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POOL-TYPE REACTORS RBT-6 AND RBT10/2: OPERATION AND AGEING MANAGEMENT EXPERIENCE

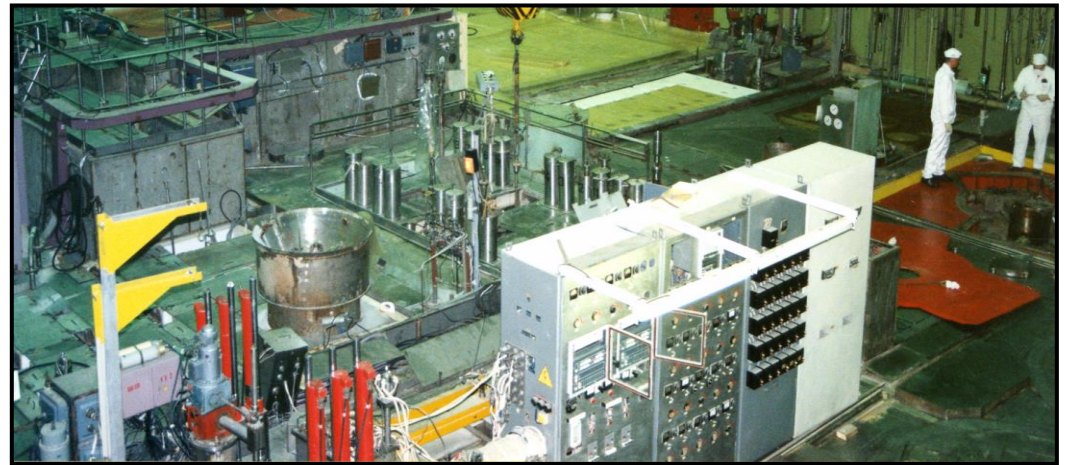
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Reactors RBT-6 and RBT-10/2

Pool-type reactors RBT-6 and RBT-10/2 are satellites of high-flux research reactor SM since they use its spent fuel.

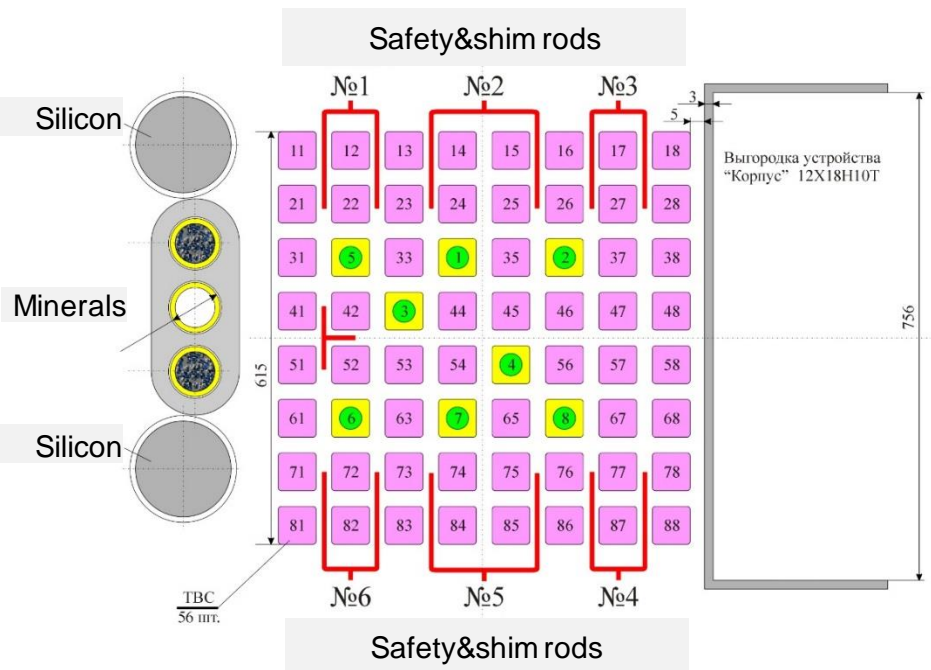
The reactors are intended to test materials under irradiation at a neutron flux achieving 10^{14} n/cm²s, to accumulate radioisotopes (¹³¹I and ⁹⁹Mo) and for silicon doping and irradiation coloring of minerals.



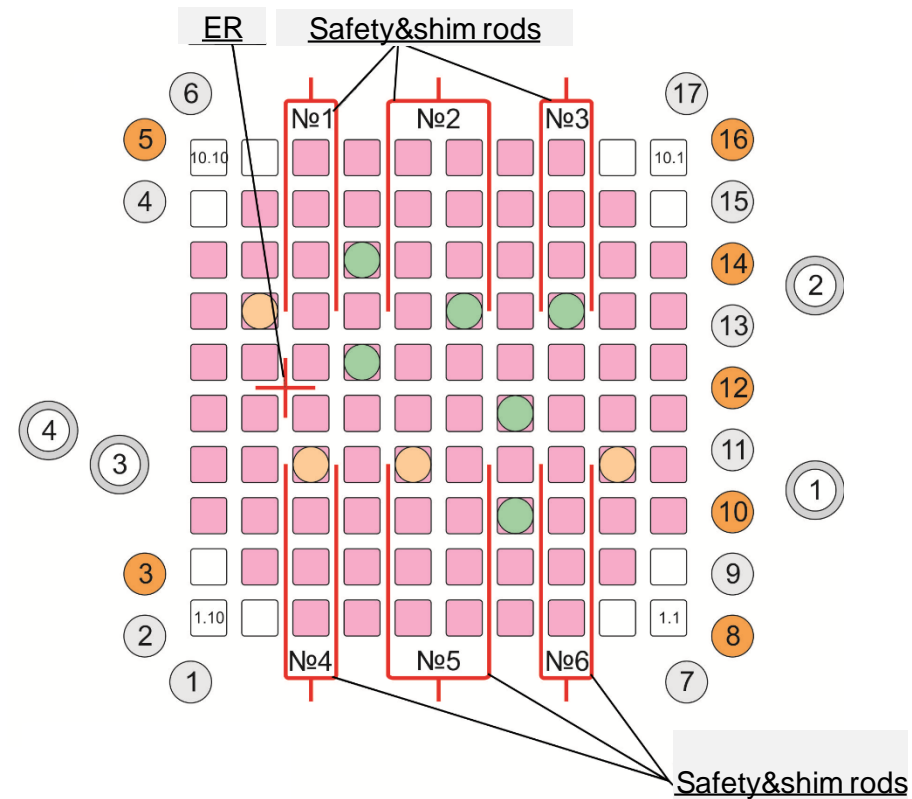
RBT-6 and RBT-10/2 Cores



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RBT-6 core



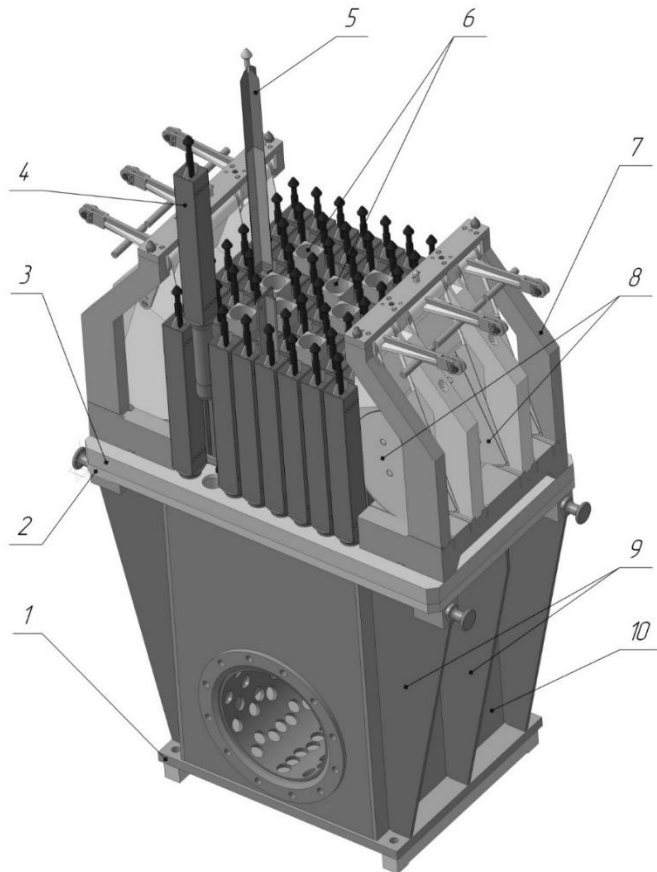
RBT-10/2 core



RBT-6 and RBT-10/2 Cores

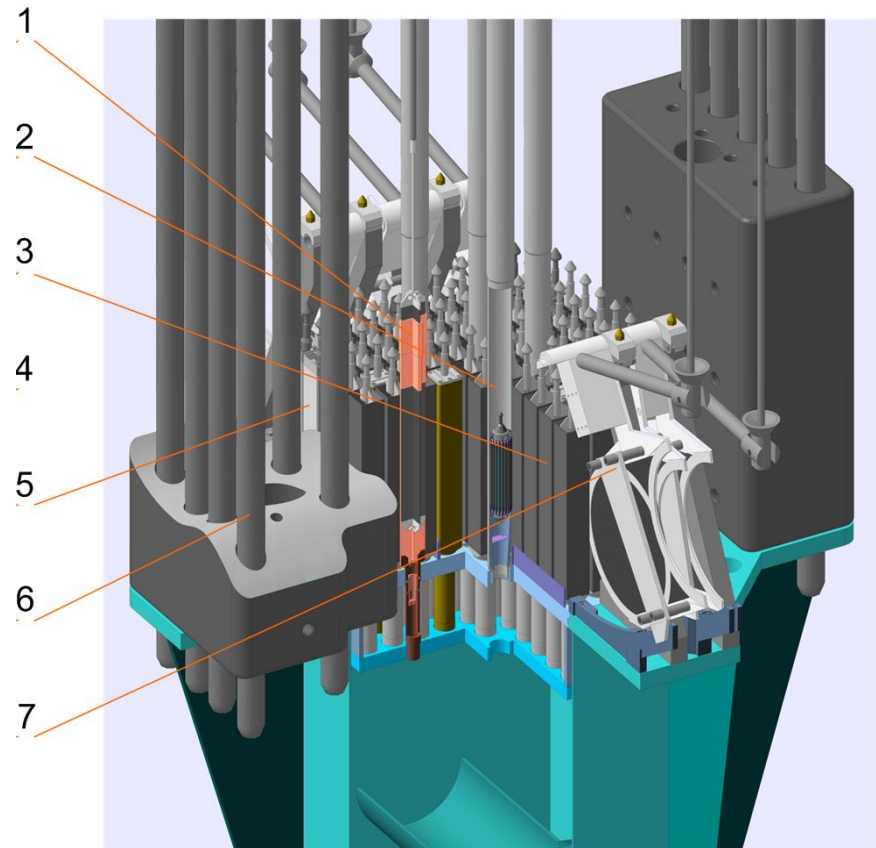


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RBT-6 core

1 – bottom plate; 2 – body plate;
3 – removable plate; 4 – FA; 5 – ER; 6 – displacers;
7 – safety&shim rods case; 8 – safet&shim rod section;
9 – stiffeners; 10 – body walls.



RBT-10/2

1 - ER; 2 –irradiation channel; 3 – FA;
4 – peripheral irradiation channels;
5 – angle reflectors; 6 - ionizing chamber;
7 – safety&shim rods



RBT-6 and RBT-10/2 Key Parameters



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Parameter	RBT-6	RBT-10/2
Max thermal capacity, MW	6	10
Cells for FAs	56	78
Core volume occupied with FAs, l	132	208
Coolant T: - at the core inlet, °C; - at the core outlet, °C.	up to 60 up to 70	up to 60 up to 70
Coolant	distillate	distillate
Control rods: - Safety&shim rods - automatic control rod	6 1	6 1
Control rod absorber	Cd	Eu ₂ O ₃

Extension of RBT-10/2 Lifetime



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RBT-10/2 was commissioned in 1985.

The 30-year designed lifetime ended in 2015.

In 2010 we started extending its lifetime beyond the designed one.

A comprehensive survey of RBT-10/2 building structures, equipment and systems important to safety found it possible to extend the reactor lifetime by means of:

- new DAMS
- replacement of the obsolete 280 V battery with a 12 OCSM 1380 one
- reconstruction of emergency power supply
- upgrading of dosimetric control



Extension of RBT-10/2 Lifetime

To increase N&RS during the extended lifetime, the following works were performed at RBT-10/2:

- an anti-seismic protection system to continuously monitor the vibration amplitude of the building and send signals to the emergency protection system when the set threshold is exceeded;
- an emergency power supply system using diesel power plants;
- equipment of new control rod system; the system was put into operation in 2020;



Extension of RBT-10/2 Lifetime

Based on the results of a comprehensive survey, the residual operation time of RBT-10/2 was determined till 31.12.2033, provided the proper operation, maintenance and repair is ensured.

In accordance with clause 2.2 NP-024-2000, the RBT-10/2 lifetime is set till 31.12.2027 taking into account the time required to decommission the reactor (~ 5 years).

To ensure the operability and reliability of RBT-10/2 during the extended lifetime, work continues on the "Ageing Management Program".

Timely replacement of reactor equipment and systems is based on the survey and analysis of the failure rate.



Extension of RBT-6 Lifetime

In accordance with NP-024-2000, to assess the actual state of RBT-6 equipment and pipelines, to determine the residual life of its elements and systems important to safety, the General Program for the Comprehensive Survey of the RBT-6 was developed and approved.

Schedule for surveying RBT-6 equipment important for safety for further extension of its lifetime and Plan for extending the RBT-6 lifetime were elaborated.

RBT-6 systems under survey:

- reactor building
- reactor tanks, body and removable plate
- reactor cooling system, emergency reactor cooling system
- special purification system, filling and feeding system, special sewerage system
- control and protection system
- process parameters control system
- fuel handling, storage and transportation system
- power supply system including emergency power supply system
- special ventilation system
- radiation and dosimetric control system



Extension of RBT-6 Lifetime



The comprehensive survey of the technical condition and assessment of the residual life of structures, equipment and systems important to safety, presented in the report "Results of a Comprehensive Survey of RBT-6 buildings, structures, systems and elements important to safety" dated 01.10.2020 No.O-196, showed that the criteria and requirements established by the norms and rules in the field of atomic energy use have been met.

Based on the results of Comprehensive Survey carried out in accordance with NP-024-2000, the RBT-6 Lifetime Extension Program and the Ageing Management Program for components and systems important to safety were issued.

Lifetime extension activities were carried out in accordance with requirements of NP-024-2000 and NP-033-11, using rules, GOSTs, standards and survey methods agreed with Rostekhnadzor.

The RBT-6 lifetime was extended till December 31, 2030 by the decision as of December 29, 2020 No. 254/44.

The RBT-6 operability and reliability during extended lifetime is ensured by the Ageing Management Program.

Timely replacement of equipment and systems of the reactor plant is based on the survey and analysis of the failure rate.



Restoration of Cooling Tower Performance

In 2020, the cooling tower performance was restored



Water distribution and irrigation system



Irrigation pipeline

Upgrading of RBT-6 Control & Protection System



Work is underway to further upgrade the reactor.

In 2020:

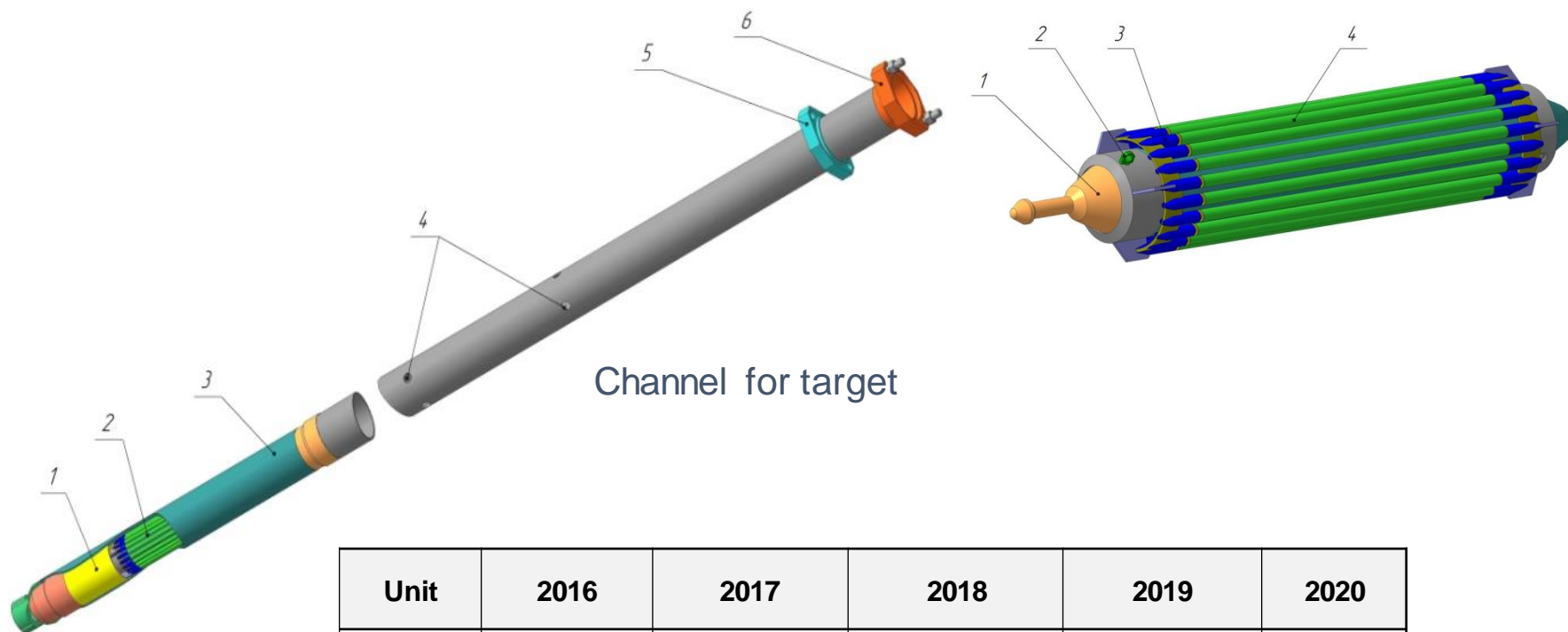
- CJSC "SNIIP-SYSTEMATOM" has developed a project to upgrade the initiating part of the control and protection system
- Technical Assignment for design work has been developed to tie the ASUZ-27R equipment to the RBT-6 conditions
- preparatory work is underway to upgrade measuring systems for thermal control and management
- Primary circuit pump 10AX-9I and pump D3200-33-2-U3 were replaced with new ones.

Activities at RBT-6 and RBT-10/2

^{99}Mo

Accumulation of ^{99}Mo in targets with uranium intermetallic 90% enriched in ^{235}U .

Target to accumulate ^{99}Mo



Unit	2016	2017	2018	2019	2020
Ci	12 976	13 329	15 919	14 134	10 748

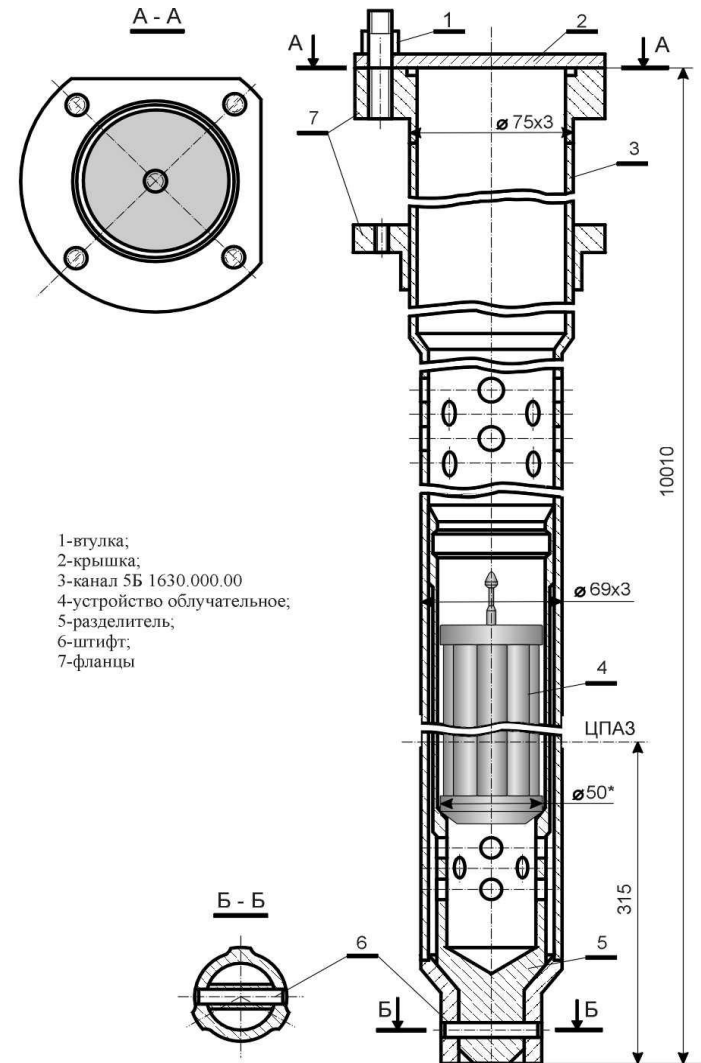
Activities at RBT-6 and RBT-10/2



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I-131

- Irradiation of tellurium dioxide targets to accumulate I-131 in flow-through capsule channels.
- Channel design provides for loading/unloading the target during the reactor operation.
- Output - 3000 Ci/y.



Channel for accumulate I-131



Activities at RBT-10/2



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Silicon doping

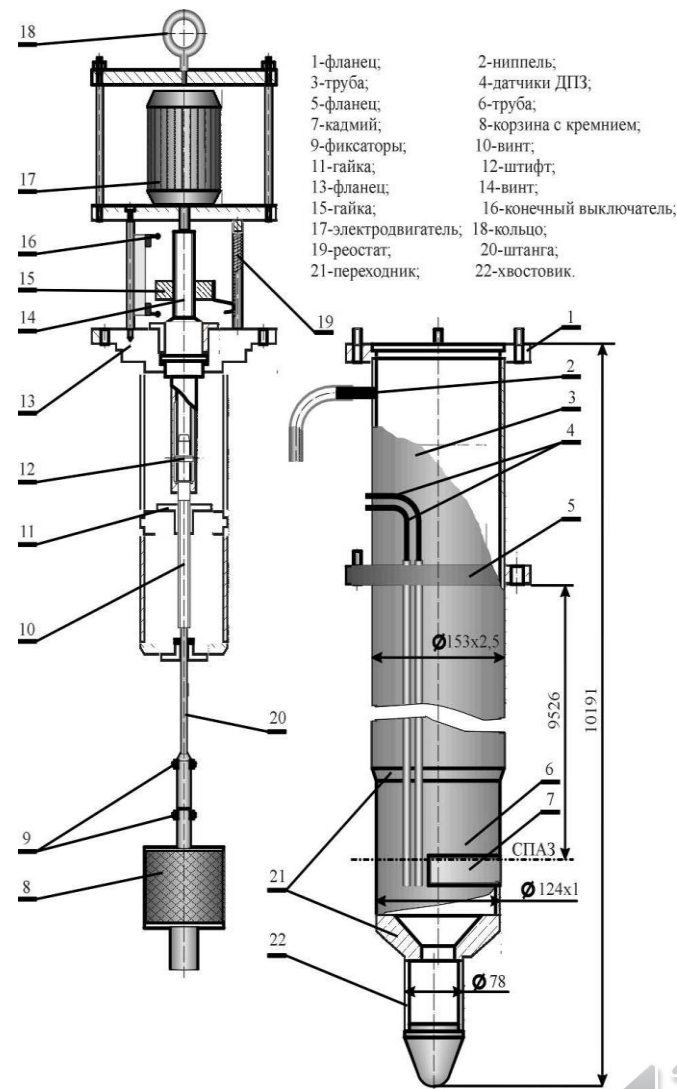
Silicon is doped in the periphery channels in the DOK IR.

The IR has an electrically-driven suspension to move the container along the core with a simultaneous rotation around the longitudinal axis for an ingot to be doped uniformly over its height and diameter.

The ingots are loaded/unloaded during the reactor operation.

Output— up to 1.5 t/y.

Ingot diameter achieves 125 mm.



Activities at RBT-10/2

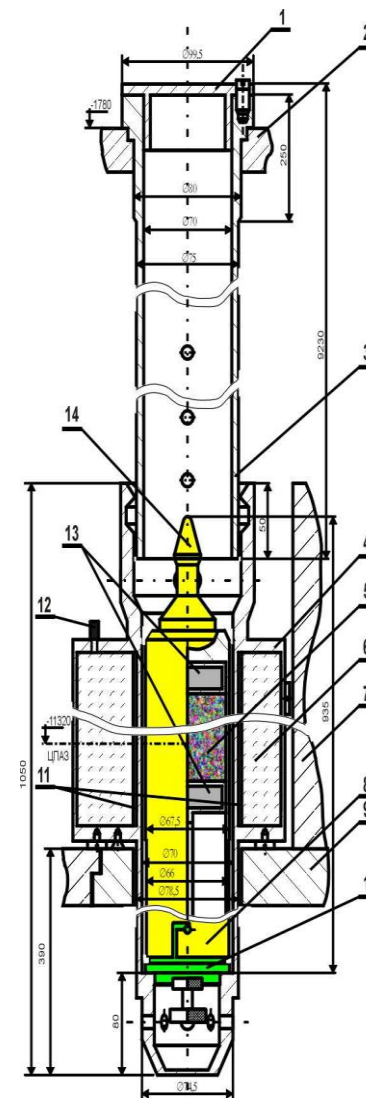


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Radiation coloring of minerals

Minerals are irradiated for 2÷16 days depending on the reactor power, fluence and size of gemstones.

Output – up to 1.0 t/y.



- 1 - Заглушка
- 2 - Площадка обслуживания реактора
- 3 - Канал
- 4 - Блок-фильтр
- 5 - Минералы
- 6 - Карбид бора и Al-пудра
- 7 - Свинцовая защита ИК
- 8 - Пенал
- 9 - Верхняя плита опорной конструкции реактора
- 10 - Пробка с байонетом
- 11 - Поглотитель кольцевой из кадмия
- 12 - Предохранительный клапан
- 13 - Пробка-фильтр из кадмия
- 14 - Головка пенала



Modernization of silicon doping and radiation coloring of minerals

Install in the RBT-10/2 two irradiation channels with a diameter of 200 mm with a system of electromechanical drives;

Manufacture and install a modernized silicon annealing furnace with increased productivity;

Update measuring and laboratory equipment.

Development and manufacture of irradiation devices for irradiating minerals under specified conditions;

Retrofit and relocate the irradiation coloring of minerals to RBT-6.

Increased amount of doped silicon up to 3 tons per year (with the possibility of doping ingots of larger diameter);

Increased productivity of radiation coloring of minerals up to 2 tons per year with reservation of irradiation possibilities;

Redundancy of irradiation capabilities and increased efficiency of the RBT-6 and RBT-10/2 reactors

Conclusion

RBT-10/2 and RBT-6 are reliable and high-demand reactors to test materials and accumulate radioisotopes.

The extension of RBT-10/2 and RBT-6 lifetime till 2027 and 2030, respectively, will ensure their safety, optimize their performance and increase their efficiency.

THANK YOU FOR ATTENTION!

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