Design and Construct of In-Hospital Neutron Irradiator

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Rabat, Morocco
- IHNI and its systems
- Construct
- Startup
IHNI and its systems
Use
- Boron Neutron Capture Therapy
- Neutron Activation Analysis (NAA, PGNAA)
- Research
- Education and training

Inherent Safe Feature
- Negative temperature coefficient
- Limited excess reactivity (4-4.5 mk)
IHNI and its systems

- Reactor and its systems

IHNI is a pool-tank type reactor.

- UO$_2$ as fuel meat (12.5%)
- Zr-4 as fuel cladding
- Light water as moderator and coolant,
- Metal beryllium as reflector.

The fission heat produced by the reactor is removed by the natural convection.
IHNI Systems

- Reactor Pool
- Reactor Unit
- Reactor Control System
- Gamma radiation monitoring system
- Thermodynamic measuring system
- Reactor Water purification System
- Reactor Pool Water purification System
- Reactor gas purge System
Reactor pool  The reactor pool is located at the center of the reactor hall.
Up Part: 4000×2300 ×4700mm
Lower Part : 2600×1100 ×1800mm
Depth : 6500mm
Reactors vessel (tank)

- 6.0m in height;
- Inner diameter 0.6m;
- thickness 10 cm.
- Up 4.88m;
- Lower part 1.21m

Link by 16 tie Rods
Two reactivity regulators
One central control rod
One auxiliary control rod
Two fission chambers.
Central Control Rod

- Material: Cd tube outer dia. 40mm, inner dia. 20mm,
- Length: 230mm;
- Inside Cd tube: Al rod ø2.0×230 (mm);
- Outside Cd tube: SS tube outer dia. 5mm wall thickness: 0.5mm
- Total length: 450mm.

Auxiliary Control Rod

- Outer dia. 20mm Inner dia. 25mm Al
- Total Height: 530mm
- Lower height: 250mm Be
- Middle height: 20mm Al
- Up height: 250mm Cd Dia. 25mm wall thickness: 1mm
- Inside Cd
- Al rod: dia. 23mm, height 250mm

Reactivity Regulator

- Cd tube outer dia. 30.0mm, inner dia. 23.0mm;
- Inside Cd tube: Al rod ø28.0×250 (mm);
- Outside Cd tube: Al tube ø34.0×250 (mm).
Final Loading:
302 fuel elements.
Fuel element:  
Cladding: Zr-4  
Outer dia.: 5.1mm  
Inner: 4.3mm  
Height: 256mm

Fuel meat: UO2  
Dia.: 4.2mm  
Height: 240mm
Reactor core-Be reflector
Reactor control system
Flow: 0.5m³/h
PH: 6.0±0.5（25℃）
Conduct: <1μs/cm（25℃）
Flow: 2m³/h
Conduct: ≤3μs/cm (25°C)
PH: 6.0±0.5 (25°C)
Reactor gas purge system
Site was approved by NNSA in 2007.10
Total: 1145m²

- Reactor: 477m²
- Office: 668m²
Construct

IHNI cross-section of reactor building
Equipment installation from 2008.11 to 2009.2
Construct
Startup

Loading approved by NNSA in 2009.8
Fuel Loading in Dec. 2009
First Critical experiment  2009-12-7
Excess reactivity: 4.2 mk
Max. operation time at 30kW: 12 Hours
Error: less then 3%
• Less than 1 µGy/h. Dose rate at 30kW
Startup

Irradiation Room 1
Epithermal neutron

Observing

Irradiation Room 2
Thermal neutron

Observing

0.85 (0.08)

0.07 (0.07)

备用间
过厅
电梯机房

上
下
Fig. Power Transient Following 3.4mk Step Increase in Reactivity
• Peak power: 85 kW

**Fig.** Power Transient Following 4.2mk Step Increase in Reactivity
Main Technical Data

- Thermal power: 30kW
- The central control rod worth: -6.8mk
- The auxiliary control rod worth: -5.8mk
- Total top beryllium worth: -17mk
- Critical mass: 296 fuel elements
- Excess reactivity (at cold, initial state): 4.5mk
- Temperature coefficient: -0.1mk/°C (40-20°C)
• **Main Technical Data**

<table>
<thead>
<tr>
<th>Table 1 Calculated results at thermal neutron port</th>
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<tbody>
<tr>
<td>$\phi_{th}$</td>
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<tr>
<td>/n cm$^{-2}$ s$^{-1}$</td>
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<td>2.14×10$^8$</td>
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<td>2.90×10$^6$</td>
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# Small thermal neutron beam parameters at the port.

<table>
<thead>
<tr>
<th>Table 2 Calculated results at epithermal neutron beam port</th>
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<tr>
<td>$\phi_{epi}$</td>
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<td>/n cm$^{-2}$ s$^{-1}$</td>
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<td>4.31×10$^8$</td>
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Thanks