MBIR International Research Center: Current Progress and Prospects

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ROSATOM

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High flux research reactors in the world

- **BR-2** (Belgium) **OPERATIONAL**
  - First criticality – 1961

- **JHR** (France) **UNDER CONSTRUCTION**

- **ATR** (USA) **OPERATIONAL**
  - First criticality – 1967

- **CEFR** (China) **OPERATIONAL**
  - First criticality – 2010

- **JOYO** (Japan) **TEMPORARY SHUTDOWN**
  - First criticality – 1977

- **HANARO** (South Korea) **OPERATIONAL**
  - First criticality – 1995

- **MBIR** (Russia) **PLANNED (~2020)**

- **PIK** (Russia) **UNDER CONSTRUCTION**

- **Bor-60** (Russia) **OPERATIONAL**
  - First criticality – 1961

- **MIR.M1** (Russia) **OPERATIONAL**
  - First criticality – 1966

*) - powerful and high flux research reactors, using IAEA’s databases
Nuclear research needs

Advances in nuclear fuel cycle play a critical role in sustaining and advancing nuclear energy

- Basis of core construction materials crucially influence lifetime extension issues for current reactor feet as well as optimizing of fuel cycle options providing main challenges
  - Licensing of most commercial PWRs for the 60 years
  - Increasing of nuclear fuel cycle duration
  - Development of robust fuel for current LWR fleet
  - Minor actinide transmutation
  - Proliferation resistance fuel

- Materials for future VHTR, SFR, GFR, LFR, Supercritical WR, MSR are to be tested and approved

We need a research infrastructure of new type
New generation of nuclear R&D infrastructure

- New tasks appears for innovation reactor design concepts basing. Thus, a unique infrastructure is needed which will be able to join on site
  - ✓ High flux reactor
  - ✓ Experimental loops with different types of coolant
  - ✓ Instrumented reactor cells for in-pile testing
  - ✓ PIE hot cells
  - ✓ Research labs for pre-testing works and results validation
  - ✓ Manufacturing of samples, test devices, assemblies, etc.
  - ✓ Complexes of spent fuel handling

- On site fuel manufacturing chain providing reliable fuel supply is the major advantage for the research reactor

- Operation experience with research potential

- Developed social infrastructure and acceptable transportation availability
Unique research facility

MBIR is a Multipurpose Sodium Fast Research Reactor

- 150 MW(t)
- Maximum neutron flux $5.3 \cdot 10^{15}\ n/(\text{cm}^2\cdot\text{s})$
- Designed life time 50 years
- Upgradeable experimental capabilities: more loops, irradiation devices, channels, neutron beams, etc.
- Priority on research activities providing reliability and safety of operation
- Using of existing infrastructure (incl. fuel supply), the unique operation experience and staff resources of RIAR
- Closed fuel cycle
- Commissioning in 2020 (target)

Top intended mission — enhancement of international R&D infrastructure
Research activities

- Advanced fuels, absorbers, construction materials
- Closed fuel cycle issues
- MA utilisation
- Life tests of new types of equipment — steam generators, emergency core cooling systems, oxide traps, control core devices, reactor protection on passive principles
- Researches of advanced and modified liquid metal coolants
- Codes V&V
- Applied R&D and activities such as isotope production, neutron beams for medical applications,
- Generation of thermal and electrical energy

Sodium fast reactor could be a unique research machine
### Reactor and primary circuit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Capacity, MW</td>
<td>150</td>
</tr>
<tr>
<td>Electric Capacity, MW</td>
<td>55</td>
</tr>
<tr>
<td>Reactor Arrangement</td>
<td>Loop-type</td>
</tr>
<tr>
<td>Number of Loops</td>
<td>2</td>
</tr>
<tr>
<td>Number of Circuits</td>
<td>3</td>
</tr>
<tr>
<td>Coolant (I / II / III)</td>
<td>Na / Na / water</td>
</tr>
<tr>
<td>$T_{\text{Na}}$ (inlet / out), °C</td>
<td>330 / 512</td>
</tr>
<tr>
<td>Reactor Flow Rate</td>
<td>650 kg / sec</td>
</tr>
</tbody>
</table>

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IHX – Intermediate Heat Exchanger  
EHX – Emergency Heat Exchanger  
RCP-I – Reactor Coolant Pump  

*) Only Primary Circuit is demonstrated*
### Core cross section

![Core cross section diagram](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective core diameter, cm</td>
<td>88.8</td>
</tr>
<tr>
<td>Core height, cm</td>
<td>55.0</td>
</tr>
<tr>
<td>Fuel cycle, EFPD</td>
<td>100</td>
</tr>
<tr>
<td>Reactivity loss through cycle, %</td>
<td>2.9</td>
</tr>
<tr>
<td>Average FA power, MW</td>
<td>1.49</td>
</tr>
<tr>
<td>Maximum linear heat rate, W/cm</td>
<td>480.0</td>
</tr>
<tr>
<td>Maximum / average fuel burn-up of discharged FAs, % h.a.</td>
<td>8.0 / 10.3</td>
</tr>
<tr>
<td>Maximum / average neutron flux, cm⁻²·s⁻¹</td>
<td>5.5·10¹⁵ / 3.5·10¹⁵</td>
</tr>
<tr>
<td>Fast neutron (En &gt; 0.1 MeV) share in the core</td>
<td>0.7</td>
</tr>
</tbody>
</table>

- **Fuel assembly (93 pcs.)**
- **Material test assembly (14 pcs.)**
- **Instrumented in-pile experimental devices (3 pcs.)**
- **Control rod (8 pcs.)**
- **Blanket assembly (278 pcs.)**
- **In-pile fuel storage (38 pcs.)**
- **Shielding assembly (74 pcs.)**
Fuel assembly

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width across flats, mm</td>
<td>72.2</td>
</tr>
<tr>
<td>Height, mm</td>
<td>2700</td>
</tr>
<tr>
<td>Wrapper material</td>
<td>martensitic steel EP-450sh</td>
</tr>
<tr>
<td>Number of fuel pins</td>
<td>91</td>
</tr>
<tr>
<td>Fuel cladding material</td>
<td>austenitic steel ChS-68</td>
</tr>
<tr>
<td>Height of fuel pin, mm</td>
<td>1575</td>
</tr>
<tr>
<td>Approved fuel type</td>
<td>Vibro-MOX*)</td>
</tr>
<tr>
<td>Fuel core effective density, g/cm³</td>
<td>9.0 ± 0.2</td>
</tr>
<tr>
<td>PuO₂ share in fresh fuel, %</td>
<td>up to 38.5</td>
</tr>
<tr>
<td>Fuel types</td>
<td>pellet MOX / metal fuel / dense fuel</td>
</tr>
</tbody>
</table>

*) Vibro-packed mechanical mixture of MOX-granulate (93 wt%) and uranium metal powder (7 wt%)
Material test assembly

- Four MTA design options depending on the inner tube’s form (round or hexagonal) and sodium inlet mode (from the high-pressure or low-pressure chambers)
- Samples hanger design is developed by separate performance specifications depending on the User’s experimental tasks
- MTA design provides continuation of BOR-60 irradiations. Two full-size BOR-60 irradiation devices could be placed inside MBIR MTA wrapper

### Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Width across flats, mm</td>
<td>72.2</td>
</tr>
<tr>
<td>Height, mm</td>
<td>2 700.0</td>
</tr>
<tr>
<td>MTA useful volume, cm³</td>
<td>2 280.0</td>
</tr>
<tr>
<td>Number of MTA (core).</td>
<td>14</td>
</tr>
<tr>
<td>Number of MTA (1ˢᵗ row of blanket)</td>
<td>up to 36</td>
</tr>
<tr>
<td>Dose rate in core, dpa / year *)</td>
<td>20±24</td>
</tr>
<tr>
<td>Dose rate in 1ˢᵗ blanket row, dpa / year *)</td>
<td>14±17</td>
</tr>
<tr>
<td>Maximum neutron flux, (En &gt; 0.1 MeV), cm⁻²</td>
<td>1.5·10²³</td>
</tr>
</tbody>
</table>

*) in case of MBIR’s utilization rate = 0.65
External loop channel

**Sodium loop parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total height of loop channel, mm</td>
<td>11900</td>
</tr>
<tr>
<td>Outer diameter of loop channel cover (core level), mm</td>
<td>120</td>
</tr>
<tr>
<td>Outer / inner diameter of loop channel removable unit (core level), mm</td>
<td>63.0 / 60.0</td>
</tr>
<tr>
<td>Experimental fuel assembly coolant temperature (inlet/outlet), °C</td>
<td>up to 600 / up to 850</td>
</tr>
<tr>
<td>Sodium flow rate, kg/s</td>
<td>up to 2.9</td>
</tr>
</tbody>
</table>

**Experimental FA parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width across flats, mm</td>
<td>50.0</td>
</tr>
<tr>
<td>Total height, mm</td>
<td>1435</td>
</tr>
<tr>
<td>Height of the fuel column, mm</td>
<td>550</td>
</tr>
<tr>
<td>Capacity, kW (th)</td>
<td>up to 500</td>
</tr>
</tbody>
</table>

* 3D-view of sodium loop channel
Instrumented in-pile experimental devices

- Instrumented in-pile experimental devices allow:
  - testing of structural and fuel materials in the set environment with measurement and regulation of irradiation temperature (320-1800 °C);
  - in-pile investigation of material mechanical characteristics.
- Design of instrumented devices is developed by a separate performance specifications depending on the User’s experimental tasks

### Pb-Bi loop channel parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total height, mm</td>
<td>10890</td>
</tr>
<tr>
<td>Width across flats, mm</td>
<td>72.2</td>
</tr>
<tr>
<td>Inner / outer diameter of cylindrical cover at core level, mm</td>
<td>68.0 / 65.0</td>
</tr>
<tr>
<td>Coolant flow rate in Pb-Bi chamber, kg/s</td>
<td>up to 6.0</td>
</tr>
<tr>
<td>Maximum coolant temperature (in the self-contained Pb-Bi Chamber), °C</td>
<td>390±10</td>
</tr>
<tr>
<td>Outer / inner FA diameter, mm</td>
<td>45.0 / 41.0</td>
</tr>
</tbody>
</table>

*) 3D-view of lead-bismuth loop channel
Horizontal and vertical experimental channels

Six horizontal experimental channels:
- for neutron radiography
- for physical researches
- for medical applications

Neutron radiography research cell
7.1 m (length) × 4.1 m (width) × 2.9 m (height)

Cutting-edge silicon doping facility:
- up to 12 vertical channels (Ø 350 mm)
- Silicon irradiation and transportation container height 885 mm
- Irradiation temperature up to 80.0 °C
PIE facilities

Additional facilities provided in the MBIR Research Complex:

- Experiment preparation and support labs
- Analytical labs equipped with the cutting-edge examination devices (spectrometry, radiographic, microscopes, diffractometers etc.)
PIE facilities in the MBIR research complex

Each complex of Hot-Cell for MTAs Handling & Examination*):

- 4 sub-cells interconnected by the technological penetrations
- each sub-cell is equipped with the analytical and scientific devices
- 4.0 m (length) × 2.7 m (width) × 4.5 m (height)
- service zone and crane equipment

MBIR Research Complex includes 8 hot cells able to provide handling operations with one full-size MTA

*) Each complex of hot cells for radioisotopes assemblies handling has the same structure and dimensions.
International cooperation

MBIR is sited at Research Institute of Atomic Reactors in Dimitrovgrad

- Owner of the full-scale research center
- Liabilities, operation & maintenance
- R&D program execution

☑ Estimated total project cost is about $1,1 billion
☑ Available $300 M funding is provided by Russian Government for the reactor construction
☑ Additional funding up to $800 M for equipping and general conveniences

- Marketing and promotion
- R&D program management
- User’s joint activities facilitating

ROSATOM / RIAR

International Research Center MBIR
IRC management structure

Case-by-case users

Associated members (long term commitments)
- Aggregation of requests
- Review & shortlisting

Advisory Board consists of:
- representatives of signatory members;
- representatives of Associated members, and
- independent world-known experts

Signatory members (members with admission)
- Research program approval
- Audit & control

Steering Committee
- Operation & Maintenance
- R&D Program Execution

IRC Facilities
- Reactor
- Hot cells
- Labs & offices
- Auxiliary facilities
Time schedule

MBIR Reactor
- Main reactor building with auxiliaries
- RPV & reactor internals
- Fuel manufacturing chain
- Security systems

MBIR Project R&D

Licensing
- Site License
- Construction License
- First Concrete

MBIR construction
- RPV & vessel internals Installation
- Commissioning
- First Criticality

Full-Scale MBIR Research Facility
- BOP & Auxiliary Buildings
- Experimental Loops & Channels
- Hot Cells Equipment
  (scope and schedule of equipping depends on available financial resources)

Potential partners have the unique window of opportunities for early-bird participation
Thank you for your attention!

For further information please contact:
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