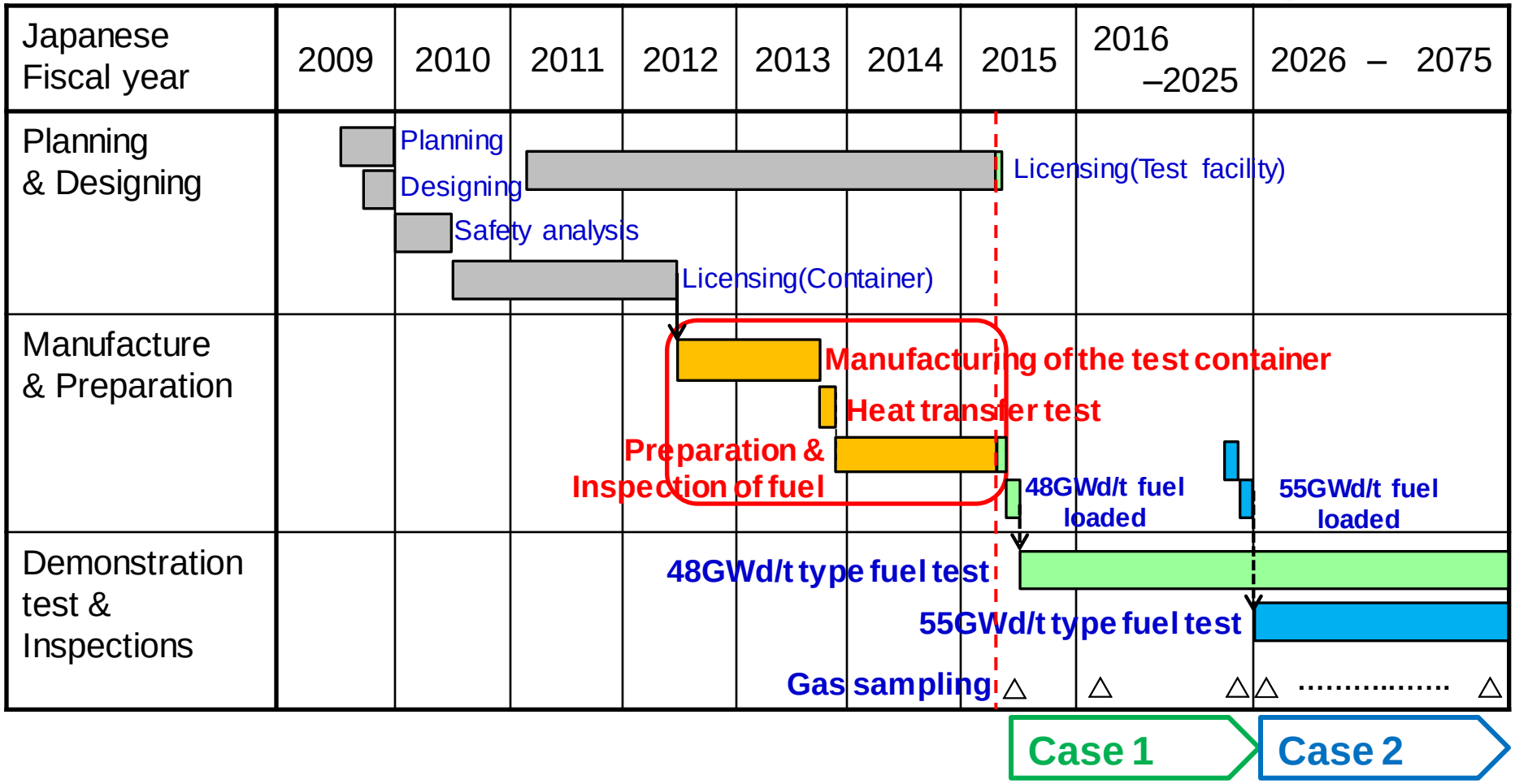
Test Facility
-Nuclear Development Corporation (NDC)



2. Demonstration Test Program (2/4)

Test Overview and Process

Time Schedule of Demonstration Test for PWR Fuel Storage



2. Demonstration Test Program (3/4)
Fuel Specification for Demonstration Test

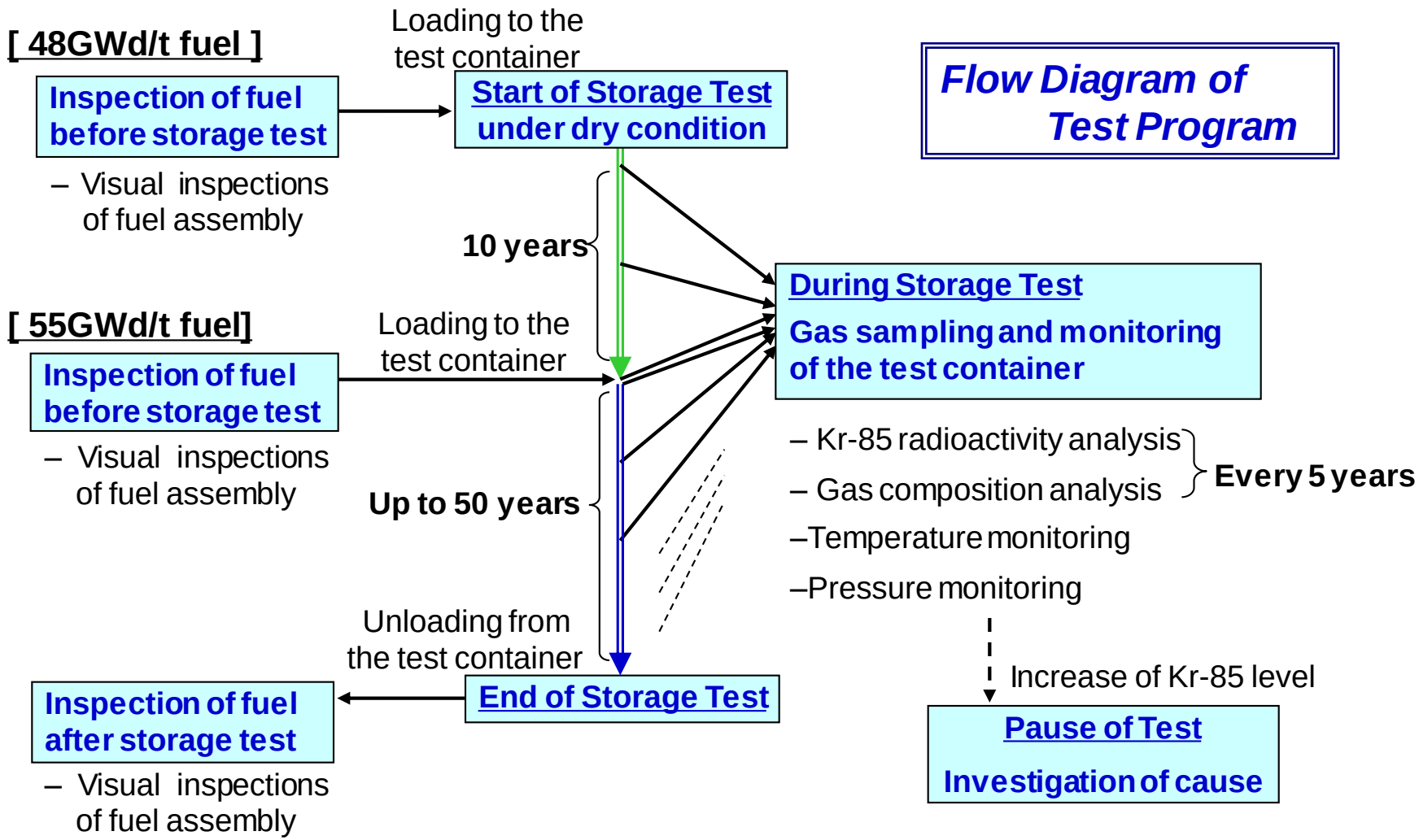
- Two spent fuel assemblies are planned to be loaded in the test container.

Fuel Specification for Demonstration Test

Fuel Type	48GWd/t	55GWd/t
	17x17	17x17
Burn-up [MWd/t]	42,800 (past record)	≤55,000 (assumption)
Cladding material	Zircalloy-4	MDA or ZIRLO
Cooling period when loaded [years]	21 (as of June, 2015)	≥10 (as of October, 2025)
Time to loading	At the middle of 2015	At the middle of 2025
Remarks	15 empty fuel rods (used for PIE)	a proper spent fuel will be prepared in the future

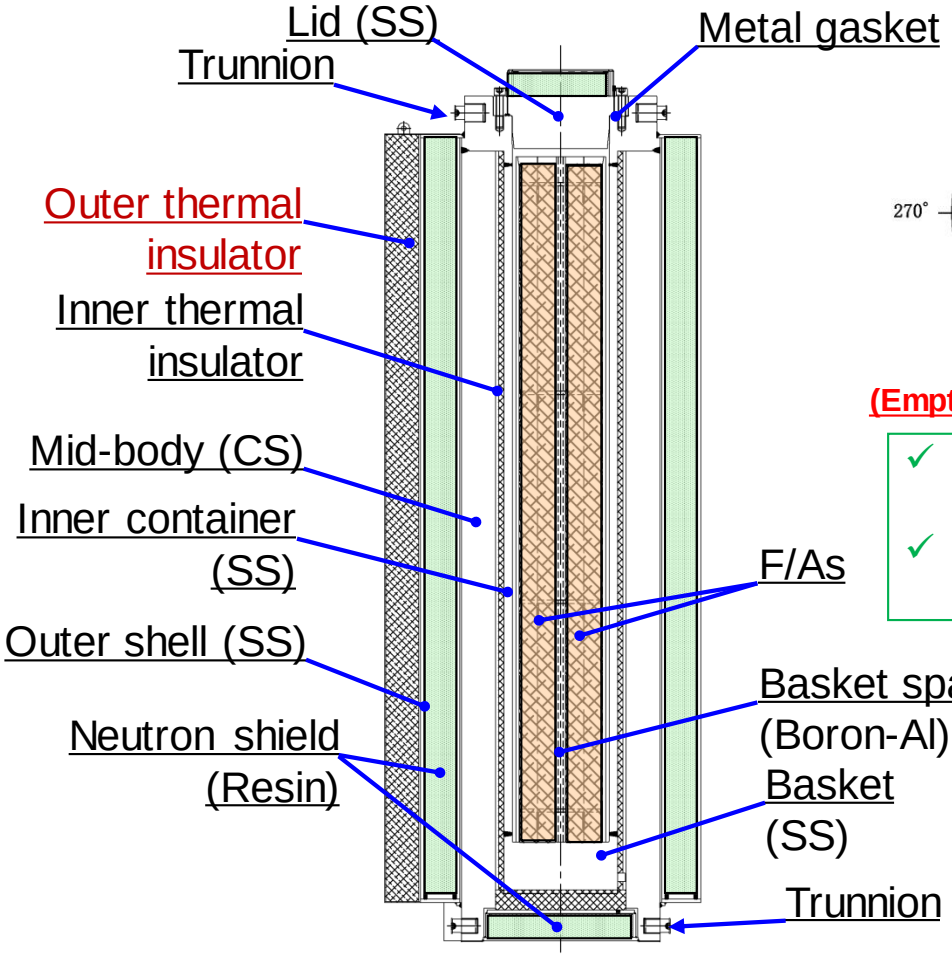
2. Demonstration Test Program (4/4)

Verification Method of Fuel Integrity

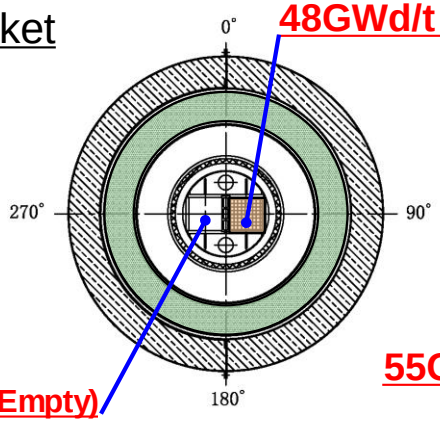


3. Test Container (1/5)

Outline of Test Container

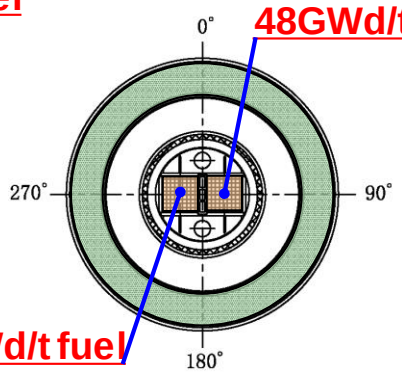


Case 1



- ✓ With outer thermal insulator
- ✓ Vacuum inside (negative pressure)

Case 2

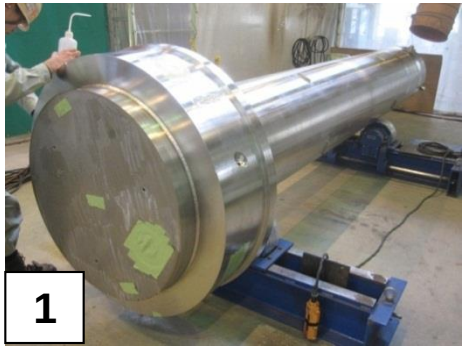


- ✓ Without outer thermal insulator
- ✓ Helium gas filled in

Size	Approx. Φ5.2m x 2.1m
Contents	Two PWR spent fuels

3. Test Container (2/5)

Manufacturing of Test Container



1

Welding of Flange, Inner Container and Base plate

2

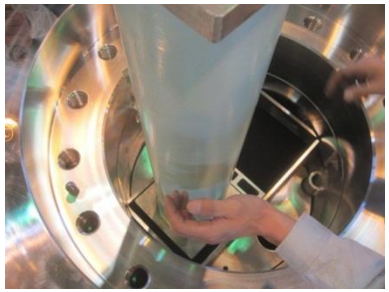
Installing of Inner Thermal Insulator

3

Welding of Mid-body

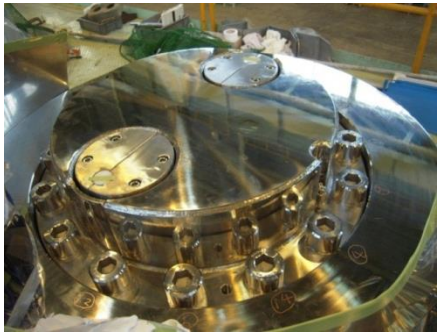
4

Attachment of Outer Shell with Resin Filled in



5

Gauge Test and Pressure Test



(Top View)

6

Test Container Completed

(Overview)

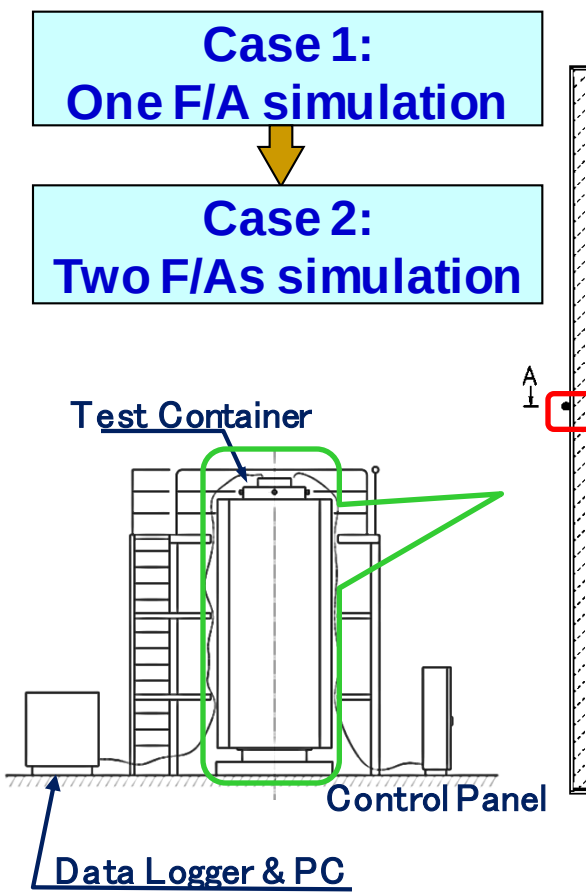
3. Test Container (3/5)

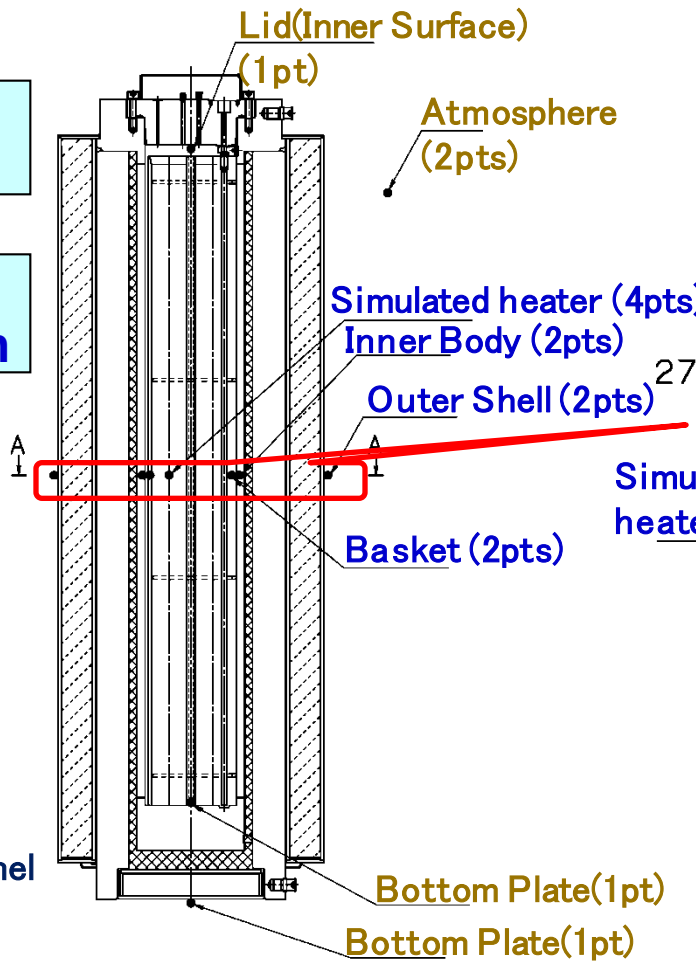
Heat-transfer Test Plan

- Two heat transfer tests were conducted in order to evaluate thermal performance of the test container.

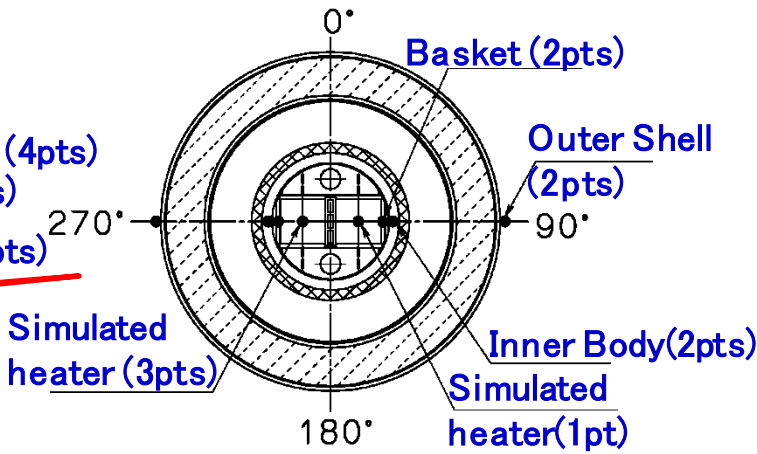
Case 1:
One F/A simulation

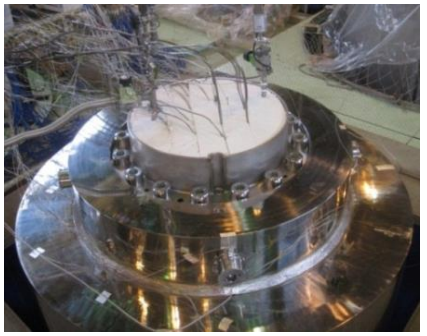
Case 2:
Two F/As simulation





Thermo-couples :
Total 15 points

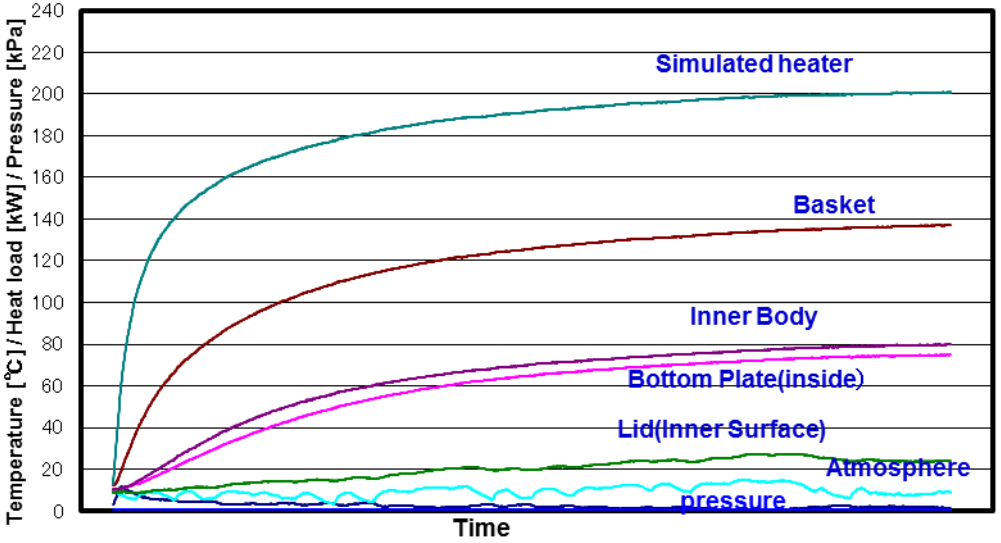


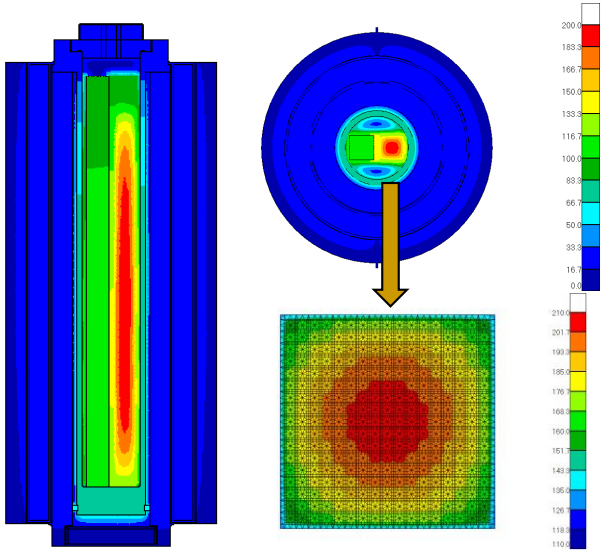


3. Test Container (4/5)

Test Results and Thermal Analysis (Case 1)

- One of dummy fuels was heated electrically under the vacuum condition in the cavity to simulate the 48 GWd/t type fuel storage test.
- Thermal analysis was conducted by using ABAQUS code.
- Temperatures estimated are well agreed with the heat transfer test results.





Heat Load	513W
Cover Gas	Vacuum
Thermal Insulator	Attached

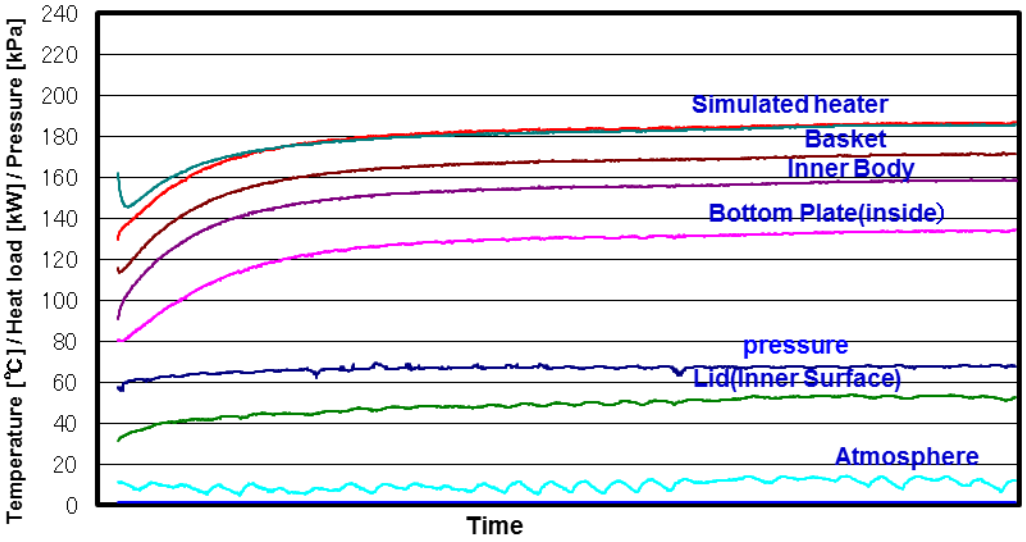
	Test	Analysis
Outer Shell	22.5˚C	25.6˚C
Dummy Fuel (48GWd/t)	206.2˚C	205.9˚C

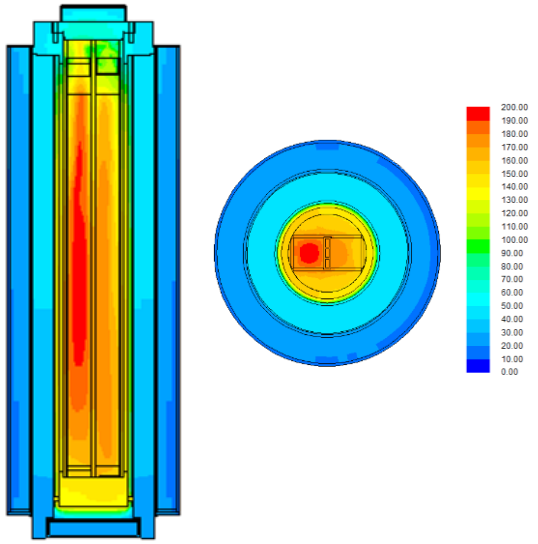
Temperature estimation method for the 48 GWd/t type storage test was verified.

3. Test Container (5/5)

Test results and Thermal Analysis (Case 2)

- Both of dummy fuels were heated electrically under the Helium gas condition in the cavity to simulate the 48/55 GWd/t type fuels storage test.
- Thermal analysis was conducted by using FLUENT code in order to consider a convection heat transfer with Helium gas.
- Temperatures estimated are well agreed with the heat transfer test results.





Heat Load	1397W (428W / 969W)
Cover Gas	Helium Gas
Thermal Insulator	Detached

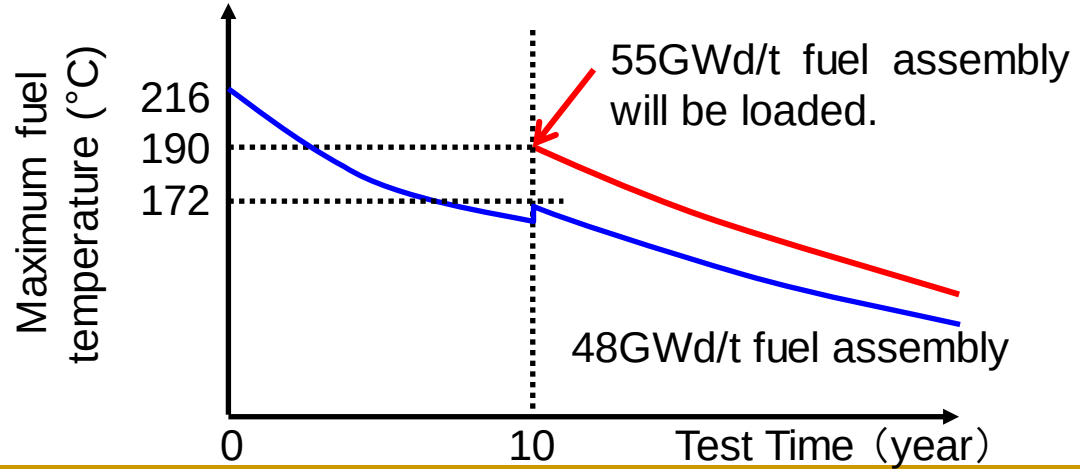
	Test	Analysis
Outer Shell	18.5˚C	19.0˚C
Dummy Fuel (48GWd/t)	186.5˚C	179.8˚C
Dummy Fuel (55GWd/t)	192.4˚C	198.6˚C

Temperature estimation method for the 48/55 GWd/t type storage test was verified.

4. Preparation for Demonstration Test (1/2)
Fuel Temperature Estimated

- Temperatures of the fuels at the beginning of each test case are estimated by using the verified temperature estimation methods.

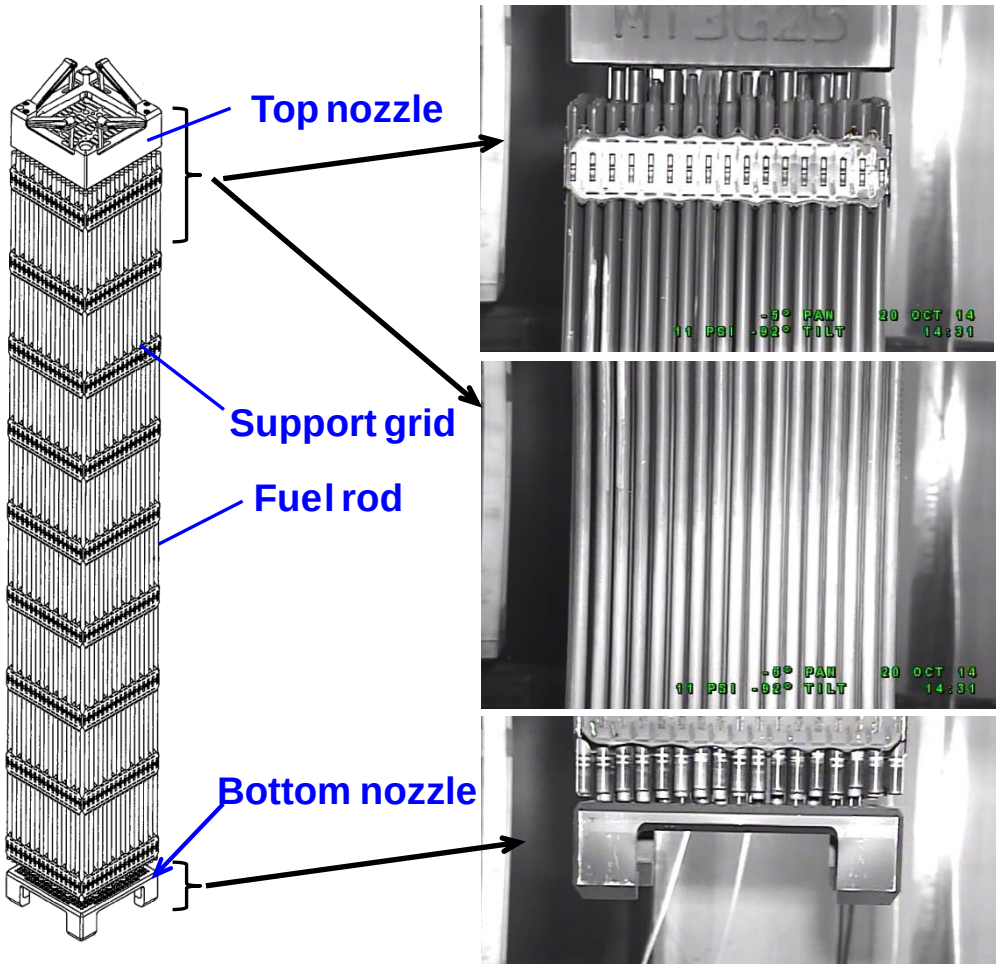
	Case 1	Case 2	
Fuel type	48GWd/t fuel	48GWd/t fuel	55GWd/t fuel
Heat load	513W	428W	969W
Ambient temperature	10˚C	10˚C	10˚C
Max. fuel temperature estimated	216˚C	172˚C	190˚C



4. Preparation for Demonstration Test (2/2)
Fuel Inspections

- Before loading the 48 GWd/t type fuel into the test container, visual inspections of the fuel were carried out.
- Visual / dimensional inspections of four fuel rods extracted from the fuel were also carried out.

✓ No significant crack,
✓ No deformation
✓ No adhesion of foreign substances



External Surface of 48GWd/t Type Fuel

5. Summary

- Some Japanese utilities planned to conduct the demonstration test for up to 60 years to accumulate knowledge and experiences on long-term integrity of PWR spent fuel during dry storage.

- The test container was manufactured. Heat-transfer tests were carried out to evaluate a thermal performance of the test container and thermal estimation methods were established.

- Maximum fuel temperatures at the beginning of the test were estimated by using the verified temperature estimation methods.

- Visual inspections for 48GWd/t type fuel have been carried out before loading and its integrity was confirmed.

- Final licensing procedure for the test facility is being performed. The demonstration test will start at the middle of JFY2015.

✓ Others --- We thank Nuclear Regulation Authority (Formerly Japan Nuclear Energy Safety Organization) for incorporating in the heat-transfer tests.

Thank you for your attention.