<table>
<thead>
<tr>
<th>Country Research reactor</th>
<th>Power Type</th>
<th>Fuel</th>
<th>Coolant</th>
<th>Moderator</th>
<th>Reflector</th>
<th>Irradiation positions:</th>
<th>Test configuration</th>
<th>Instrumentation and control</th>
<th>Auxiliary facilities (on-core)</th>
<th>On-site PIE capabilities</th>
<th>Design, manufacturing, disposition, shipping, waste handling and other capabilities</th>
<th>Method of access and degree of utilization</th>
<th>Miscellaneous and readiness for material testing research (MTR)</th>
</tr>
</thead>
</table>
| Egypt  
ETRR-2  
1997–2020  
30 years of operation  
10 cycles per year  
Each cycle of 15 days | Thermal power: 22 MW  
Reactor type: pool  
Moderator: light water  
Coolant: light water  
Reflector: light water and beryllium |  |  |  |  | One cobalt irradiation device (CID) in the core centre position with neutron flux of $2.7 \times 10^{14} \text{n cm}^{-2} \text{s}^{-1}$  
Two positions in the core with neutron flux of $2 \times 10^{14} \text{n cm}^{-2} \text{s}^{-1}$  
23 irradiation boxes at the irradiation grids with neutron flux $10^{13} - 10^{14} \text{n cm}^{-2} \text{s}^{-1}$  
and two rigs in thermal column with flux $10^{13} \text{n cm}^{-2} \text{s}^{-1}$  
Max thermal flux: $2.8 \times 10^{13} \text{n cm}^{-2} \text{s}^{-1}$  
Max fast flux: $7.6 \times 10^{13} \text{n cm}^{-2} \text{s}^{-1}$ | Two irradiation positions in the core with neutron flux of $2 \times 10^{14} \text{n cm}^{-2} \text{s}^{-1}$  
2 pneumatic tubes for fast irradiation for use in neutron activation analysis applications | Neutron transmutation doping (NTD) irradiation rig  
NAA labs  
Large sample neutron activation analysis (LSNAA) | Radio isotope production cells  
Material testing cell | Very good engineering and workshop capabilities  
Training capabilities  
Code validation and benchmarking against experiments | Access of experimenters during full power operation | Limited capability for in-core material testing research |
<table>
<thead>
<tr>
<th>Country</th>
<th>Facility</th>
<th>Description</th>
<th>Reactor Type</th>
<th>Fuel</th>
<th>Coolant</th>
<th>Moderator</th>
<th>Reflectors</th>
<th>Flux (th)</th>
<th>Flux (Fast)</th>
<th>Irradiation</th>
<th>Future Plans</th>
<th>Hot Cell Use</th>
<th>Other Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hungary</td>
<td>BRR (Budapest research reactor)</td>
<td>10 MW Tank type reactor VVR-U type LE fuel (20% U-235) Light water as coolant and moderator Beryllium reflector</td>
<td>9–10 operation cycles in a year 1993–2023</td>
<td>2 gas cooled irradiation rigs Temperature range 150–650°C</td>
<td>Future plans – supercritical water rig</td>
<td>Beams with material structure and elemental analysis, NAA facility, neutron-, gamma- and X-ray radiography and tomography</td>
<td>2.5 × 10^{14} n·cm^{-2}·s^{-1} Fast 1×10^{14} n·cm^{-2}·s^{-1} in flux trap 60 irradiation channels Fast flux 1.5 × 10^{13} n·cm^{-2}·s^{-1} 0.5 dpa in steel</td>
<td>2.3 × 10^{14} n·cm^{-2}·s^{-1} Power ramp test facility (PRTF) 40 cm length</td>
<td>2.3 × 10^{14} n·cm^{-2}·s^{-1} Power ramp test facility (PRTF) 40 cm length</td>
<td>Main irradiation facilities: – Irradiation holes for general irradiation power ramp test facility (PRTF) – Capsule type ramping test of LWR fuel (PWR, BWR environment), 130 to 160 bar, 3.6 L/h cooling, 0.1 to 1 W/cm², 900 W/cm max power velocity, 100 W/cm min, max power ramp 500 W/cm – Beam tubes – Maximum heat flux 2.20 MW/m²</td>
<td>Beams with material structure and elemental analysis, NAA facility, neutron-, gamma- and X-ray radiography and tomography</td>
<td>Suitable for material testing research, but system upgrade required</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>RSG-GAS</td>
<td>30 MW LEU (U3Si2, 19.75%) fuel Light water as coolant and moderator Beryllium reflector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NAA, isotope production, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 3 (cont.) RESEARCH REACTORS WITH POTENTIAL FOR MATERIAL TESTING RESEARCH. OVERVIEW OF CAPABILITIES AND CAPACITIES

<table>
<thead>
<tr>
<th>Country</th>
<th>Research reactor</th>
<th>Power</th>
<th>Type</th>
<th>Fuel</th>
<th>Coolant</th>
<th>Moderator</th>
<th>Reflector</th>
<th>Irradiation positions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>JOYO</td>
<td>140 MW</td>
<td>Sodium cooled loop-type fast reactor</td>
<td>MOX (18% U-235, 30 wt% Pu) fuel</td>
<td>Liquid Na coolant in primary and secondary circuit</td>
<td>Number: 21 irradiation rigs (max)</td>
<td>Height of core: 600 mm</td>
<td>Flux total: $5.7 \times 10^{15}$ n·cm$^{-2}$·s$^{-1}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 cycle/year</td>
<td>60 days/cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Operation cycle**
5 cycle/year
60 days/cycle

**Test configuration**
- Test environment temperature and pressure range
- Test configuration

**Instrumentation and control**
- (in-pile temperature, pressure, fission gas monitoring, stress strain, etc.)

**Auxiliary facilities**
- (beams, neutron activation analysis, gamma-ray, etc.)

**On-site PIE capabilities**
- (hot cells, glove boxes, tools for stress analysis, etc.)

**Design, manufacturing, disposition, shipping, waste handling and other capabilities**
- Run-to cladding-breath (RTCB) PIE facilities:
  - Fuel monitoring facility (FMF)
  - Material monitoring facility (MMF)
  - Alpha Gamma facility (AGF)
  - Stainless steel-lined, nitrogen-gas-tight hot cells
  - X-ray computed tomography
  - Helium accumulation fluence monitors for dosimetry
  - Field-emission transmission electron microscopy TEM

**On-site PIE capabilities**
- Material testing rig with temperature control (MARICO)
  - Instrumented test assembly (INTA) with thermocouple and gas pressure gauge

**Method of access and degree of utilization**
- High potential, advanced
- Time of restart uncertain
<table>
<thead>
<tr>
<th>Country</th>
<th>Reactor Type</th>
<th>Fuel Type</th>
<th>Coolant</th>
<th>Moderator</th>
<th>Reflector</th>
<th>Thermal Flux</th>
<th>Fast Flux</th>
<th>Channels</th>
<th>Safety Features</th>
<th>Research Facilities</th>
<th>Waste Handling</th>
<th>Contract Agreement</th>
<th>Research Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kazakhstan</td>
<td>WWR-K</td>
<td>HEU (36%)</td>
<td>Light water</td>
<td>Light water and beryllium reflector</td>
<td>3 vertical channels with Ø 62 mm and 600 mm in height Flux (th) 1 x 10^14 n·cm^{-2}·s^{-1} Flux (fast) 3 x 10^{13} n·cm^{-2}·s^{-1}</td>
<td>Gas-vacuum loop (helium) Temperature: 50–1200°C Pressure: 10^4–10^5 MPa</td>
<td>In-pile temperature (thermocouples), neutron flux (SPND), fission gas monitoring</td>
<td>5 radial and 1 tangential horizontal beam tubes; NAA lab with pneumatic rabbit, neutron radiography; critical assembly</td>
<td>Concrete and steel-shielded hot cells (dismantling, cutting, grinding) mechanical testing and microstructure research equipment outside hot cells</td>
<td>Waste handling and disposal, Radiochemistry</td>
<td>Contract or collaborative research agreement</td>
<td>Limited capability for in-core material testing research</td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>MARIA</td>
<td>HEU and LEU (36% and 19.75%)</td>
<td>Light water</td>
<td>Light water as coolant, beryllium moderator and graphite reflector</td>
<td>20 to 30 MW (thermal) Channel in pool type reactor 36% enriched HEU and 19.75% enriched LEU fuels</td>
<td>Thermal flux 4 x 10^{14} n·cm^{-2}·s^{-1} Fast flux 2 x 10^{14} n·cm^{-2}·s^{-1} 6 horizontal channels for controlled use of neutron beams channels of Ø 23 mm in Be blocks, channels of Ø 28 mm in graphite reflector, channels of Ø 38 mm in graphite reflector, channels of Ø 18 mm inside modified fuel element, channel located under safety rod, channels equipped with hydraulic transport system. &gt; 5 inch silicon doping channel Irradiation of U target for Mo-99 production</td>
<td>NA</td>
<td>NA</td>
<td>Out-of-core irradiation facility to irradiate the large-size (up to 90 mm in Ø) target materials/devices with fast neutron flux density up to 1.7 x 10^{12} n·cm^{-2}·s^{-1} and well reduced thermal neutron flux limited down to 3.4 x 10^{10} n·cm^{-2}·s^{-1} 6 horizontal channels equipped with scattering and diffraction instruments for condensed matter studies</td>
<td>Hot cells for radioisotope production</td>
<td>NA</td>
<td>NA</td>
<td>Limited capability for in-core material testing research</td>
</tr>
</tbody>
</table>