JNES Incorporated Administrative Agency
Japan Nuclear Energy Safety Organization

JNES-04N-0015

[CONFIDENTIAL]

# OECD/NRC BENCHMARK BASED ON NUPEC BWR FULL-SIZE FINE-MESH BUNDLE TESTS (BFBT)

## Assembly Specifications and Benchmark Database

October 4, 2004

Incorporated Administrative Agency
Japan Nuclear Energy Safety Organization

## 1. Test facility

Figure 1.1 is a diagram of the test facility, which was made of SUS304. Demineralised water was used as the cooling fluid. The maximum operating conditions for this facility were 10.3 MPa in pressure, 315 Celsius in temperature, 12 MW in test power, and 75 t/h in flow rate. The test facility has a full range of steady-state testing capabilities over BWR operating conditions and can also simulate unsteady characteristics of complicated BWR operational transients.

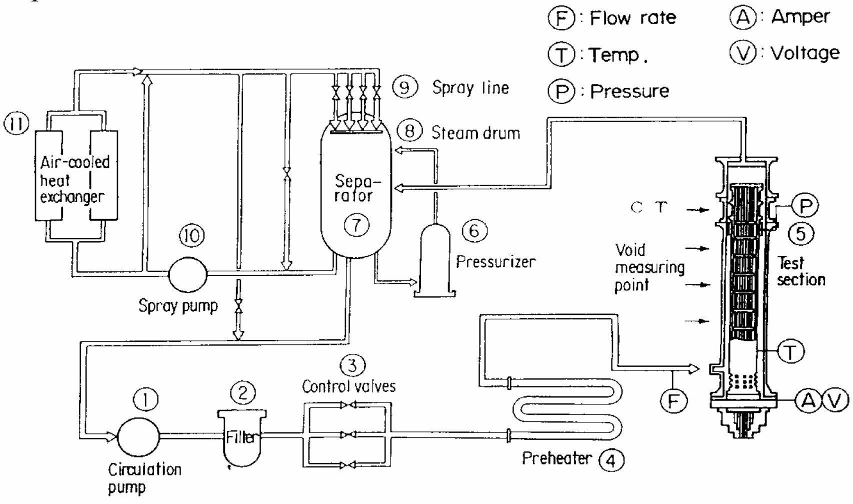



**Figure 1.1 System diagram of test facility for NUPEC rod bundle test series**

The test section, shown in Figure 1.2, consists of a pressure vessel, a simulated flow channel, and electrodes. The full-scale BWR simulated fuel assembly was installed within this section.

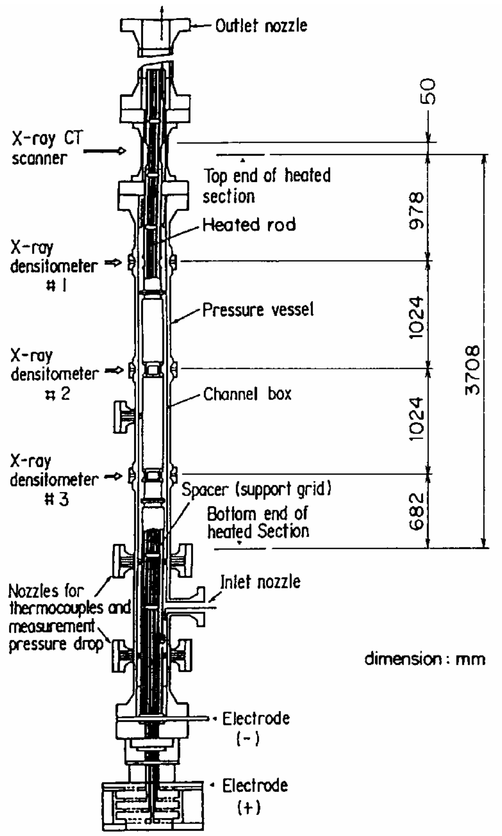
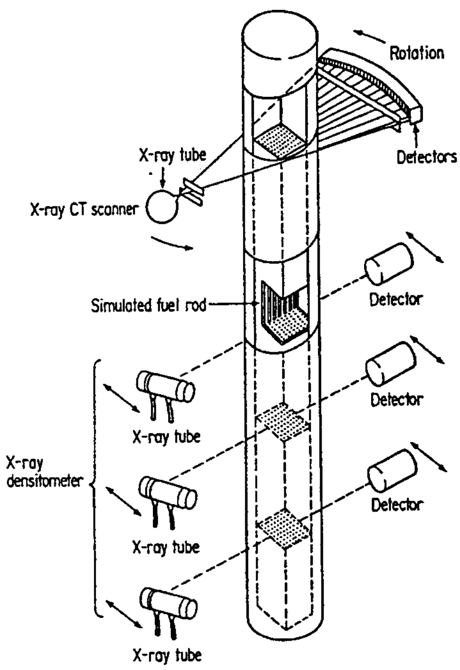


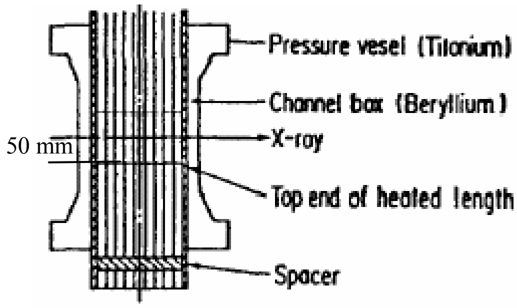

**Figure 1.2 Cross-sectional view of test section**

## 1.1 Void distribution measurement

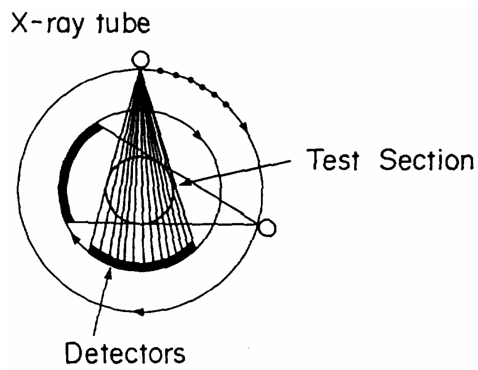
Two kinds of void distribution measurement systems[1], as shown in Figure 1.1.1, the X-ray CT scanner and the X-ray densitometer were employed in this test.




(a) Measuring structure




(c) Scanning section




(b) Scanning method

**Figure 1.1.1 Void fraction measurement system**

Table 1.1.1 summarises the estimated accuracies of the major process parameters in this test series.

**Table 1.1.1 Estimated accuracy of main process parameters for void distribution measurement**

| Quantity | Accuracy |
|---|---|
| Pressure | 1% |
| Flow | 1% |
| Power | 1.5% |
| Inlet fluid temperature | 1.5 Celsius |
| X-ray CT scanner | |
| Local void fraction | 8% |
| Sub-channel void fraction | 3% |
| Cross-sectional void fraction | 2% |
| Spatial resolution | 0.3 mm × 0.3 mm |
| Scanning time | 15 seconds |
| X-ray densitometer | |
| Sampling time | Max. 60 seconds |

## 1.2 Critical power measurement

The pressure loss was monitored at several locations as depicted in Figure 1.2.1.

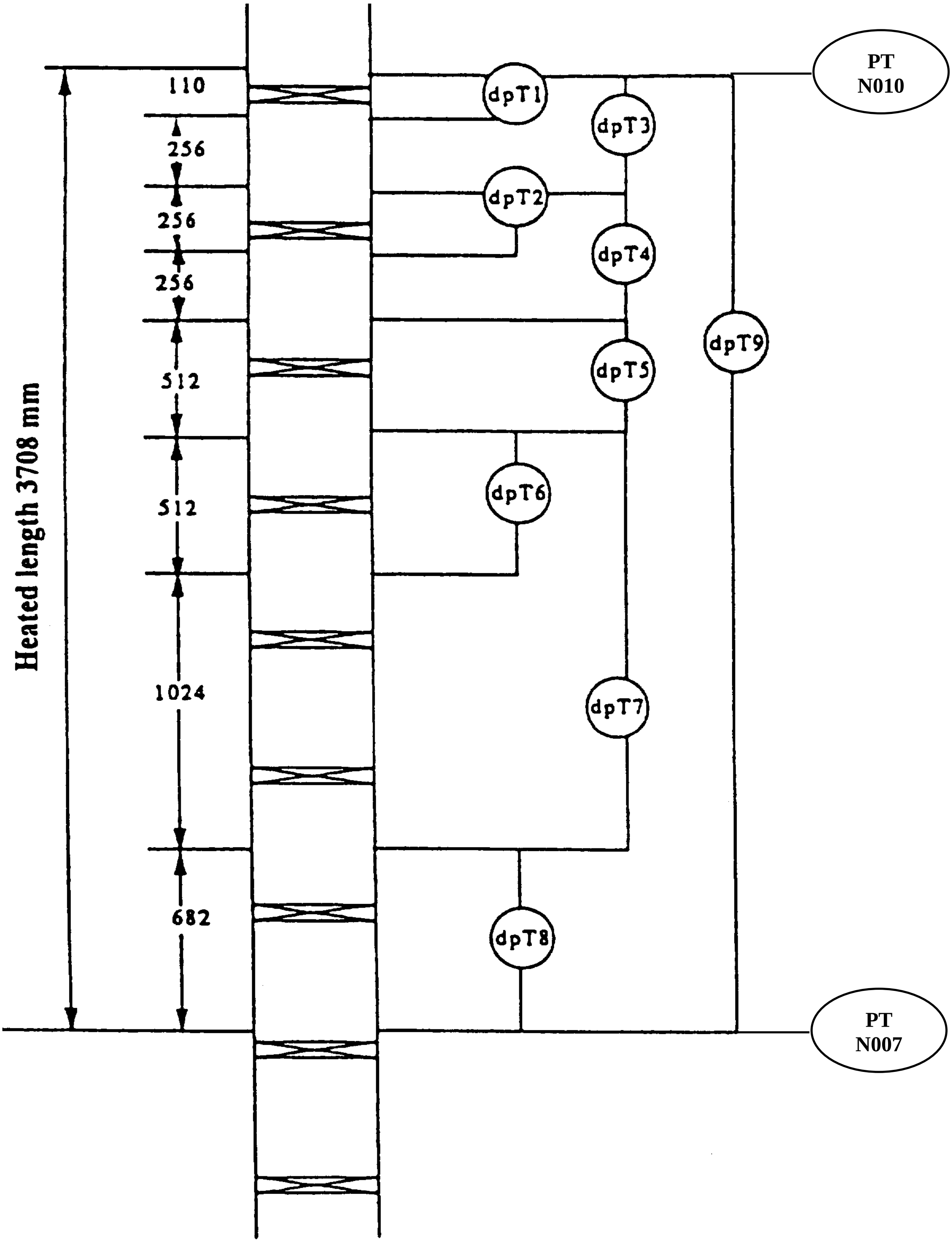



**Figure 1.2.1 Location of pressure taps for critical power measurement**

The rod surface temperature was monitored at several locations as depicted in Figure 1.2.2 to 1.2.4

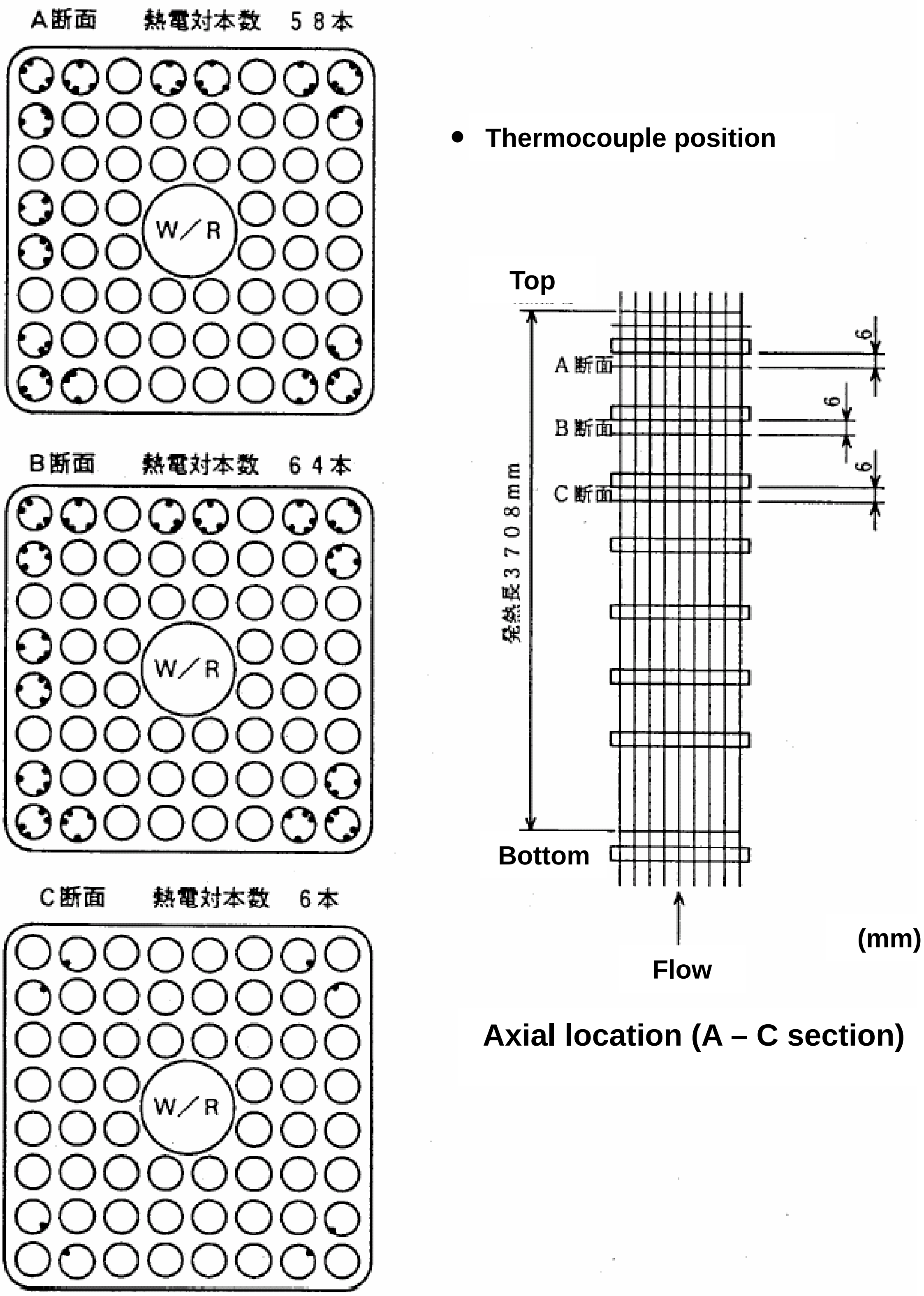



**Figure 1.2.2　Location of thermocouples for critical power measurement (C2A)**

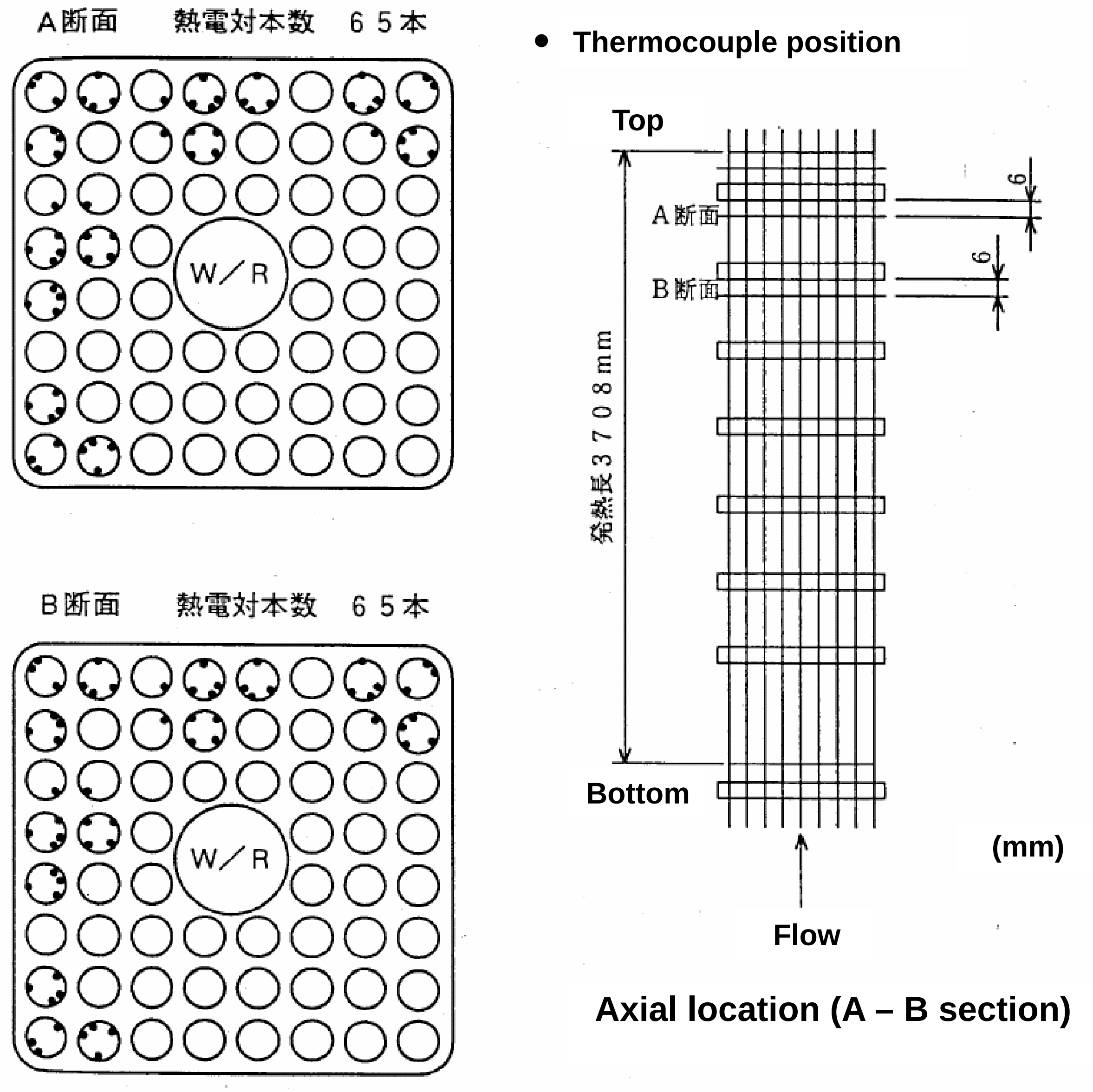
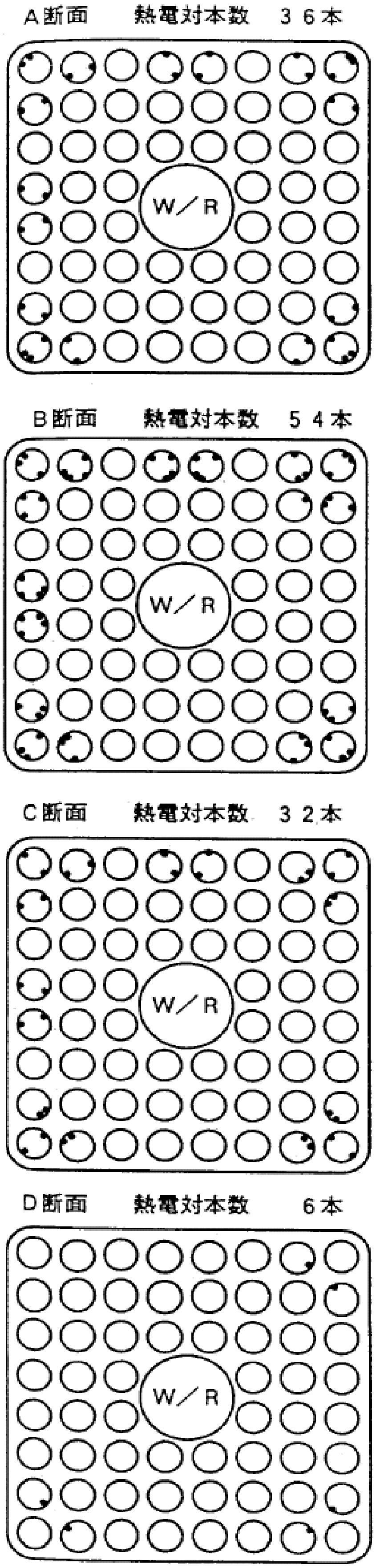
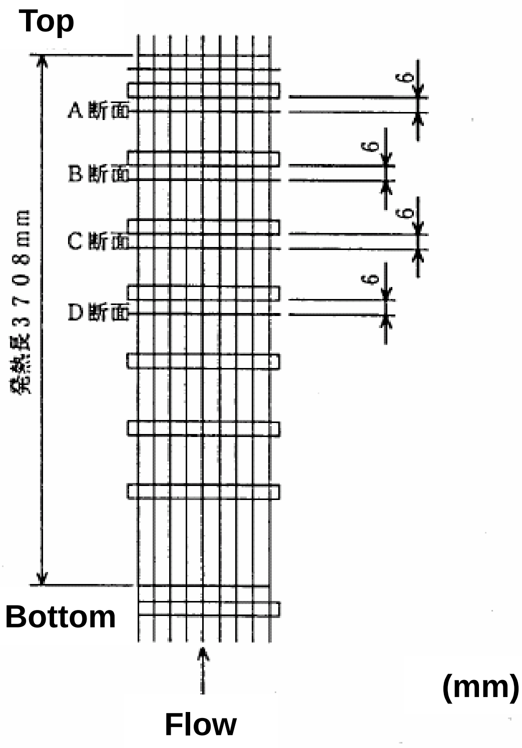



**Figure 1.2.3　Location of thermocouples for critical power measurement (C2B)**




- **Thermocouple position**




**Axial location (A – D section)**

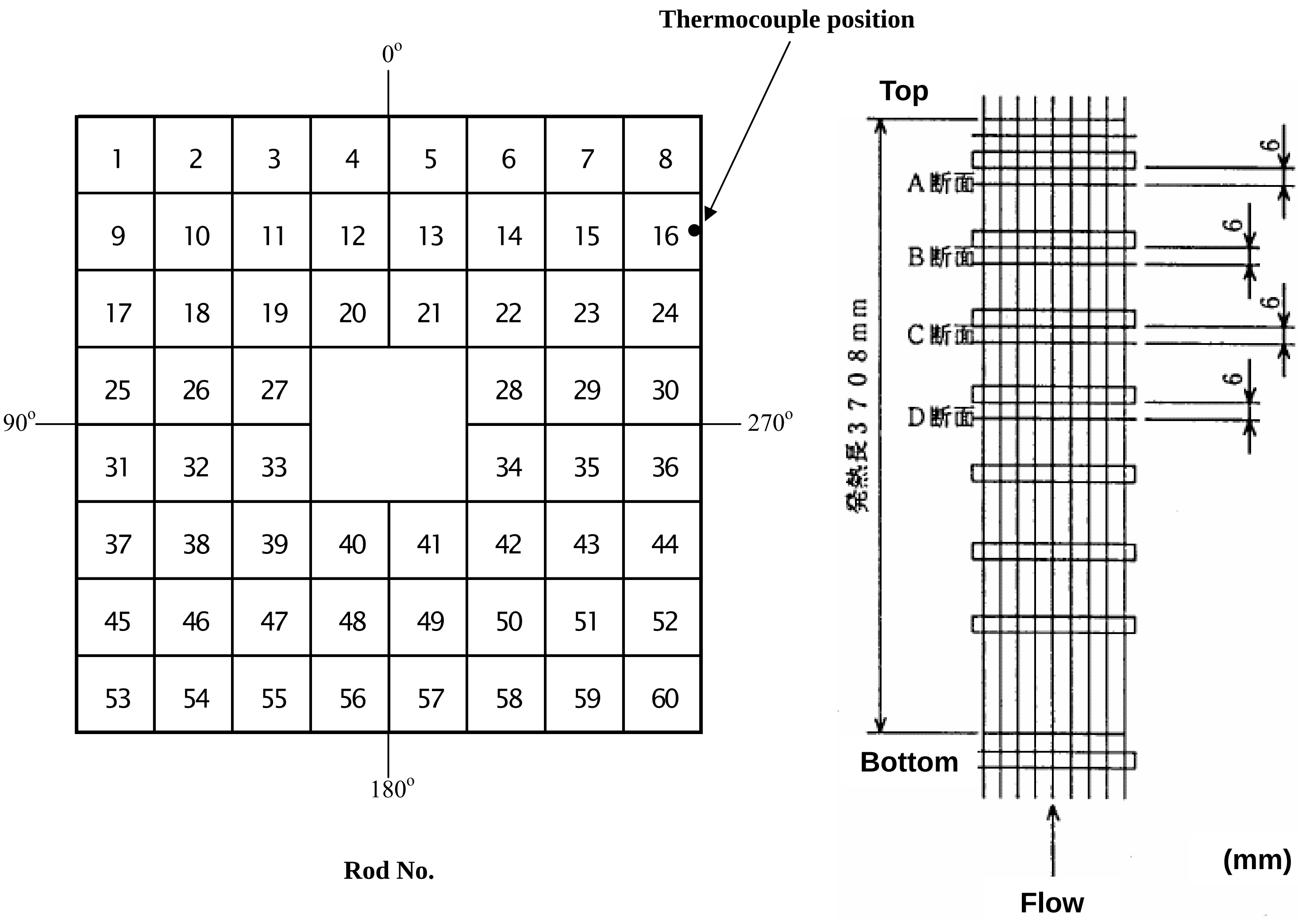
**Figure 1.2.4　Location of thermocouples for critical power measurement (C3)**

Figure 1.2.5 shows definition of thermocouple position. Thermocouple position is identified as follows;

**Rod No. – Axial location – Rotational angle**

for example

**16 – B – 270.**



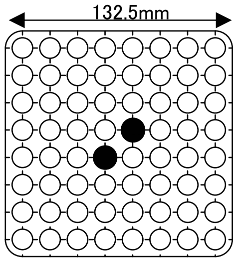
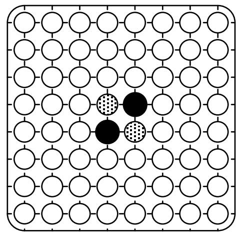
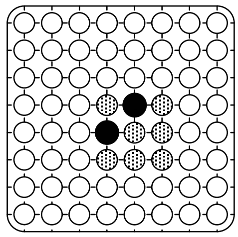

**Axial location (A – D section)**

**Figure 1.2.5 Definition of thermocouple position**

## 2. Assembly specifications

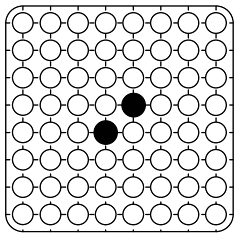
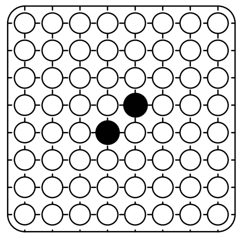
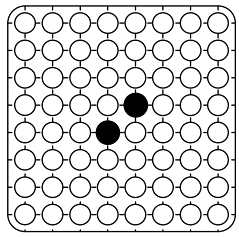
### 2.1 Geometry and power shape

**Table 2.1.1 Geometry and power shape of assembly 0-1, 0-2 and 0-3**

| Item | Data | | |
|---|---|---|---|
| Assembly |   |  |  |
| | 0-1 | 0-2 | 0-3 |
| Simulated fuel assembly type | 8×8 | | |
| Number of heated rods | 62 | 60 | 55 |
| Number of unheated rods | 0 | 2 | 7 |
| Heated rods outer diameter (mm) | 12.3 | | |
| Heated rods pitch (mm) | 16.2 | | |
| Axial heated length (mm) | 3708 | | |
| Number of water rods | 2 | | |
| Water rods outer diameter (mm) | 15.0 | | |
| Channel box inner width (mm) | 132.5 | | |
| Channel box corner radius (mm) | 8.0 | | |
| In channel flow area ($mm^2$) | 9781 | | |
| Spacer type | Grid | | |
| Number of spacers | 7 | | |
| Spacer pressure loss coefficients | 1.2 | | |
| Spacer location (mm) | 455, 967, 1479, 1991, 2503, 3015, 3527 (Distance from bottom of heated length to spacer bottom face) | | |
| Radial power shape | Uniform | | |
| Axial power shape | Uniform | | |

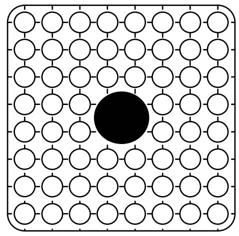
○ : Heated rod ◍ : Unheated rod ● : Water rod : no flow in water rods

**Table 2.1.2 Geometry and power shape of assembly 1, 2 and 3**

| Item | Data | | |
|---|---|---|---|
| Assembly |  |  |  |
| | 1 | 2 | 3 |
| Simulated fuel assembly type | 8×8 | | |
| Number of heated rods | 62 | | |
| Heated rods outer diameter (mm) | 12.3 | | |
| Heated rods pitch (mm) | 16.2 | | |
| Axial heated length (mm) | 3708 | 1747 | 3708 |
| Number of water rods | 2 | | |
| Water rods outer diameter (mm) | 15.0 | | |
| Channel box inner width (mm) | 132.5 | | |
| Channel box corner radius (mm) | 8.0 | | |
| In channel flow area ($mm^2$) | 9781 | | |
| Spacer type | Grid | | |
| Number of spacers | 7 | | |
| Spacer pressure loss coefficients | 1.2 | | |
| Spacer location (mm) | 455, 967, 1479, 1991, 2503, 3015, 3527 (Distance from bottom of heated length to spacer bottom face) | | |
| Radial power shape | Simulation pattern for beginning of operation | | |
| Axial power shape | Cosine | Half-cosine | Inlet Peak |

○ : Heated rod ◍ : Unheated rod ● : Water rod : no flow in water rods

**Table 2.1.3 Geometry and power shape of assembly 4, C2A, C2B and C3**

| Item | Data | | | |
|---|---|---|---|---|
| Test assembly |  | | | |
| | 4 | C2A | C2B | C3 |
| Simulated fuel assembly type | High burn-up 8×8 | | | |
| Number of heated rods | 60 | | | |
| Heated rods outer diameter (mm) | 12.3 | | | |
| Heated rods pitch (mm) | 16.2 | | | |
| Axial heated length (mm) | 3708 | | | |
| Number of water rods | 1 | | | |
| Water rods outer diameter (mm) | 34.0 | | | |
| Channel box inner width (mm) | 132.5 | | | |
| Channel box corner radius (mm) | 8.0 | | | |
| In channel flow area ($mm^2$) | 9463 | | | |
| Spacer type | Ferrule | | | |
| Number of spacers | 7 | | | |
| Spacer pressure loss coefficients | 1.2 | | | |
| Spacer location (mm) | 455, 967, 1479, 1991, 2503, 3015, 3527<br>(Distance from bottom of heated length to spacer bottom face) | | | |
| Radial power shape | A | A | B | A |
| Axial power shape | Uniform | Cosine | Cosine | Inlet-peak |

○ : Heated rod ● : Water rod : no flow in water rods
A: Simulation pattern for beginning of operation
B: Simulation pattern for middle of operation

## Table 2.1.4 Radial power shape

**Pattern for Assembly 1 to 3**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.15 | 1.30 | 1.15 | 1.30 | 1.30 | 1.15 | 1.30 | 1.15 |
| 1.30 | 0.45 | 0.89 | 0.89 | 0.89 | 0.45 | 1.15 | 1.30 |
| 1.15 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.45 | 1.15 |
| 1.30 | 0.89 | 0.89 | 0.89 | | 0.89 | 0.89 | 1.15 |
| 1.30 | 0.89 | 0.89 | | 0.89 | 0.89 | 0.89 | 1.15 |
| 1.15 | 0.45 | 0.89 | 0.89 | 0.89 | 0.89 | 0.45 | 1.15 |
| 1.30 | 1.15 | 0.45 | 0.89 | 0.89 | 0.45 | 1.15 | 1.30 |
| 1.15 | 1.30 | 1.15 | 1.15 | 1.15 | 1.15 | 1.30 | 1.15 |

**A (for Assembly 4, C2A, C3)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.15 | 1.30 | 1.15 | 1.30 | 1.30 | 1.15 | 1.30 | 1.15 |
| 1.30 | 0.45 | 0.89 | 0.89 | 0.89 | 0.45 | 1.15 | 1.30 |
| 1.15 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.45 | 1.15 |
| 1.30 | 0.89 | 0.89 | | | 0.89 | 0.89 | 1.15 |
| 1.30 | 0.89 | 0.89 | | | 0.89 | 0.89 | 1.15 |
| 1.15 | 0.45 | 0.89 | 0.89 | 0.89 | 0.89 | 0.45 | 1.15 |
| 1.30 | 1.15 | 0.45 | 0.89 | 0.89 | 0.45 | 1.15 | 1.30 |
| 1.15 | 1.30 | 1.15 | 1.15 | 1.15 | 1.15 | 1.30 | 1.15 |

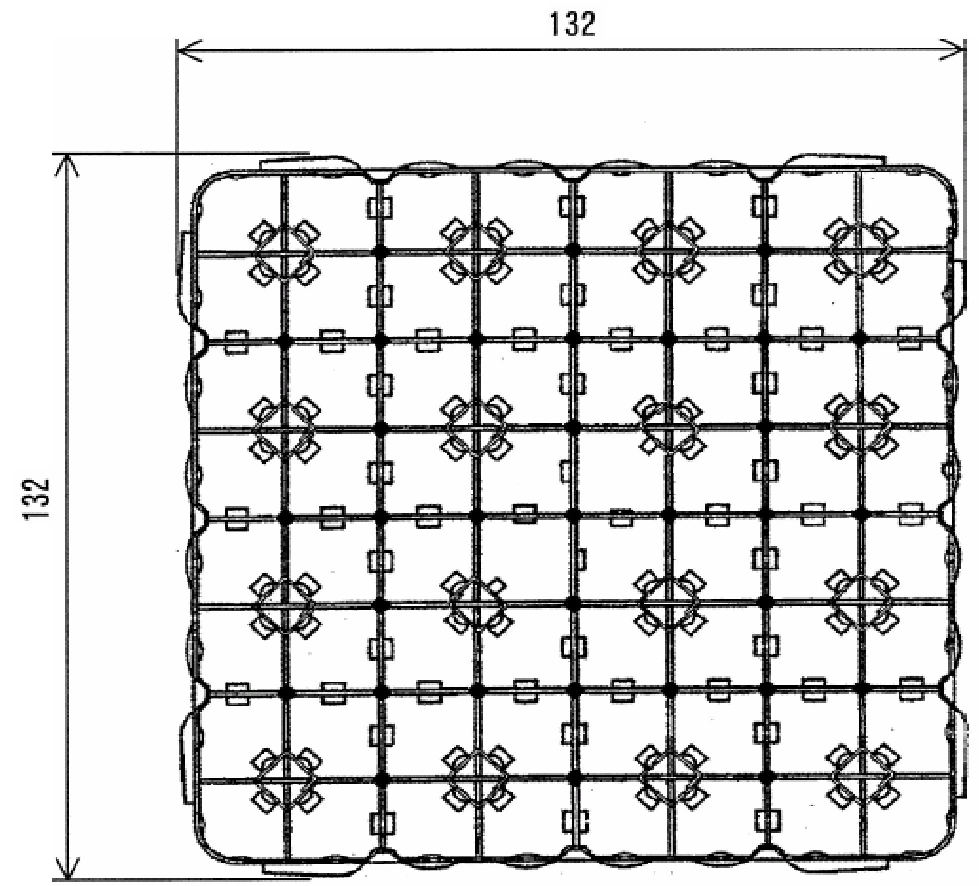
**B (for Assembly C2B)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.99 | 1.18 | 0.99 | 1.18 | 1.18 | 0.99 | 1.18 | 0.99 |
| 1.18 | 0.75 | 0.99 | 1.18 | 0.99 | 0.75 | 0.99 | 1.18 |
| 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.45 | 0.99 |
| 1.18 | 1.18 | 0.99 | | | 0.99 | 0.99 | 0.99 |
| 1.18 | 0.99 | 0.99 | | | 0.99 | 0.99 | 0.99 |
| 0.99 | 0.75 | 0.99 | 0.99 | 0.99 | 0.99 | 0.75 | 0.99 |
| 1.18 | 0.99 | 0.75 | 0.99 | 0.99 | 0.75 | 0.99 | 0.99 |
| 0.99 | 1.18 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |

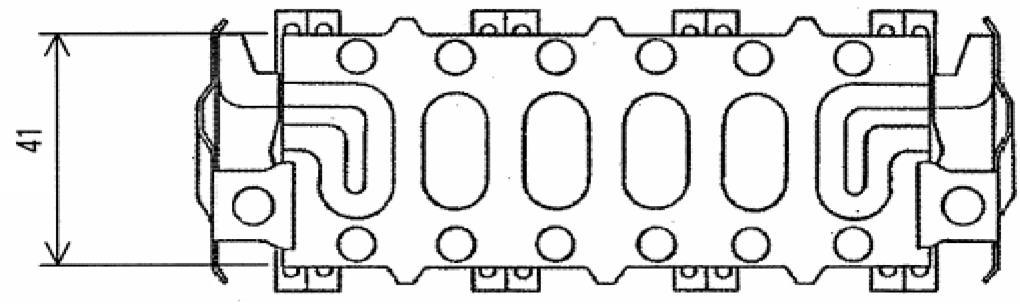
Table 2.1.5 Axial power shape

| Node | Relative power | | |
|---|---|---|---|
| | Cosine | Inlet-peak | Half-cosine |
| (Bottom) | | | |
| 1 | 0.46 | 0.53 | 0 |
| 2 | 0.58 | 0.83 | 0 |
| 3 | 0.69 | 1.00 | 0 |
| 4 | 0.79 | 1.17 | 0 |
| 5 | 0.88 | 1.28 | 0 |
| 6 | 0.99 | 1.34 | 0 |
| 7 | 1.09 | 1.37 | 0 |
| 8 | 1.22 | 1.39 | 0 |
| 9 | 1.22 | 1.40 | 0 |
| 10 | 1.34 | 1.39 | 0 |
| 11 | 1.34 | 1.37 | 0 |
| 12 | 1.40 | 1.34 | 0 |
| 13 | 1.40 | 1.28 | 0.46 |
| 14 | 1.34 | 1.21 | 0.58 |
| 15 | 1.34 | 1.10 | 0.69 |
| 16 | 1.22 | 1.00 | 0.79 |
| 17 | 1.22 | 0.89 | 0.88 |
| 18 | 1.09 | 0.79 | 0.99 |
| 19 | 0.99 | 0.71 | 1.09 |
| 20 | 0.88 | 0.64 | 1.22 |
| 21 | 0.79 | 0.58 | 1.22 |
| 22 | 0.69 | 0.53 | 1.34 |
| 23 | 0.58 | 0.46 | 1.34 |
| 24 | 0.46 | 0.40 | 1.40 |
| (Top) | | | |

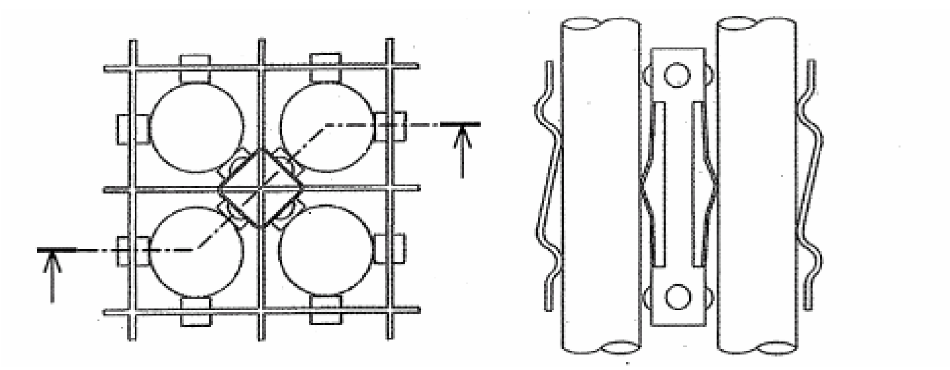
[mm]




**(a) Top view**

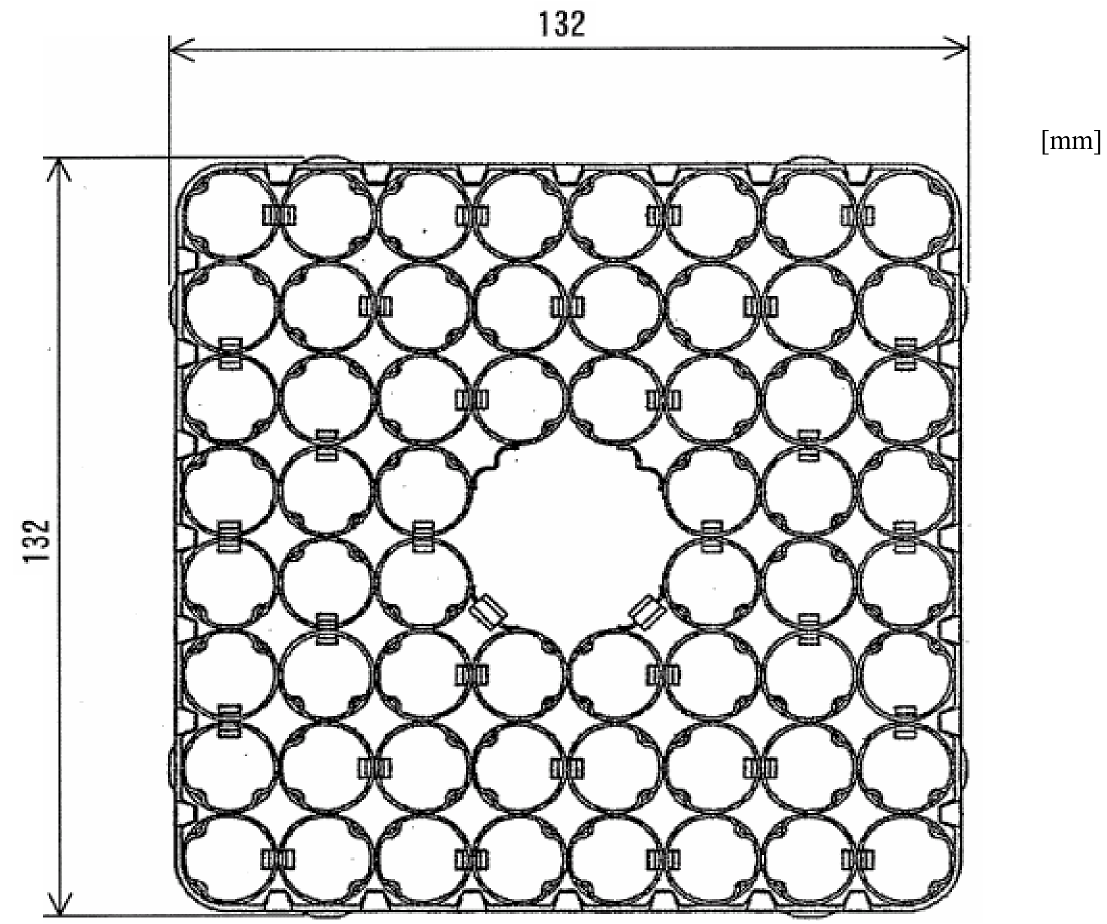



**(b) Side view**

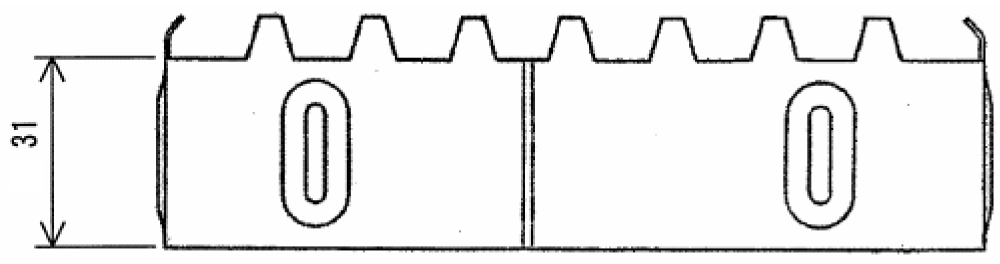


**(c) Elementary structure**

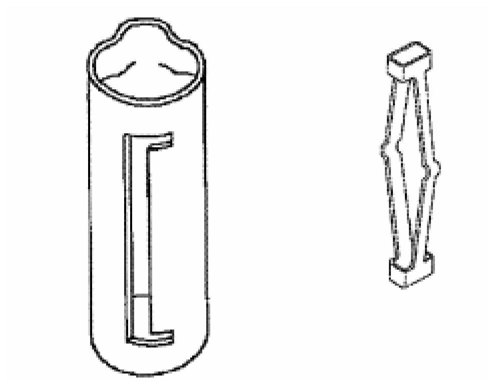
**Figure 2.1.1 Schematic of grid spacer**




(a) Top view




(b) Side view



(c) Elementary structure

**Figure 2.1.2 Schematic of ferrule spacer**

## 2.2 Heater rod specifications

Heater rod structure is specified in Table 2.2.1. Figure 2.2.1 shows cross-sectional view of heater rod.

**Table 2.2.1 Heater rod structure**

| Item | | Data |
|---|---|---|
| **Heater** | Outer diameter (mm) | 7.3 |
| | Material | Nichrome |
| **Insulator** | Outer diameter (mm) | 9.7 |
| | Material | Boron Nitride |
| **Cladding** | Thickness (mm) | 1.3 |
| | Material | Inconel 600 |

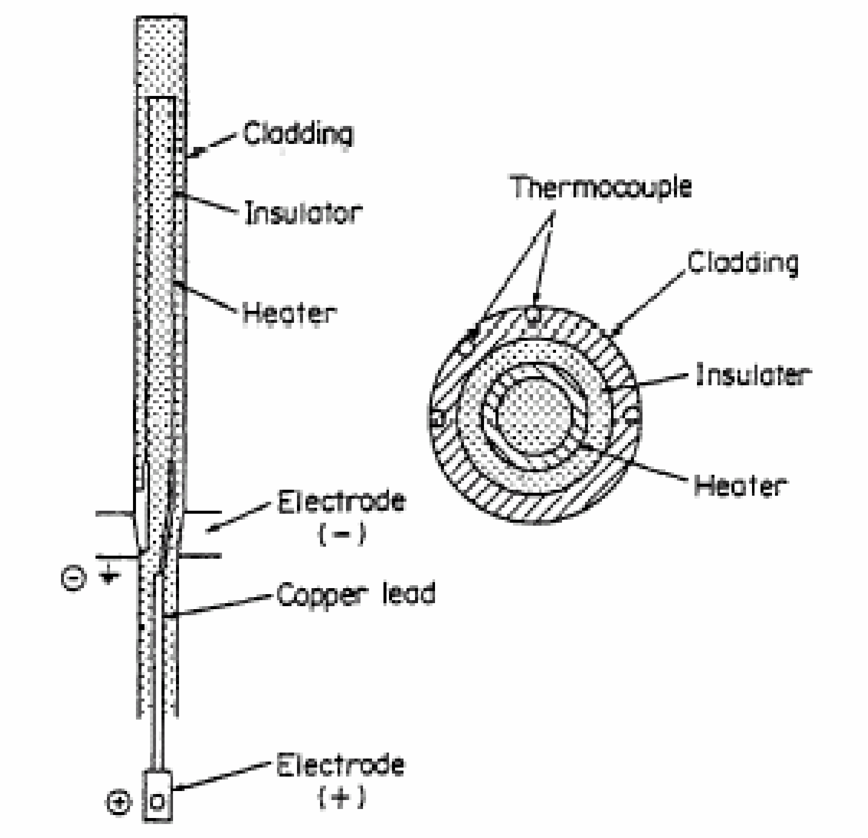



**Figure 2.2.1 Cross-sectional view of heater rod**

**2.3 Properties**
The properties were based on the MATPRO model used in TRAC code[2].

**2.3.1 Property of Nichrome**
We assume that Nichrome coils have similar properties with that of Constantan.

**(1) Density**
A constant value of 8393.4 kg/m$^3$ is used.

**(2) Specific Heat**
The specific heat is

$$c_p = 110\ T_f^{\ 0.2075}\ ,$$

where $c_p$ is the specific heat (J/ kg･K) and $T_f$ is the temperature (F).

**(3) Thermal Conductivity**
The thermal conductivity is

$$k = 29.18 + 2.683 \times 10^{-3}\ (T_f\ - 100)\ ,$$

where $k$ is the thermal conductivity (W/m･K) and $T_f$ is the temperature (F).

**2.3.2 Property of Boron Nitride**

**(1) Density**
A constant value of 2002 kg/m$^3$ is used.

**(2) Specific Heat**
The specific heat is

$$c_p = 760.59 + 1.7955\ T_f - 8.6704 \times 10^{-4}\ T_f^2 + 1.7955 \times 10^{-7}\ T_f^3$$

where $c_p$ is the specific heat (J/ kg･K) and $T_f$ is the temperature (F).

**(3) Thermal Conductivity**
The boron-nitride thermal-conductivity calculation, based on a conversion to SI units of a curve fit reported in Ref. B-6., is

$$k = 25.27 - 1.365 \times 10.3\ T_f\ ,$$

where $k$ is the thermal conductivity (W/m･K) and $T_f$ is the temperature (F).

**2.3.3 Property of Inconel 600**

**(1) Density**
The density is

$$\rho = 16.01846 \times (5.261008 \times 10^{2} - 1.345453 \times 10^{-2} T_f\ - 1.194357 \times 10^{-7}\ T_f^2),$$

where ρ is the density (kg/m$^3$) and $T_f$ is the temperature (F).

**(2) Specific Heat**
The specific heat is

$$c_p = 4186.8 \times (0.1014 + 4.378952 \times 10^{-5} T_f\ - 2.046138 \times 10^{-8} T_f^2 + 1.7955 \times 10^{-7}\ T_f^3$$
$$-2.060318 \times 10^{-13}\ T_f^4 + 3.682836 \times 10^{-16} T_f^5\ - 2.458648 \times 10^{-19}\ T_f^6 + 5.597571 \times 10^{-23}\ T_f^7),$$

where $c_p$ is the specific heat (J/ kg･K) and $T_f$ is the temperature (F).

**(3) Thermal Conductivity**
The thermal conductivity is

$$k = 1.729577 \times (8.011332 + 4.643719 \times 10^{-3} T_f\ + 1.872857 \times 10^{-6}\ T_f^2 - 3.914\ 512 \times 10^{-9}\ T_f^3$$
$$+ 3.475513 \times 10^{-12}\ T_f^4 - 9.936696 \times 10^{-16} T_f^5)\ ,$$

where $k$ is the thermal conductivity (W/m･K) and $T_f$ is the temperature (F).

## 3. Benchmark database

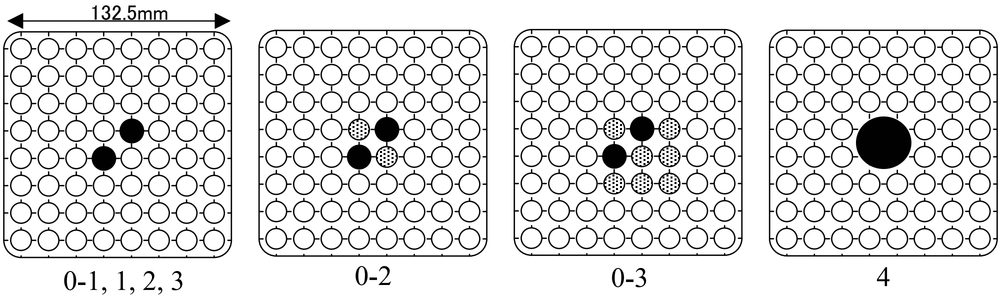
Much data has been accumulated by NUPEC BWR full-size mock-up test series. NUPEC BFBT benchmark database is summarized in Table 3.1. NUPEC BFBT data is provided not only for exercise cases but also for all cases defined in the test matrixes. These NUPEC BFBT data would be opened for the benchmark participants through the website with a password security. Selection has been made to use the accumulated data for benchmark exercises. Steady-state exercise cases were based on BWR rated conditions. Transient exercise cases were chosen as BWR representative plant transients.

**Table 3.1 NUPEC BFBT benchmark database**

| Exercise Issues | No. of Data |
|---|---|
| Phase 1 – Void Distribution Benchmark | |
| Exercise 1– Steady-state sub-channel grade benchmark | 392 |
| Exercise 2– Steady-state microscopic grade benchmark | 392 |
| Exercise 3– Transient macroscopic grade benchmark | 2 |
| Phase 2 – Critical Power Benchmark | |
| Exercise 1–Steady-state benchmark | |
| -Single-phase pressure drop exercise | 36 |
| -Two-phase pressure drop exercise | 33 |
| -Steady-state critical power exercise | 151 |
| Exercise 2– Transient benchmark | 4 |

### 3.1 Void distribution measurements

**Table 3.1.1 Steady-state void distribution measurement conditions**

| | | |
|---|---|---|
| Assembly |  | |
| Boundary Conditions | Pressure (MPa)<br>Flow rate (t/h)<br>Inlet sub-cooling (kJ/kg)<br>Exit quality (%) | 7.2<br>55<br>50.2<br>2 5 8 12 18 25 |
| Data | Void distribution matrix in sub-channel mesh size<br>Void distribution matrix in 0.3 × 0.3 mm mesh size (512 × 512 = 262K pixels)<br>Corresponding boundary conditions | |
| No. of Cases | Data supplied cases<br>Exercise cases | 392<br>sub-channel: 15<br>microscopic: 3 |

Exit quality: Thermal equilibrium quality

**Table 3.1.2 Test matrix of steady-state void distribution measurements**

| Assembly | Pressure (Mpa) | Inlet sub-cooling (kJ/kg) | Flow rate (t/h) | Exit quality (%) | | | | | | No. of data |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2 | 5 | 8 | 12 | 18 | 25 | |
| 0-1 | 1.0 | 50.2 | 10 | X | X | X | X | - | - | 13 |
| | | | 30 | X | X | X | X | - | - | |
| | | | 55 | X | X | W | X | - | - | |
| | 3.9 | | 10 | X | X | X | X | X | X | 19 |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | X | X | X | X | X | W | |
| | 7,2 | 20.9 | 45 | - | X | - | X | - | - | 36 |
| | | 50.2 | 10 | X | X | X | X | X | X | |
| | | | 20 | X | X | X | X | X | X | |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | W | E1X | W | E1X | W | E1X | |
| | | | 70 | X | X | X | X | X | - | |
| | | 126 | 55 | - | X | - | X | - | - | |
| | 8.6 | 50.2 | 10 | X | X | X | X | X | X | 18 |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | X | X | X | X | W | - | |
| 0-2 | 3.9 | 50.2 | 55 | X | X | X | X | X | W | 28 |
| | 7.2 | | 10 | X | X | X | X | X | X | |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | W | E1X | W | E1X | W | E1X | |
| | | | 70 | X | X | X | X | X | - | |
| | 8.6 | | 55 | X | X | X | X | W | - | |
| 0-3 | 3.9 | 50.2 | 55 | X | X | X | X | X | W | 28 |
| | 7.2 | | 10 | X | X | X | X | X | X | |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | W | E1X | W | E1X | W | E1X | |
| | | | 70 | X | X | X | X | X | - | |
| | 8.6 | | 55 | X | X | X | X | W | - | |
| 1 | 1.0 | 50.2 | 10 | X | X | X | X | - | - | 13 |
| | | | 30 | X | X | X | X | - | - | |
| | | | 55 | X | X | W | X | - | - | |
| | 3.9 | | 10 | X | X | X | X | X | X | 19 |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | X | X | X | X | X | W | |
| | 7,2 | 20.9 | 45 | - | X | - | X | - | - | 36 |
| | | 50.2 | 10 | X | X | X | X | X | X | |
| | | | 20 | X | X | X | X | X | X | |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | W | E1X | W | E1X | W | E1X | |
| | | | 70 | X | X | X | X | X | - | |
| | | 126 | 55 | - | X | - | X | - | - | |
| | 8.6 | 50.2 | 10 | X | X | X | X | X | X | 18 |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | X | X | X | X | W | - | |

X: test case, W: duplicated test case, E1: exercise 1 case, E2: exercise 2 case

**Table 3.1.2 Test matrix of steady-state void distribution measurements (cont'd)**

| Assembly | Pressure (Mpa) | Inlet sub-cooling (kJ/kg) | Flow rate (t/h) | Exit quality (%) | | | | | | No. of data |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2 | 5 | 8 | 12 | 18 | 25 | |
| 2 | 3.9 | 50.2 | 10 | X | X | X | X | - | X | 14 |
| | | | 30 | X | X | X | X | - | - | |
| | | | 55 | X | X | X | X | - | - | |
| | 7.2 | | 10 | X | X | X | X | - | X | 23 |
| | | | 20 | X | X | X | X | - | X | |
| | | | 30 | X | X | X | X | - | X | |
| | | | 55 | X | X | X | W | - | - | |
| | | | 70 | X | X | X | - | - | - | |
| | 8.6 | | 10 | X | X | X | X | - | X | 13 |
| | | | 30 | X | X | X | X | - | - | |
| | | | 55 | X | X | W | - | - | - | |
| 3 | 3.9 | 50.2 | 55 | X | X | X | X | X | W | 28 |
| | 7.2 | | 10 | X | X | X | X | X | X | |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | W | X | W | X | W | X | |
| | | | 70 | X | X | X | X | X | - | |
| | 8.6 | | 55 | X | X | X | X | W | - | |
| 4 | 1.0 | 50.2 | 10 | X | X | X | X | - | - | 13 |
| | | | 30 | X | X | X | X | - | - | |
| | | | 55 | X | X | W | X | - | - | |
| | 3.9 | | 10 | X | X | X | X | X | X | 19 |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | X | X | X | X | X | W | |
| | 7,2 | 20.9 | 45 | - | X | - | X | - | - | 36 |
| | | 50.2 | 10 | X | X | X | X | X | X | |
| | | | 20 | X | X | X | X | X | X | |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | W | E1E2X | W | E1E2X | W | E1E2X | |
| | | | 70 | X | X | X | X | X | - | |
| | | 126 | 55 | - | X | - | X | - | - | |
| | 8.6 | 50.2 | 10 | X | X | X | X | X | X | 18 |
| | | | 30 | X | X | X | X | X | X | |
| | | | 55 | X | X | X | X | W | - | |

X: test case, W: duplicated test case, E1: case for exercise 1, E2: case for exercise 2

**Table 3.1.3 Test No. of steady-state void distribution measurements(Note)**

| Test No. | Assembly | Pressure (Mpa) | Flow rate (t/h) | Inlet sub-cooling (kJ/kg) | Exit quality (%) | Exercise cases | |
|---|---|---|---|---|---|---|---|
| 0011-53 | 0-1 | 7.18 | 54.5 | 51.5 | 2.0 | - | - |
| 0011-54 | 0-1 | 7.17 | 54.2 | 52.3 | 1.9 | - | - |
| 0011-55 | 0-1 | 7.18 | 54.0 | 52.6 | 5.0 | E1 | - |
| 0011-56 | 0-1 | 7.17 | 54.8 | 51.6 | 7.8 | - | - |
| 0011-57 | 0-1 | 7.16 | 54.8 | 49.8 | 8.0 | - | - |
| 0011-58 | 0-1 | 7.17 | 54.9 | 51.0 | 12.0 | E1 | - |
| 0011-59 | 0-1 | 7.18 | 54.8 | 50.2 | 17.9 | - | - |
| 0011-60 | 0-1 | 7.19 | 55.0 | 52.1 | 18.0 | - | - |
| 0011-61 | 0-1 | 7.21 | 54.8 | 50.9 | 24.9 | E1 | - |
| 0021-15 | 0-2 | 7.16 | 54.7 | 52.3 | 1.9 | - | - |
| 0021-16 | 0-2 | 7.19 | 54.9 | 54.0 | 4.8 | E1 | - |
| 0021-17 | 0-2 | 7.17 | 54.8 | 51.1 | 7.9 | - | - |
| 0021-18 | 0-2 | 7.17 | 54.9 | 49.8 | 12.1 | E1 | - |
| 0021-19 | 0-2 | 7.17 | 54.9 | 49.4 | 18.0 | - | - |
| 0021-20 | 0-2 | 7.16 | 54.8 | 51.5 | 17.8 | - | - |
| 0021-21 | 0-2 | 7.18 | 54.9 | 51.4 | 24.9 | E1 | - |
| 0031-15 | 0-3 | 7.17 | 55.0 | 52.3 | 1.9 | - | - |
| 0031-16 | 0-3 | 7.18 | 55.0 | 52.4 | 4.9 | E1 | - |
| 0031-17 | 0-3 | 7.16 | 54.8 | 50.5 | 8.0 | - | - |
| 0031-18 | 0-3 | 7.18 | 54.8 | 50.0 | 12.1 | E1 | - |
| 0031-19 | 0-3 | 7.17 | 54.8 | 50.8 | 18.0 | - | - |
| 0031-20 | 0-3 | 7.16 | 54.8 | 49.6 | 18.0 | - | - |
| 0031-21 | 0-3 | 7.17 | 54.9 | 49.4 | 25.0 | E1 | - |
| 1071-53 | 1 | 7.18 | 54.6 | 52.2 | 1.9 | - | - |
| 1071-54 | 1 | 7.17 | 54.4 | 52.4 | 1.9 | - | - |
| 1071-55 | 1 | 7.19 | 54.6 | 52.8 | 4.9 | E1 | - |
| 1071-56 | 1 | 7.20 | 54.6 | 54.0 | 7.9 | - | - |
| 1071-57 | 1 | 7.17 | 54.6 | 52.3 | 7.9 | - | - |
| 1071-58 | 1 | 7.16 | 55.1 | 50.3 | 11.9 | E1 | - |
| 1071-59 | 1 | 7.18 | 54.7 | 51.3 | 18.0 | - | - |
| 1071-60 | 1 | 7.18 | 55.0 | 51.8 | 17.9 | - | - |
| 1071-61 | 1 | 7.20 | 54.7 | 51.8 | 25.1 | E1 | - |
| 4101-53 | 4 | 7.18 | 54.7 | 52.8 | 1.9 | - | - |
| 4101-54 | 4 | 7.19 | 54.6 | 52.7 | 1.9 | - | - |
| 4101-55 | 4 | 7.20 | 54.6 | 52.9 | 5.0 | E1 | E2 |
| 4101-56 | 4 | 7.17 | 54.6 | 51.8 | 7.9 | - | - |
| 4101-57 | 4 | 7.17 | 54.6 | 52.4 | 8.0 | - | - |
| 4101-58 | 4 | 7.15 | 54.6 | 50.6 | 12.1 | E1 | E2 |
| 4101-59 | 4 | 7.19 | 54.6 | 52.1 | 18.1 | - | - |
| 4101-60 | 4 | 7.18 | 54.6 | 50.5 | 18.2 | - | - |
| 4101-61 | 4 | 7.18 | 54.7 | 52.5 | 25.1 | E1 | E2 |

E1: case for exercise 1, E2: case for exercise 2
(Note) Cases listed in Table 3.1.3 are a part of cases in the matrix shown in Table 3.1.2.

**Table 3.1.4 Transient void distribution measurement conditions**

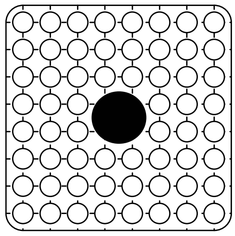
| | | |
|---|---|---|
| Assembly |  4 | |
| Rated Initial Conditions | Pressure (MPa)<br>Power (MW)<br>Flow rate (t/h)<br>Inlet temperature (Celsius) | 7.2<br>4.5<br>55<br>279 |
| Transients | Turbine trip without bypass<br>Re-circulation pump trip | |
| Data | Time histories of cross sectional averaged void fraction in each axial level during transients<br>Corresponding boundary conditions during transients | |
| No. of Cases | Data supplied cases<br>Exercise cases | <br>2 |

**Table 3.1.5 Test matrix of transient void distribution measurements**

| Assembly | Initial Conditions | | | | Transients | Exercise cases | No. of Cases |
|---|---|---|---|---|---|---|---|
| | Pressure (Mpa) | Power (MW) | Flow rate (t/h) | Inlet temperature (Celsius) | | | |
| 4 | 7.2 | 4.5 | 55 | 279 | Turbine trip without bypass | E | 2 |
| | | | | | Re-circulation pump trip | E | |

E: case for exercise

**Table 3.1.6 Test No. of transient void distribution measurements**

| Test No. | Assembly | Initial Conditions | | | | Transients | Exercise cases |
|---|---|---|---|---|---|---|---|
| | | Pressure (Mpa) | Power (MW) | Flow rate (t/h) | Inlet temperature (Celsius) | | |
| 4102-001~009 | 4 | 7.2 | 4.5 | 55 | 279 | Turbine trip without bypass | E |
| 4102-019~027 | 4 | 7.2 | 4.5 | 55 | 279 | Re-circulation pump trip | E |

E: exercise case

## 3.2 Critical power measurements

**Table 3.2.1 Single-phase pressure drop measurement conditions**

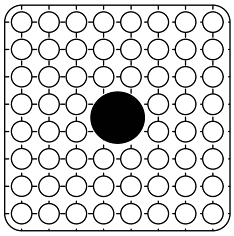
| | | |
|---|---|---|
| Assembly |  C2A | |
| Boundary Conditions | Pressure (MPa)<br>Flow rate (t/h) | 0.1 0.98 7.2<br>10 15 20 25 30 35 40 45 55 60 65 70 |
| Data | Pressure drop along with axial heated length<br>Corresponding boundary conditions | |
| No. of Cases | Data supplied cases<br>Exercise cases | 36 |
| Concerned Issues | Single-phase pressure drop from bottom to top of heated length (Ref.3, Fig.19) | |

**Table 3.2.2 Test matrix of single-phase pressure drop measurements**

| Assembly | Pressure (Mpa) | Flow rate (t/h) | | | | | | | | | | | | No. of data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 55 | 60 | 65 | 70 | |
| C2A | 0.1 | X | X | X | X | X | X | X | X | X | X | X | X | 36 |
| | 1.0 | X | X | X | X | X | X | X | X | X | X | X | X | |
| | 7.2 | X | X | X | X | X | X | X | X | X | X | X | X | |

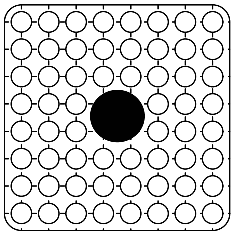
X: test case, E: case for exercise

**Table 3.2.3 Test No. of single-phase pressure drop measurements**

| Test No. | Assembly | Pressure (Mpa) | Flow rate (t/h) | Exercise cases |
|---|---|---|---|---|
| P70001 | C2A | 0.2 | 9.9 | - |
| P70002 | C2A | 0.2 | 14.5 | - |
| P70003 | C2A | 0.2 | 19.9 | - |
| P70004 | C2A | 0.2 | 24.9 | - |
| P70005 | C2A | 0.2 | 29.8 | - |
| P70006 | C2A | 0.2 | 34.8 | - |
| P70007 | C2A | 0.2 | 39.7 | - |
| P70008 | C2A | 0.2 | 44.8 | - |
| P70009 | C2A | 0.2 | 54.6 | - |
| P70010 | C2A | 0.2 | 59.8 | - |
| P70011 | C2A | 0.2 | 64.2 | - |
| P70012 | C2A | 0.2 | 69.2 | - |
| P70013 | C2A | 1.0 | 9.9 | - |
| P70014 | C2A | 0.99 | 14.9 | - |
| P70015 | C2A | 0.99 | 20.3 | - |
| P70016 | C2A | 0.98 | 24.8 | - |
| P70017 | C2A | 0.98 | 29.9 | - |
| P70018 | C2A | 0.99 | 34.7 | - |
| P70019 | C2A | 0.99 | 39.8 | - |
| P70020 | C2A | 0.99 | 45.3 | - |
| P70021 | C2A | 1.0 | 54.8 | - |
| P70022 | C2A | 0.98 | 59.8 | - |
| P70023 | C2A | 0.98 | 64.8 | - |
| P70024 | C2A | 0.98 | 69.8 | - |
| P70025 | C2A | 7.17 | 9.9 | - |
| P70026 | C2A | 7.15 | 15.4 | - |
| P70027 | C2A | 7.15 | 20.3 | - |
| P70028 | C2A | 7.16 | 24.9 | - |
| P70029 | C2A | 7.16 | 29.8 | - |
| P70030 | C2A | 7.16 | 34.7 | - |
| P70031 | C2A | 7.16 | 39.7 | - |
| P70032 | C2A | 7.16 | 44.6 | - |
| P70033 | C2A | 7.15 | 55.0 | - |
| P70034 | C2A | 7.15 | 59.7 | - |
| P70035 | C2A | 7.16 | 64.8 | - |
| P70036 | C2A | 7.15 | 69.9 | - |

E: exercise case

**Table 3.2.4 Two-phase pressure drop measurement conditions**

| | | |
|---|---|---|
| Assembly | <br>C2A | |
| Boundary Conditions | Pressure (MPa) | 7.2 8.6 |
| | Flow rate (t/h) | 20 45 55 70 |
| | Inlet sub-cooling (kJ/kg) | 50.2 |
| | Exit quality (%) | 7 10 15 20 25 |
| Data | Pressure drop along with axial heated length<br>Corresponding boundary conditions | |
| No. of Cases | Data supplied cases | 33 |
| | Exercise cases | |

Exit quality: Thermal equilibrium quality

**Table 3.2.5 Test matrix of two-phase pressure drop measurements**

| Assembly | Pressure (Mpa) | Flow rate (t/h) | Inlet sub-cooling (kJ/kg) | Exit quality (%) | | | | | No. of data |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 7 | 10 | 15 | 20 | 25 | |
| C2A | 7.2 | 20 | 50.2 | X | X | X | X | W | 21 |
| | | 45 | | X | X | X | X | X | |
| | | 55 | | X | X | X | X | W | |
| | | 70 | | X | X | X | X | - | |
| | 8.6 | 20 | 50.2 | X | - | X | - | X | 12 |
| | | 45 | | X | - | X | - | X | |
| | | 55 | | X | - | X | - | W | |
| | | 70 | | X | - | X | - | - | |

X: test case, W: duplicated test case, E: exercise case

**Table 3.2.6 Test No. of two-phase pressure drop measurements**

| Test No. | Assembly | Pressure (Mpa) | Flow rate (t/h) | Inlet sub-cooling (kJ/kg) | Exit quality (%) | Exercise cases |
|---|---|---|---|---|---|---|
| P60001 | C2A | 7.16 | 20.2 | 53.3 | 6.7 | - |
| P60002 | C2A | 7.16 | 20.1 | 51.8 | 9.9 | - |
| P60003 | C2A | 7.16 | 20.1 | 50.8 | 14.8 | - |
| P60004 | C2A | 7.16 | 20.2 | 51.3 | 19.9 | - |
| P60005 | C2A | 7.16 | 20.0 | 51.1 | 24.9 | - |
| P60006 | C2A | 7.16 | 20.1 | 50.8 | 24.9 | - |
| P60007 | C2A | 7.17 | 55.0 | 51.1 | 7.0 | - |
| P60008 | C2A | 7.17 | 55.0 | 49.0 | 10.1 | - |
| P60009 | C2A | 7.17 | 55.0 | 51.1 | 15.0 | - |
| P60010 | C2A | 7.17 | 54.9 | 47.3 | 20.1 | - |
| P60011 | C2A | 7.17 | 54.9 | 50.6 | 25.1 | - |
| P60012 | C2A | 7.17 | 55.0 | 49.7 | 25.1 | - |
| P60013 | C2A | 7.16 | 69.9 | 47.2 | 7.3 | - |
| P60014 | C2A | 7.16 | 70.1 | 50.6 | 10.0 | - |
| P60015 | C2A | 7.17 | 70.0 | 49.5 | 15.1 | - |
| P60016 | C2A | 7.18 | 70.1 | 50.3 | 20.0 | - |
| P60017 | C2A | 7.16 | 45.1 | 51.0 | 6.8 | - |
| P60018 | C2A | 7.17 | 44.9 | 50.8 | 10.0 | - |
| P60019 | C2A | 7.17 | 45.0 | 49.4 | 15.1 | - |
| P60020 | C2A | 7.16 | 45.1 | 51.8 | 19.8 | - |
| P60021 | C2A | 7.16 | 45.1 | 50.8 | 25.0 | - |
| P60022 | C2A | 8.64 | 20.2 | 50.7 | 7.0 | - |
| P60023 | C2A | 8.63 | 20.2 | 52.3 | 14.8 | - |
| P60024 | C2A | 8.63 | 20.2 | 52.9 | 24.9 | - |
| P60025 | C2A | 8.64 | 55.0 | 51.3 | 6.9 | - |
| P60026 | C2A | 8.64 | 55.1 | 53.0 | 14.7 | - |
| P60027 | C2A | 8.64 | 55.1 | 51.5 | 24.9 | - |
| P60028 | C2A | 8.63 | 55.1 | 51.3 | 24.9 | - |
| P60029 | C2A | 8.64 | 70.1 | 51.5 | 6.9 | - |
| P60030 | C2A | 8.64 | 70.2 | 51.4 | 14.9 | - |
| P60031 | C2A | 8.64 | 45.1 | 53.0 | 6.9 | - |
| P60032 | C2A | 8.63 | 45.2 | 51.3 | 14.9 | - |
| P60033 | C2A | 8.63 | 45.1 | 51.6 | 24.9 | - |

E: exercise case

**Table 3.2.7 Steady-state critical power measurement conditions**

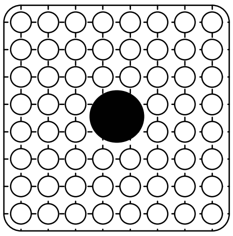
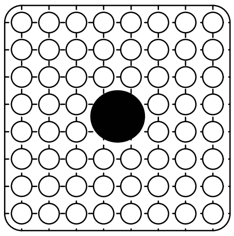
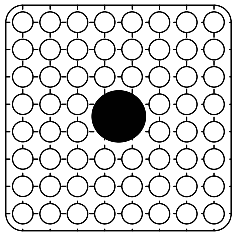
| | | | |
|---|---|---|---|
| Assembly |  C2A |  C2B |  C3 |
| Boundary Conditions | Pressure (MPa)<br>Flow rate (t/h)<br>Inlet sub-cooling (kJ/kg) | 5.5 7.2 8.6<br>10 20 30 45 55 60 65<br>25 50 84 104 126 | |
| Data | Critical power, Location of boiling transition<br>Corresponding boundary conditions | | |
| No. of Cases | Data supplied cases<br>Exercise cases | 151<br>44 | |

**Table 3.2.8 Test matrix of steady-state critical power measurements**

| Assembly | Pressure (Mpa) | Flow rate (t/h) | Inlet sub-cooling (kJ/kg) | | | | | No. of data |
|---|---|---|---|---|---|---|---|---|
| | | | 25 | 50 | 84 | 104 | 126 | |
| C2A | 5.5 | 20 | X | EW | X | - | X | 20 |
| | | 45 | X | EX | X | - | X | |
| | | 55 | EW | EW | EW | - | EX | |
| | | 65 | X | EX | X | - | X | |
| | 7.2 | 10 | X | X | X | X | X | 35 |
| | | 20 | X | EW | X | X | X | |
| | | 30 | X | EX | X | X | X | |
| | | 45 | X | EX | X | X | X | |
| | | 55 | EW | EW | EX | EW | EX | |
| | | 60 | X | EX | X | X | X | |
| | | 65 | X | EX | X | X | X | |
| | 8.6 | 20 | X | EW | X | - | X | 20 |
| | | 45 | X | EX | X | - | X | |
| | | 55 | EW | EW | EW | - | EX | |
| | | 65 | X | EX | X | - | X | |
| C2B | 7.2 | 10 | X | X | X | X | X | 36 |
| | | 20 | X | EX | X | X | X | |
| | | 30 | X | EX | X | X | X | |
| | | 45 | X | EX | X | X | X | |
| | | 55 | EX | EW | EX | EX | EX | |
| | | 60 | X | EX | X | X | X | |
| | | 65 | X | EX | X | X | X | |
| C3 | 7.2 | 10 | X | X | X | X | X | 36 |
| | | 20 | X | EX | X | X | X | |
| | | 30 | X | EX | X | X | X | |
| | | 45 | X | EX | X | X | X | |
| | | 55 | EX | EW | EX | EX | EX | |
| | | 60 | X | EX | X | X | X | |
| | | 65 | X | EX | X | X | X | |

X: test case, W: duplicated test case, E: exercise case

**Table 3.2.9 Test No. of steady-state critical power measurements (C2A)**

| Test No. | Assembly | Pressure (Mpa) | Flow rate (t/h) | Inlet sub-cooling (kJ/kg) | Exercise cases |
|---|---|---|---|---|---|
| SA505500 | C2A | 5.49 | 20.16 | 50.95 | E |
| SA505501 | C2A | 5.49 | 20.10 | 51.35 | E |
| SA505600 | C2A | 5.51 | 20.12 | 84.79 | - |
| SA505800 | C2A | 5.50 | 20.19 | 129.38 | - |
| SA505900 | C2A | 5.49 | 20.14 | 26.04 | - |
| SA510500 | C2A | 5.48 | 55.06 | 56.41 | E |
| SA510501 | C2A | 5.51 | 55.11 | 62.48 | E |
| SA510600 | C2A | 5.51 | 54.70 | 96.16 | E |
| SA510601 | C2A | 5.52 | 55.34 | 96.79 | E |
| SA510800 | C2A | 5.51 | 54.81 | 134.97 | E |
| SA510900 | C2A | 5.52 | 54.70 | 35.33 | E |
| SA510901 | C2A | 5.51 | 55.05 | 35.02 | E |
| SA512500 | C2A | 5.54 | 65.48 | 64.36 | E |
| SA512600 | C2A | 5.51 | 64.97 | 99.60 | - |
| SA512800 | C2A | 5.50 | 65.52 | 133.75 | - |
| SA512900 | C2A | 5.52 | 65.12 | 40.30 | - |
| SA516500 | C2A | 5.51 | 44.85 | 55.98 | E |
| SA516600 | C2A | 5.52 | 45.03 | 91.83 | - |
| SA516800 | C2A | 5.50 | 45.28 | 132.07 | - |
| SA516900 | C2A | 5.52 | 45.13 | 35.66 | - |
| SA603500 | C2A | 7.18 | 10.07 | 51.85 | - |
| SA603600 | C2A | 7.16 | 10.07 | 86.12 | - |
| SA603700 | C2A | 7.17 | 9.98 | 106.75 | - |
| SA603800 | C2A | 7.16 | 9.99 | 122.79 | - |
| SA603901 | C2A | 7.18 | 10.01 | 25.82 | - |
| SA605500 | C2A | 7.16 | 20.09 | 50.55 | E |
| SA605502 | C2A | 7.17 | 20.07 | 51.44 | E |
| SA605600 | C2A | 7.17 | 20.19 | 83.57 | - |
| SA605700 | C2A | 7.17 | 20.24 | 106.22 | - |
| SA605801 | C2A | 7.16 | 20.21 | 127.20 | - |
| SA605900 | C2A | 7.16 | 20.21 | 22.61 | - |
| SA607500 | C2A | 7.13 | 30.02 | 48.35 | E |
| SA607600 | C2A | 7.15 | 30.23 | 82.55 | - |
| SA607700 | C2A | 7.16 | 30.00 | 106.63 | - |
| SA607800 | C2A | 7.18 | 30.12 | 126.80 | - |
| SA607900 | C2A | 7.15 | 30.23 | 23.42 | - |
| SA610503 | C2A | 7.17 | 55.20 | 59.39 | E |
| SA610504 | C2A | 7.17 | 55.47 | 58.09 | E |
| SA610600 | C2A | 7.18 | 55.05 | 89.53 | E |
| SA610700 | C2A | 7.13 | 55.20 | 107.61 | E |
| SA610701 | C2A | 7.21 | 54.88 | 113.28 | E |
| SA610800 | C2A | 7.24 | 55.30 | 137.26 | E |
| SA610900 | C2A | 7.27 | 55.10 | 37.73 | E |
| SA610902 | C2A | 7.18 | 55.42 | 32.94 | E |
| SA611500 | C2A | 7.13 | 60.23 | 54.89 | E |
| SA611600 | C2A | 7.12 | 60.18 | 89.39 | - |
| SA611700 | C2A | 7.23 | 60.10 | 114.29 | - |

E: exercise case

**Table 3.2.9 Test No. of steady-state critical power measurements (C2A) (cont'd)**

| Test No. | Assembly | Pressure (Mpa) | Flow rate (t/h) | Inlet sub-cooling (kJ/kg) | Exercise cases |
|---|---|---|---|---|---|
| SA611800 | C2A | 7.15 | 60.07 | 131.68 | - |
| SA611900 | C2A | 7.16 | 60.30 | 33.18 | - |
| SA612500 | C2A | 7.16 | 65.36 | 55.66 | E |
| SA612600 | C2A | 7.17 | 64.99 | 91.82 | - |
| SA612700 | C2A | 7.17 | 65.19 | 107.82 | - |
| SA612800 | C2A | 7.18 | 65.01 | 132.81 | - |
| SA612900 | C2A | 7.16 | 65.72 | 32.31 | - |
| SA616500 | C2A | 7.13 | 45.17 | 54.21 | E |
| SA616600 | C2A | 7.19 | 45.01 | 88.72 | - |
| SA616700 | C2A | 7.23 | 45.13 | 110.60 | - |
| SA616800 | C2A | 7.15 | 45.07 | 128.01 | - |
| SA616900 | C2A | 7.14 | 45.35 | 30.59 | - |
| SA805500 | C2A | 8.63 | 20.30 | 51.00 | E |
| SA805501 | C2A | 8.64 | 20.30 | 50.28 | E |
| SA805600 | C2A | 8.62 | 20.26 | 82.58 | - |
| SA805800 | C2A | 8.60 | 20.31 | 125.79 | - |
| SA805900 | C2A | 8.63 | 20.13 | 27.84 | - |
| SA810501 | C2A | 8.62 | 55.15 | 54.89 | E |
| SA810502 | C2A | 8.64 | 55.16 | 55.12 | E |
| SA810600 | C2A | 8.56 | 55.00 | 83.85 | E |
| SA810601 | C2A | 8.64 | 55.21 | 88.54 | E |
| SA810800 | C2A | 8.64 | 55.28 | 130.30 | E |
| SA810900 | C2A | 8.66 | 55.38 | 30.97 | E |
| SA810901 | C2A | 8.60 | 55.15 | 27.55 | E |
| SA812500 | C2A | 8.64 | 65.25 | 58.08 | E |
| SA812600 | C2A | 8.64 | 64.95 | 91.08 | - |
| SA812800 | C2A | 8.67 | 65.27 | 135.52 | - |
| SA812900 | C2A | 8.65 | 65.22 | 29.55 | - |
| SA816500 | C2A | 8.61 | 45.24 | 52.22 | E |
| SA816600 | C2A | 8.67 | 45.52 | 88.65 | - |
| SA816800 | C2A | 8.60 | 45.23 | 128.18 | - |
| SA816900 | C2A | 8.65 | 45.24 | 27.81 | - |

E: exercise case

**Table 3.2.10 Test No. of steady-state critical power measurements (C2B)**

| Run No. | Assembly | Pressure (Mpa) | Flow rate (t/h) | Inlet sub-cooling (kJ/kg) | Exercise cases |
|---|---|---|---|---|---|
| SB603500 | C2B | 7.17 | 9.93 | 50.50 | - |
| SB603602 | C2B | 7.15 | 9.96 | 84.59 | - |
| SB603700 | C2B | 7.17 | 9.99 | 104.90 | - |
| SB603800 | C2B | 7.15 | 10.09 | 128.57 | - |
| SB603900 | C2B | 7.14 | 10.01 | 23.14 | - |
| SB605500 | C2B | 7.15 | 20.03 | 51.66 | E |
| SB605600 | C2B | 7.14 | 19.93 | 80.09 | - |
| SB605700 | C2B | 7.16 | 20.18 | 103.88 | - |
| SB605800 | C2B | 7.17 | 20.07 | 126.40 | - |
| SB605900 | C2B | 7.14 | 19.84 | 21.06 | - |
| SB607500 | C2B | 7.13 | 30.05 | 49.90 | E |
| SB607600 | C2B | 7.17 | 29.95 | 83.37 | - |
| SB607700 | C2B | 7.16 | 29.83 | 105.04 | - |
| SB607800 | C2B | 7.14 | 29.97 | 126.27 | - |
| SB607900 | C2B | 7.18 | 29.76 | 24.61 | - |
| SB610500 | C2B | 7.2 | 54.84 | 54.28 | E |
| SB610501 | C2B | 7.19 | 54.91 | 51.16 | E |
| SB610600 | C2B | 7.18 | 54.91 | 82.45 | E |
| SB610700 | C2B | 7.18 | 54.71 | 105.31 | E |
| SB610800 | C2B | 7.14 | 54.90 | 122.48 | E |
| SB610900 | C2B | 7.2 | 54.88 | 26.55 | E |
| SB611500 | C2B | 7.19 | 59.88 | 54.03 | E |
| SB611600 | C2B | 7.19 | 59.95 | 87.15 | - |
| SB611700 | C2B | 7.13 | 59.74 | 101.34 | - |
| SB611800 | C2B | 7.18 | 59.88 | 127.26 | - |
| SB611900 | C2B | 7.13 | 59.83 | 26.83 | - |
| SB612500 | C2B | 7.18 | 64.60 | 48.65 | E |
| SB612600 | C2B | 7.18 | 64.68 | 81.47 | - |
| SB612700 | C2B | 7.21 | 64.05 | 106.23 | - |
| SB612800 | C2B | 7.15 | 64.82 | 125.63 | - |
| SB612900 | C2B | 7.16 | 64.85 | 21.18 | - |
| SB616501 | C2B | 7.14 | 44.82 | 47.96 | E |
| SB616600 | C2B | 7.18 | 44.91 | 83.57 | - |
| SB616700 | C2B | 7.18 | 44.93 | 107.37 | - |
| SB616800 | C2B | 7.16 | 45.01 | 127.09 | - |
| SB616900 | C2B | 7.18 | 44.82 | 27.54 | - |

E: exercise case

**Table 3.2.11 Test No. of steady-state critical power measurements (C3)**

| Test No. | Assembly | Pressure (Mpa) | Flow rate (t/h) | Inlet sub-cooling (kJ/kg) | Exercise cases |
|---|---|---|---|---|---|
| SC603900 | C3 | 7.14 | 9.95 | 21.70 | - |
| SC603500 | C3 | 7.15 | 9.95 | 50.88 | - |
| SC603600 | C3 | 7.16 | 10.01 | 88.57 | - |
| SC603700 | C3 | 7.17 | 9.93 | 105.55 | - |
| SC603800 | C3 | 7.16 | 9.98 | 125.35 | - |
| SC605900 | C3 | 7.12 | 19.95 | 22.11 | - |
| SC605500 | C3 | 7.16 | 19.96 | 50.40 | E |
| SC605600 | C3 | 7.15 | 19.86 | 80.19 | - |
| SC605700 | C3 | 7.13 | 19.93 | 102.45 | - |
| SC605800 | C3 | 7.15 | 19.91 | 125.18 | - |
| SC607900 | C3 | 7.17 | 29.88 | 23.62 | - |
| SC607500 | C3 | 7.15 | 29.83 | 51.09 | E |
| SC607600 | C3 | 7.15 | 29.92 | 82.80 | - |
| SC607701 | C3 | 7.15 | 29.91 | 105.59 | - |
| SC607800 | C3 | 7.10 | 29.99 | 122.82 | - |
| SC616900 | C3 | 7.13 | 44.93 | 22.94 | - |
| SC616500 | C3 | 7.15 | 45.04 | 50.88 | E |
| SC616600 | C3 | 7.14 | 44.95 | 82.80 | - |
| SC616701 | C3 | 7.12 | 44.91 | 102.89 | - |
| SC616800 | C3 | 7.14 | 44.89 | 123.57 | - |
| SC610900 | C3 | 7.19 | 54.90 | 31.35 | E |
| SC610500 | C3 | 7.19 | 54.90 | 50.74 | E |
| SC610502 | C3 | 7.14 | 54.76 | 49.84 | E |
| SC610600 | C3 | 7.13 | 54.66 | 81.93 | E |
| SC610700 | C3 | 7.15 | 54.83 | 103.37 | E |
| SC610800 | C3 | 7.21 | 55.06 | 128.69 | E |
| SC611900 | C3 | 7.14 | 59.97 | 25.27 | - |
| SC611500 | C3 | 7.19 | 59.72 | 51.05 | E |
| SC611600 | C3 | 7.13 | 59.91 | 81.73 | - |
| SC611700 | C3 | 7.19 | 59.91 | 104.96 | - |
| SC611800 | C3 | 7.15 | 59.78 | 124.09 | - |
| SC612900 | C3 | 7.15 | 64.99 | 24.40 | - |
| SC612500 | C3 | 7.17 | 65.02 | 52.32 | E |
| SC612600 | C3 | 7.17 | 64.87 | 84.39 | - |
| SC612700 | C3 | 7.16 | 64.86 | 104.64 | - |
| SC612800 | C3 | 7.16 | 64.87 | 125.74 | - |

E: exercise case

**Table 3.2.12 Transient boiling transition measurement conditions**

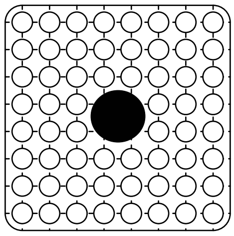
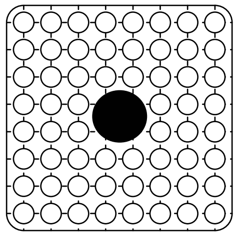
| | | |
|---|---|---|
| Assembly |  C2A |  C3 |
| Rated Initial Conditions | Pressure (MPa)<br>Power (MW)<br>Flow rate (t/h)<br>Inlet enthalpy (kJ/kg) | 7.2<br>6.2~8.5<br>45<br>1217~1227 |
| Transients | Turbine trip without bypass<br>Re-circulation pump trip | |
| Data | Time histories of cladding temperature where boiling transition occurred<br>Timing of boiling transition, Timing of rewetting, Peak cladding temperature<br>Corresponding boundary conditions during transients | |
| No. of Cases | Data supplied cases<br>Exercise cases | 4<br>2 |

**Table 3.2.13 Test matrix of transient boiling transition measurements**

| Assembly | Initial Conditions | | | | Transients | Exercise cases | No. of Cases |
|---|---|---|---|---|---|---|---|
| | Pressure (Mpa) | Power (MW) | Flow rate (t/h) | Inlet enthalpy (kJ/kg) | | | |
| C2A | 7.2 | 6.2~8.5 | 45 | 1217~1227 | Turbine trip without bypass | E | 2 |
| | | | | | Re-circulation pump trip | E | |
| C3 | 7.2 | 6.2~8.5 | 45 | 1217~1227 | Turbine trip without bypass | - | 2 |
| | | | | | Re-circulation pump trip | - | |

E: exercise case

**Table 3.2.14 Test No. of transient boiling transition measurements**

| Test No. | Assembly | Initial Conditions | | | | Transients | Exercise cases |
|---|---|---|---|---|---|---|---|
| | | Pressure (Mpa) | Power (MW) | Flow rate (t/h) | Inlet enthalpy (kJ/kg) | | |
| TGA10008 | C2A | 7.2 | 6.2~8.5 | 45 | 1217~1227 | Turbine trip without bypass | E |
| TRA10012 | C2A | 7.2 | 6.2~8.5 | 45 | 1217~1227 | Re-circulation pump trip | E |
| TGC10018 | C3 | 7.2 | 6.2~8.5 | 45 | 1217~1227 | Turbine trip without bypass | - |
| TIC10012 | C3 | 7.2 | 6.2~8.5 | 45 | 1217~1227 | Re-circulation pump trip | - |

E: exercise case

## REFERENCES

[1] "Void Fraction Distribution in BWR Fuel Assembly and Evaluation of Sub-channel Code", *J. of Nucl. Sci. and Tech*., Vol. 32, No. 7, p. 629 (1995).

[2] "TRAC-PF1/MOD2 Theory Manual, Appendix B, Material Properties", NUREG/CR-5673 (1993).