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SM-3 CORE REFURBISHMENT PROJECT

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Russian State Scientific Centre

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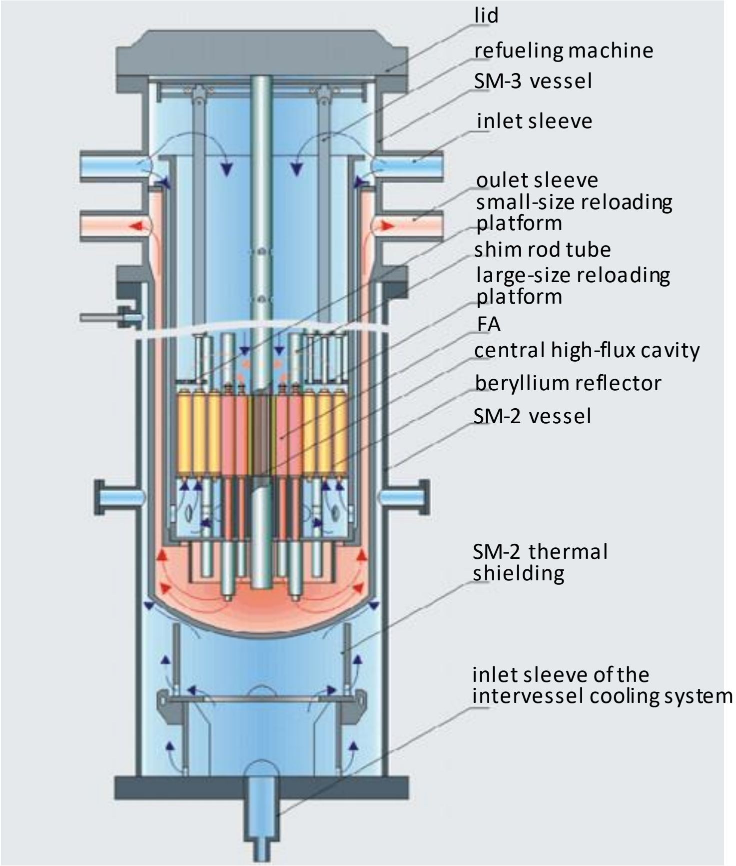
Introduction



Research reactor SM-3 was commissioned in 1961. This unique facility has the highest neutron flux density and the wide range of experimental capabilities

Intended purpose:

- irradiation of reactor materials under the specified conditions to examine changes in their properties
- production of TPEs and radionuclides

SM-3 Key Parameters

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Parameter	Value
Reactor	Vessel-type water-cooled with a trap
Power, MW	100
Max neutron flux density, $s^{-1} \cdot cm^{-2}$	$5 \cdot 10^{15}$
EFPD	~ 260
Fuel	UO2 90% enriched
Core arrangement	Square with a central trap
Core size, mm	420 ×420 x350
Number of cells for FAs	32
Operational characteristics	Power - 90 MW Load factor~ 80%

SM-3 Employment

Tests of materials and fuels for VVER, RBMK and propulsion reactors.

First results on radiation resistance of austenitic and ferritic-martensitic steels ChS-68, EP-172 and EP-450 for fuel rods and FAs of different types of reactors.

Tests of graphite grades, refractory materials for HTGR, promising Be-based materials and those for fusion reactors at temperatures 1000-2500°C and damage dose rate up to 25dpa/y.

Tests and irradiation rigs for selection and justification of materials for MSR, VVER-SCP, HTGR for hydrogen economy.

SM-3 is the only Russian reactor that accumulates TPEs (Cu, Cf, Bk) and high-active radionuclides Lu-177, Se-75, P-33, Gd-153, Ir-192, Co-60, W-188, Ni-63, Fe-55, -59, Sn-113, Sr-89, I-125, I-131, Cs-131 for medicine and industry.

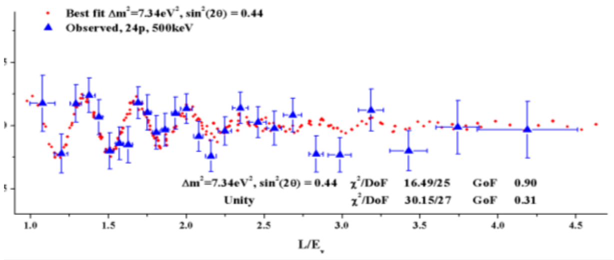
SM-3 Employment

SM-3 is a unique facility to perform a fundamental material and elementary particles researches. Together with Kurchatov Institute a NEUTRINO-4 Experiment has been launched to study the reactor anomaly of anti-neutrino and sterile neutrino.

In 2018-2019, SM-3 accumulated Cr-51 and a unique 3MCi source was prodused for the Baksan Neutrino Observatory within the frame of the Project BEST.

Based on TPEs accumulated in SM-3 in the period from the 1960s to the present, a number of new superheavy elements have been obtained at the Joint Institute for Nuclear Research in Dubna. Currently, the reactor is accumulating TPEs under the Superheavy Isotopes Program.

Neutrino detector for NEUTRINO-4 Experiment



Oscillation curve
Blue points— experiment
Red points— calculation

Purpose and Tasks of the SM-3 Refurbishment Project

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Purpose :

- ✓ To replace spent core structure elements and control&safety equipment
- ✓ To extend the reactor lifetime, enlarge its experimental capabilities and improve its efficiency
- ✓ To justify the feasibility of reactor conversion to more effective fuel

Tasks:

- ✓ Design and manufacture of:
  - neutron trap and core internals
  - control rods
  - control rod drives
  - new types of fuel rods and absorbers
- ✓ Irradiation and material tests of new-type fuel rods
- ✓ Elaboration of design and operational documents, safety justification and licensing.
- ✓ Dismounting and mounting works, start-up and commissioning

Key Results of Refurbishment

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- ✓ Reactor core and control&safety equipment were designed, manufactured and replaced
- ✓ Reactor safety and operational reliability has been increased, reactor lifetime has been extended beyond 2040
- ✓ The number of channels with the super-high neutron flux density $\geq 2\times10^{15}cm^{-2}$ was increased up to 57
- ✓ The isotope production was increased by 1.7 times. This will fully meet the demands of the growing domestic market
- ✓ Reactor experimental capabilities have been improved for:
  - justification of MSR materials to close NFC with MAs from SNF reprocessing
  - justification of materials to design VVER-SCP fuel rods, core and vessel
  - tests and study of behavior of materials and fuel to confirm HTGR solutions

Innovations in Core Refurbishment

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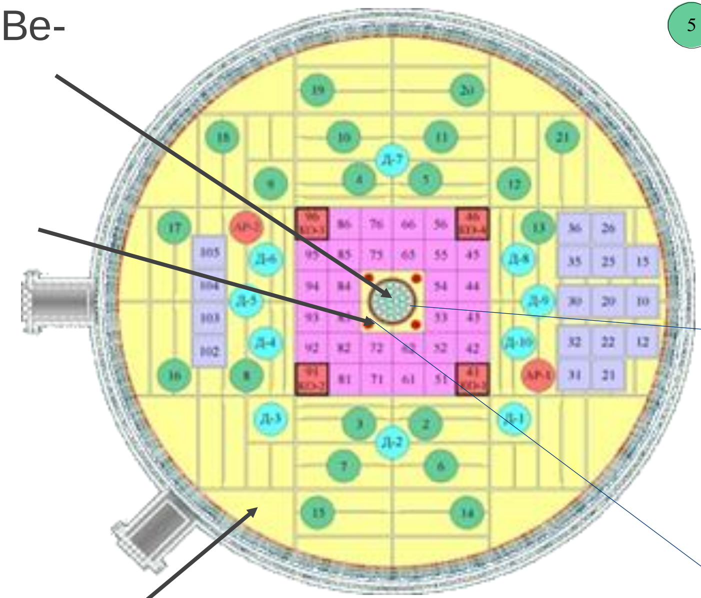
New-design trap with 57 cells instead of 27, safety rods and drives
No central shim rods, Be-block and inserts

Manufactured and replaced:

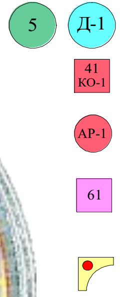
- Reflector Be-blocks
- Core metal structures
- Safety rods with guide tubes

Central Be-block

Central shim rod



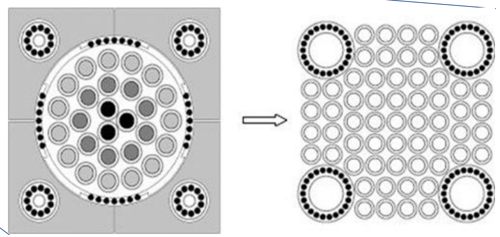
Reflector Be-blocks



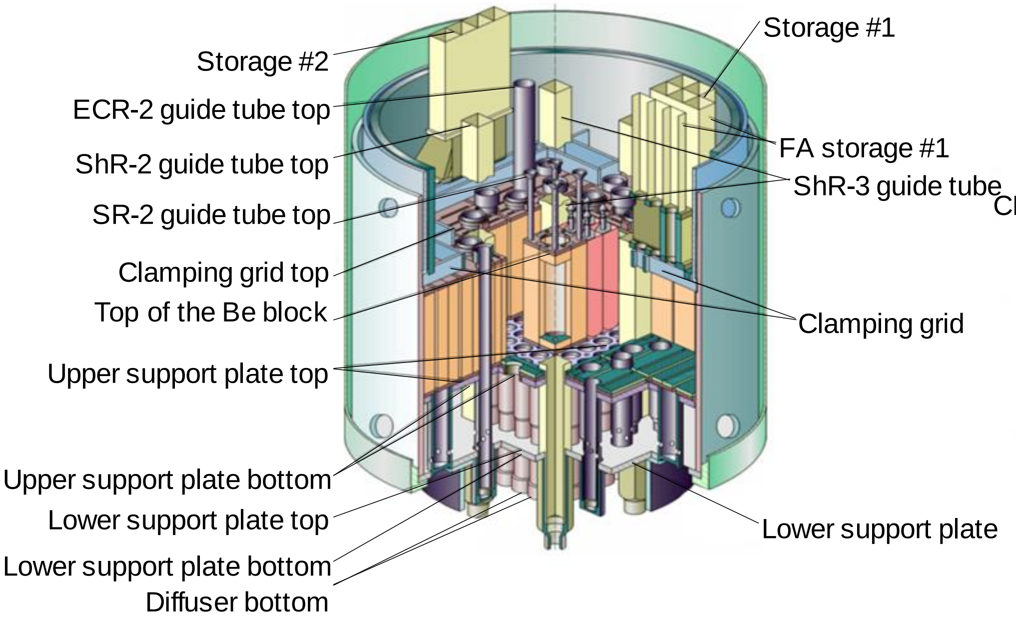
Channel #

Shim rod

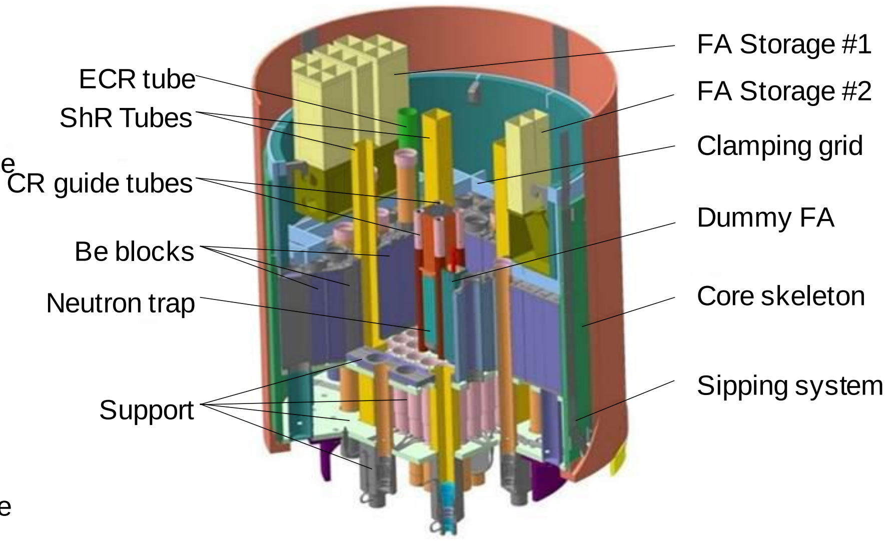
Safety rod



Core Refurbishment

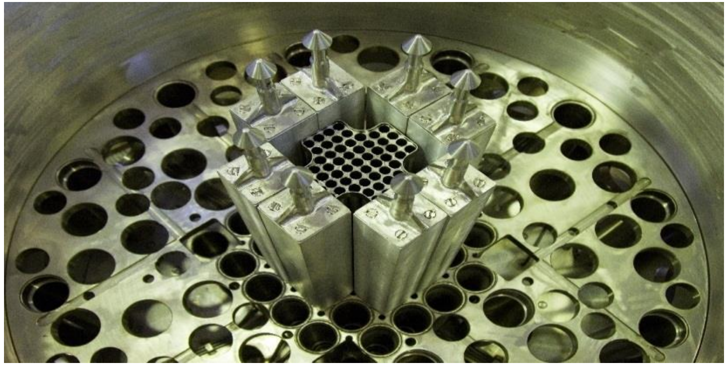


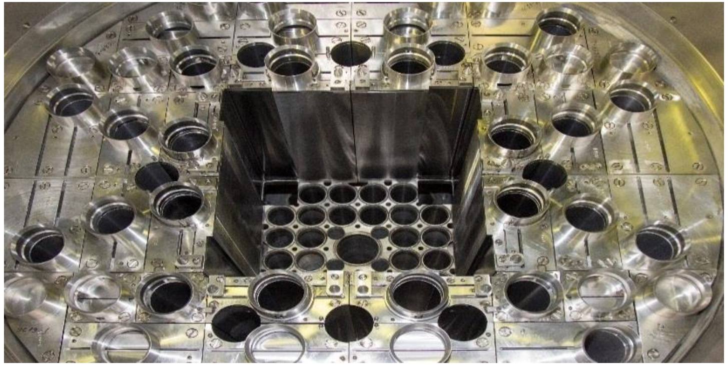
Before

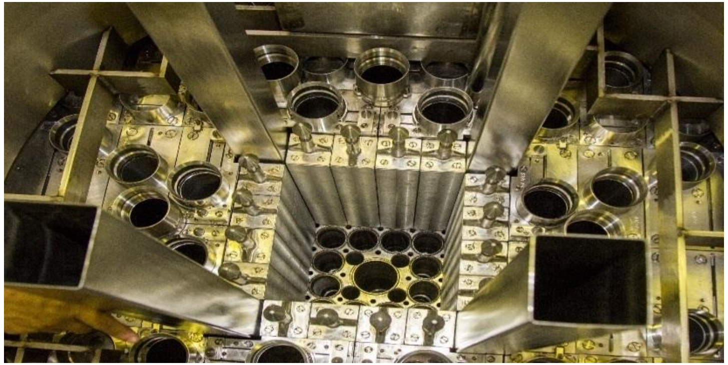


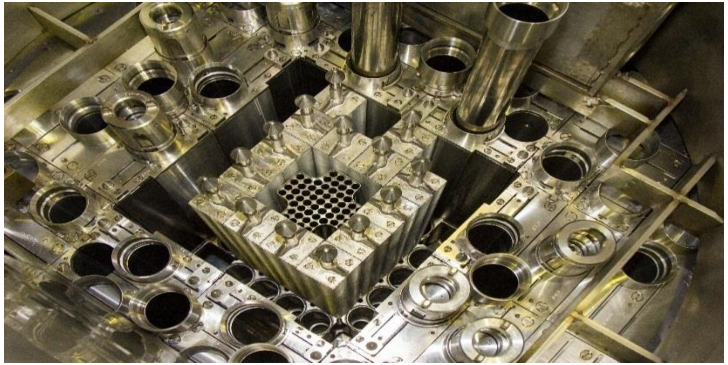
After

New Core Manufacturing









New Core Manufacturing

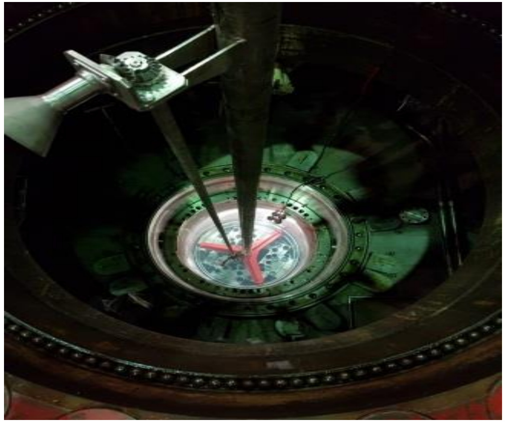
Upper support plate

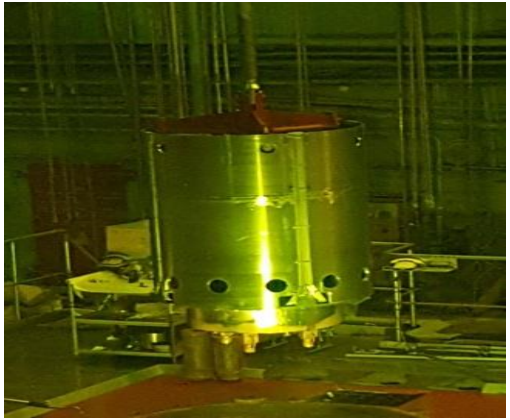
Assembled support

Clamping grid

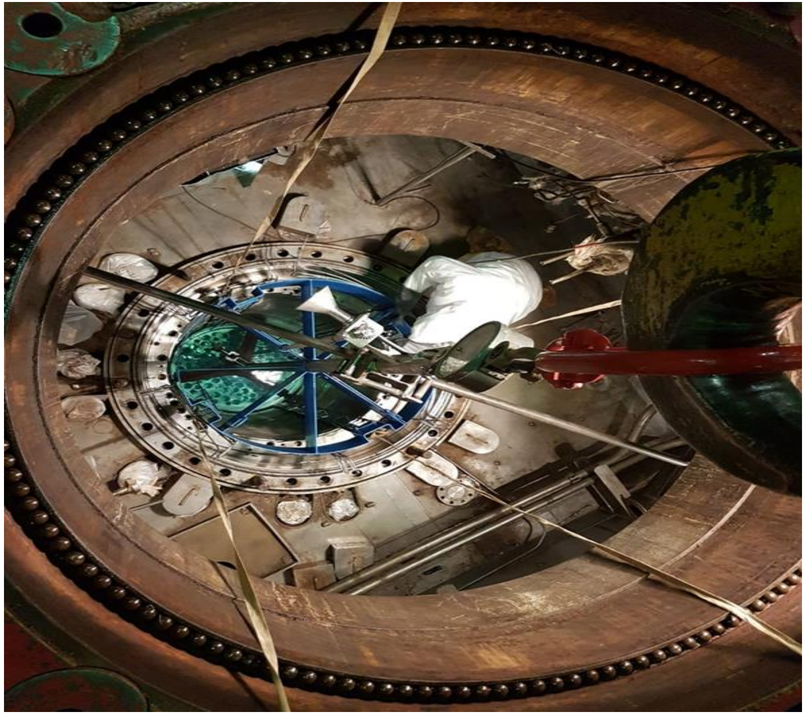
Core vessel

Spent Core Dismounting and Utilization



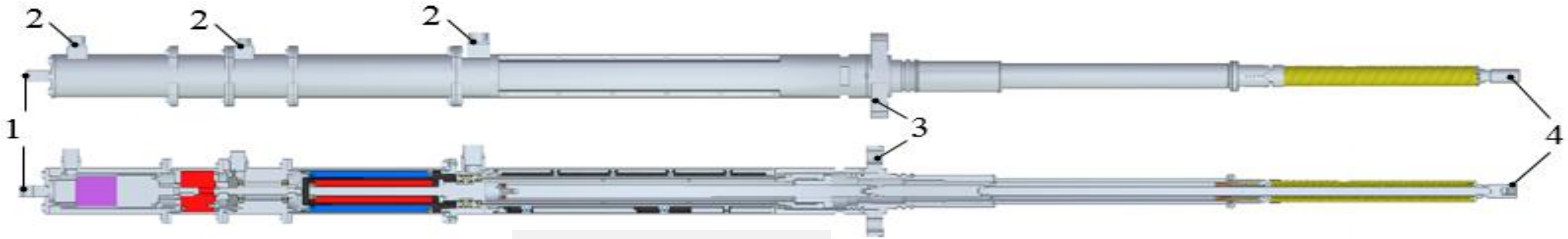


New Core Mounting



Control & Safety Equipment Mounting

New Control Rods Drives



Electromechanical drive of control rod and scram rod

Electromechanical drive of scram rod

New control rods drives

1 – shipping bracket; 2 – joints XP1, XP2, XP3; 3 – attachment flange; 4 - fixture

Conclusion

All major refurbishment activities on SM-3 reactor were performed by RIAR specialists including design and development, manufacturing of core components, dismantling, start-up and commissioning.

Development, manufacture and installation supervision of control & safety equipment were done by the contractors (SNIIP, SNIIP-Systematom). Development, manufacture and installation supervision of the control rod drives was performed by Diakont.

The SM-3 reactor was brought to the nominal power level on October 10, 2020 one month earlier than was planned.

Reactor refurbishment will increase the scope of ongoing R&D and radioisotopes accumulation by 40%. The reactor has become more reliable and safe.

Reactor lifetime will be extended beyond 2040.

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Thank you for your attention

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