

# THE HIGH FLUX TEST MODULE OF IFMIF-DONES

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# **Background and Objective**

The High Flux Test Module (HFTM) of IFMIF-DONES (International Fusion Materials Irradiation Facility - DEMO-oriented Neutron Source) is developed as device to irradiate a large number of small scale specimens of steels in the high neutron flux region (5 × 10<sup>14</sup> n/cm<sup>2</sup>/s) of DONES.

#### Irradiation performance

- 4x3 capsules with 15x39x80 mm<sup>3</sup> "payload". ~105 specimens/capsule
- Irradiation temperatures 250 550 °C, homogeneity +/-3%
- ~ 850 specimens can be irradiated to 12 25 dpa/fpy
- 13-15 appm(He)/dpa, 50-60 appm(H)/dpa
- Instrumentation: 6x type K thermocouples, activation foils, SPND, MFC.

### Major design changes in the WPENS/DONES phase

- Reversal of flow direction: to keep the upper attachment adapter at low and homogenous temperature, minimizing deflection.
- Enlargement of capsule thickness to enable larger heating winding radii for longer heater lifetime
- Extension of irradiation volume in beam direction to benefit of a low gradient zone of nuclear responses
- Change from Ni to Cu-based brazing : Less He production (swelling) and less activation
- Substituted NaK with Na as heat conduction filler to avoid argon production (several  $cm^3 \rightarrow pressurization$ , bubbles)
- New capsule sealing concept to allow depressurization
- Container with integrated minichannels : higher stiffness, improved capsule installation.

#### Characteristic data

- Bounding box : 635 (102) mm x 1700 (469) mm x 2988 mm
- Masses: Total 680 kg, 40 kg irradiation capsules with specimens
- Heating: Nuclear 2.3 W/g peak, 17 kW tot., 1.5 kW electr. per capsule
- Activation at shutdown: 8 × 10<sup>15</sup> Bq, decay heat 900 W
- Helium flow 140 g/s, 0.35 MPa , 50 °C at inlet.

## **Qualitative lifetime considerations**

- Objective: 1 year corrsp. 50 dpa, extension to 2.5 years
- Pressure bearing shell X2 CrNiMo 17 12 2 at < 160 °C</p>
  - qualified for up to 53 dpa acc. RCC-MRx
    - negligible creep, negligible swelling
- Eurofer-97 specimen capsules at 250 °C < T < 550 °C</p>
  - qualified only up to 13.3 dpa acc. RCC-MRx → no SIC
  - significant creep regime, but pressurization stresses minimized by evacuation before sealing
- Heater lifetime is investigated by reactor irradiation, voltages limited (< 150 V) to reduce RIC/RIED effects in the MgO electrical insulator.



469

10



Overall view of

IFMIF-DONES HFTM v2.1 (09/2019)

Nuclear responses (beam level)



Temperature spread in specimen stack



2x4

helium

outlet

pipes