3.10. RUSSIAN FEDERAL NUCLEAR CENTER ALL-RUSSIAN SCIENTIFIC RESEARCH INSTITUTE OF TECHNICAL PHYSICS named after E.I. Zababakhin (VNIITF)

456770, Chelyabinsk region,
Snezhinsk, Vasyljeva str., 13
Tel. (351-46) 3-26-25
Fax: (351-46) 5-22-33
Telex: 124137 SNOW RU
E-mail: otdeldou@vniitf.ru
http://www.vniitf.ru

G.N. RYKVANOV,
Member of the Academy of Sciences of the RF, VNIITF director and scientific supervisor

Russian Federal Nuclear Center All-Russian Scientific Research Institute of Technical Physics named after E.I. Zababakhin (VNIITF) is a Federal State Unitary Enterprise of Rosatom State Corporation.

The Institute was established on April 5, 1955 for developing new types of nuclear and hydrogen weapons and creating conditions for further nursing researchers and designers in this field.

Institute building

Today VNIIFT is one of two world-class nuclear weapons centers operating in Russia. Its main task is to solve scientific and technical challenges which arise in developing and testing nuclear weapons, tactical and strategic nuclear ammunition, using peaceful atom and fission energy, as well as to conduct basic and applied researches in gas dynamics, turbulence and high energy density physics.

Since 1964 research in self-quenching pulse nuclear reactor physics has been one of VNIITF's activities. Successful tests marked the beginning of development of three types of self-quenching pulse nuclear reactors namely BARS-type facilities with cylindrical cores consisting of uranium rings with the central channel (BARS-1, BARS-2, BARS-3); EBR-type pulse reactors which consisted of hemispheric uranium shells with relatively large central cavities (EBR, RUS, PRIZ); and reactors with solution cores (ELIR, IGRIK, YAGUAR).

In early 1964, core was assembled for the first reactor of BARS kind and research was conducted under steady conditions. The first fission pulse was obtained at BARS-1 facility on 28.04.1964. Experiments on irradiating samples in gamma and neutron fields began conducting at the facility almost immediately after first pulses had been generated. Test samples were installed around the core and in the central channel.

In 1969 BARS-2 reactor, which had improved performance compared to those of BARS-1 reactor, was commissioned. Its core was made of uranium-molybdenum alloy with higher strength at elevated temperatures. It was placed on self-propelled trolley which could move along the rails toward one of the reactor hall walls where radiological shielding had been installed. That shielding covered the core in the intervals between pulses. Mechanism for loading irradiation samples remotely into the central channel was developed, channel diameter was enlarged. BARS-2 reactor control system was automated and made it possible to specify movement of control rods as per "strict" program.

In 1972 BARS-3 pulse reactor was commissioned. Compared to BARS-1 and BARS-2 reactors its core had improved attachments of the parts made of enriched uranium, new operation modes including operation with large samples and in elevated neutron background were added to CPS. A technique for assessing fission pulse parameters in case of large sample irradiation assessment was developed, and pulse tail cut-off due to fast ejection of massive safety unit out of the core in case of thermal shock occurred was worked out.

Their further improvement was related to the development of new type of nuclear self-quenching pulse reactors which are neutron coupled multi-core pulse reactors.

BARS-4, BARS-5 and BARS-6 reactors are pulse reactors, each of which has two BARS cores.

In fact, each of nuclear facilities reviewed consists of two BARS-type pulse reactors combined by shared mechanical test bench and CPS. Each core is equipped with control elements having reactivity margin which make it possible to reach criticality in the core and generate fission pulses using prompt neutrons.

Among the salient features of such facilities are neutron interaction between the cores and due to this, the variety of states of neutron coupled system with miscellaneous neutronics; each core neutron fields superposition in the space; possibility of system control by control elements housed in one or in both cores; possibility of generating fission pulses with the same power density and different half-widths.

BARS-4 and BARS-5 two-core pulse reactors were designed for irradiating large-sized samples by a high power short-time neutron pulse. They were developed at the same time and had the same cores. They differed in CPS design and authorized operation modes.

BARS-4 reactor was handed over to MTsRI (now NIIP, Lytkarino) in 1979.

BARS-6 pulse reactor was manufactured at IPPE (Obninsk) as per the design documents handed over from VNIITF. The reactor can operate along with another subcritical unit, i.e. reactor-multiplier. As a result of neutron interaction the subcritical unit becomes third full-fledged core.

At the moment VNIITF operates 5 research nuclear facilities, namely: 4 research reactors and one critical facility:

- BARS-5+RUN-2 complex (V-generation self-quenching fast atomic reactor with II-generation reactor-multiplier);
- EBR-L RR (experimental fast reactor-laser);
- IGRIK RR (test complex' pulse homogenous reactor);
- YAGUAR RR (nuclear homogenous uranium aperiodic reactor);
- FKBN-2 CF (II-generation fast neutron pile).

VNIITF's research nuclear facilities

Facility type	Facility name	Thermal power, kW	Year of first criticality	State	Service life, years*
RR	BARS-5	10.00**	1986	In operation	26
RR	IGRIK	–	1975	In operation	37
RR	EBR-L	–	1981	In operation	31
RR	YAGUAR	4.00**	1988	In operation	24
CF	FKBN-2	–	2001	In operation	11

** As of 2012*
*** Under static conditions*

BARS-5 FAST APERIODIC SELF-QUENCHING REACTOR

BARS-5 RR is two-core fast aperiodic self-quenching pulse reactor designed for irradiating large-sized samples by a high power short-time neutron pulse.

The reactor was commissioned in 1986 as extended neutron source.

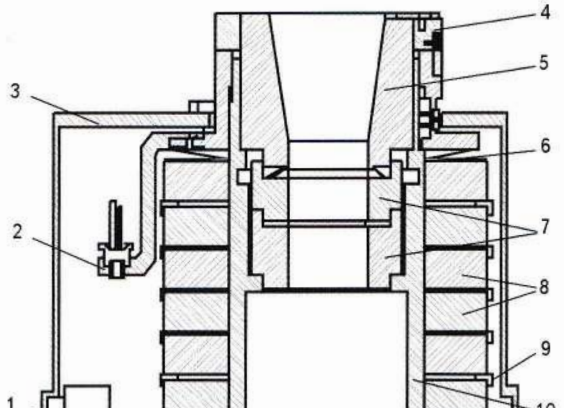
In fact, the reactor facility consists of two BARS pulse reactors combined by shared mechanical test bench, which makes it possible to change the distance between their centerlines from 33 to 150 cm, and CPS. Each core has its own neutron source, remote control mechanism for loading test samples into the central experimental channel, a set of neutron detectors and control elements, reactivity margin of which makes it possible to reach criticality in the core and generate pulses. BARS-5 reactor can be operated with one of three core configurations differing in central channel dimensions and the number of parts made of fissionable material. The most usable (main) core configuration has a central channel of 6 cm in diameter, and two other – 9 and 11.5 cm in diameter.

Main core configuration is a 21.8 cm-high cylinder, 22.6 cm in outer diameter along fissionable material. It consists of six 3 cm-thick one-piece rings. The rings are assembled on the central steel supporting tube. The rings are separated from each other by copper coated titanium gaskets.

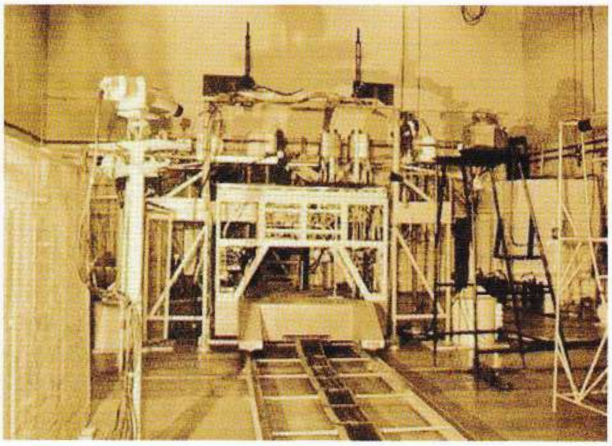
Every core has the same control elements, namely: safety unit, scram rod, fine control rod, pulse rod and reactivity controller.

A coupling controller (polyethylene plate) can be housed in the chamber between the reactors to control reactivity of coupled system by changing neutron interaction between the cores.

BARS-5 core ring



BARS-5 core:
1 – pulse rod; 2 – upper stop for pulse rod; 3 – core shroud; 4, 5 – nuts; 6 – dish spring; 7 – inserts; 8 – uranium core rings; 9 – gasket; 10 – supporting tube; 11 – support ring; 12 – safety unit; 13 – fine control rod; 14 – scram rod



BARS-5 reactor

BARS-5 main performance*

Maximum power density in a pulse	$2.5\cdot10^{17}$ fissions
Minimum pulse width	40 μs
Neutron fluence in the experimental channel	$1.0\cdot10^{15}$ cm^{-2}
Steady-state power, max.	10 kW
Maximum fuel temperature	470 °C

* *For every core*

Pulse rod made of forged copper has the shape of the plate encircling outer cylinder surface of the core. Reactivity controller (neutron trap) with neutron absorber is installed into the central channel and is an aluminum-clad cylinder made of polystyrol and boron compound (enrichment in ^{10}B is 80 %).

Each core is shielded with boron shroud (enrichment in ^{10}B is 80 %).

BARS-5 core uses alloy of 90%-enriched uranium with 10% molybdenum as fissionable material. BARS-5 core is cooled with air.

BARS-5 experimental capabilities

BARS-5 reactor is housed in the reactor hall, 18×12×9 m. There is a railway from one side of the hall to the opposite one for transferring test bench with reactor. There are a table for test samples in the centre of the hall, and core shielding by the wall. Reactor hall is equipped with a few TV cameras used to examine the reactor and irradiation samples installed near the reactor. The reactor is controlled from the control room in the building which is 400 m apart from the reactor hall.

Fission pulse is generated, if the reactor is located in the centre of the hall at the table with irradiation samples. After the pulse has been generated the test bench with reactor recoils to the wall, where the cores are covered with radiation shielding. Thanks to this a gamma dose rate is not as high as it is in the vicinity of the table with samples and reactor. So, access to the reactor hall for handling irradiated samples and maintaining the reactor is permitted almost immediately after fission pulse has been generated.

To enlarge its capacities to irradiate large samples the RUN reactor-multiplier was added to BARS-5 reactor. BARS-5+RUN complex is a reactor system with three neutron coupled cores separated from each other in the space.

BARS-5+RUN state-of-the-art complex reached first criticality in January, 1994 and was commissioned in June, 1994.

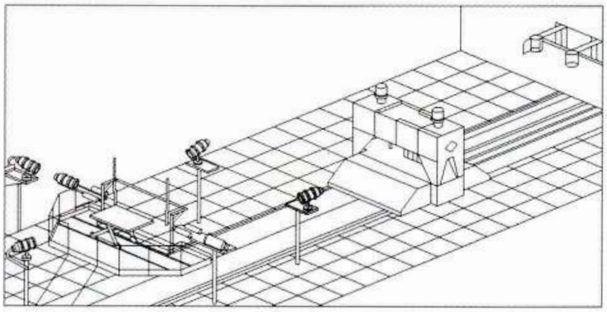
RUN consists of a mechanical test bench, unmovable upper and movable lower units, mechanisms for vertical and horizontal transfer of a lower unit, CPS.

In conducting all the complex neutronics studies BARS-5 reactor was used in unchanged configuration with similar cores. Distance between the reactor cores remained constant during all tests. BARS-5 reactor was operated in the way that core powers were equal.

Matrix arrangement of the core consisting of a large number of similar active elements (up to 60) is a salient feature of RUN design. Active element has a cylindrical shape. RUN matrix is a 22 cm-long stainless steel cylinder, with walk-through channel, which is cut along a horizontal center plane into two similar semi-cylinders (the upper one and the lower one).

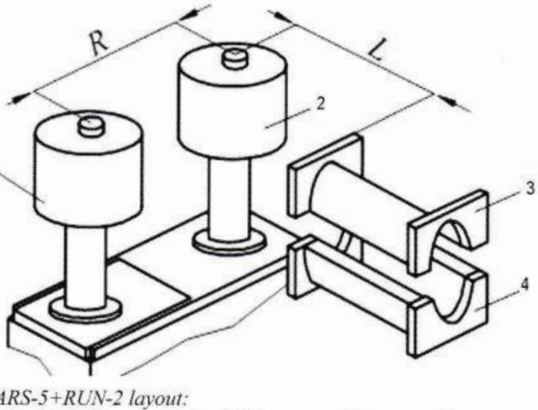
BARS-5+RUN complex can also be used in irradiation studies as gamma source. For this, n-γ-converter which consists of plates made of homogenous polyethylene-europium mixture is placed into the RUN central experimental channel. Other convertor configurations were also studied.

BARS-5+RUN complex makes it possible to conduct a wide range of radiation resistance studies of large (up to 25 cm in diameter) samples with controllable neutron fluence throughout the sample volume. Neutron fluence in the centre of the channel is up to $\sim 7 \cdot 10^{14}$ cm^{-2}, and close to its surface – up to $\sim 10^{15}$ cm^{-2}.



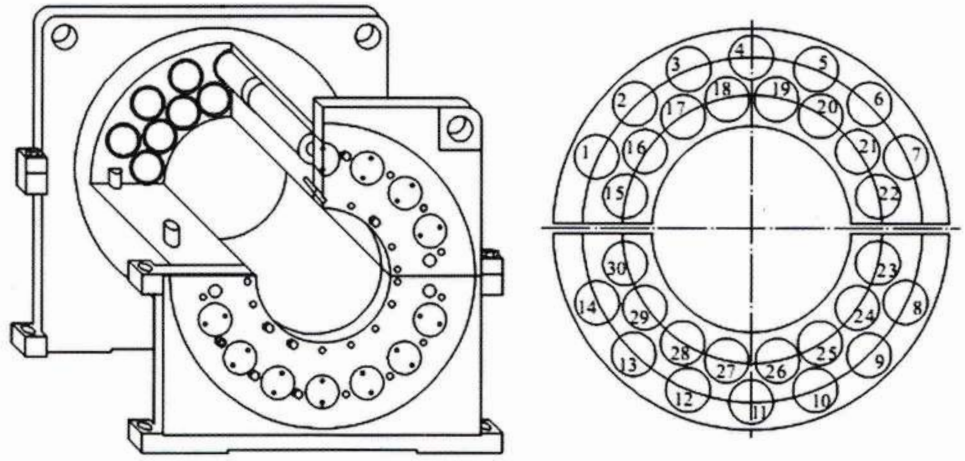
BARS-5 reactor hall

General view of BARS-5+RUN-2 complex



BARS-5+RUN-2 layout:
1, 2 – BARS-5 cores; 3, 4 – RUN upper and lower sections

Radiation analysis laboratory functions on the basis of BARS-5 reactor. Reactor channel is a class 2 neutron field reference sample.



RUN core

Main areas of studies

– Development, modernization, study of characteristics, commissioning (decommissioning) of metallic core nuclear pulse reactor, including multicore reactors.

– Radiation resistance studies of electronics and its hardware components.

– Study of physical properties of fissionable materials.

– Use of the reference measuring equipment for certifying neutron fields generated by the facilities.

– Certification of neutron fields generated by VNIITF's facilities.

Parameters of BARS-5+RUN-2 maximum fission pulse

	RUN	BARS-5	BARS-5+RUN-2
Full number of fissions per pulse	$5.5\cdot10^{17}$	$4.5\cdot10^{17}$	$1.0\cdot10^{18}$
Maximum intensity, s^{-1}	$3.1\cdot10^{21}$	$3.8\cdot10^{21}$	$6.9\cdot10^{21}$
Reactor period, μs	33	33	33
Maximum temperature, °C	440		
Neutron fluence, cm^{-2}:			
in the centre of the channel	$6.8\cdot10^{14}$		
close to inner surface of the channel	$8.0\cdot10^{14}$		

IGRIK NUCLEAR PULSE REACTOR WITH SOLUTION CORE

IGRIK RR is a homogenous pulse reactor with a solution core.

IGRIK reactor was commissioned in the static mode for the first time in March, 1975, the first fission pulse was obtained in September, 1975. In 1976 IGRIK reactor was commissioned.

Initially, IGRIK reactor as powerful gamma- and neutron source was a part of the test complex which was used for studying nuclear effects on various devices, then reactor was operated independently.

The reactor includes a core vessel with mechanism for control elements – pulse rods with neutron absorbers; test bench consisting of support plate and observation deck, which are designed for holding the core vessel; process equipment used for fuel preparation, storage and supply to the core vessel; control room.

The reactor is installed in the reactor hall, 9×9×8 m, with heavy concrete walls which protect personnel from gamma and neutron irradiation. Thickness of outer walls of the reactor hall housing IGRIK and YAGUAR reactors is 1.5 m, and thickness of inner wall separating these reactors from each other is 3 m. Reactor control room is in another building.

The bulk of process equipment is housed in a sump in the concrete bottom under the reactor test bench. Reactor sump walls are lined with stainless steel. The reactor sump has concrete wells housing main and auxiliary reservoirs – liquid fuel storages. This sump also houses a sealed dosing pump which supplies the solution to the core vessel and control shutoff valves. From the top, the reactor sump is covered with 30-cm thick steel plates which serve as radiation shielding.

Two ways of inserting reactivity has been fulfilled at IGRIK reactor:

– pulse rods are fully removed from the core. At that, excessive reactivity is controlled by changing solution volume in the core;

– fission pulses are generated at constant solution volume in the vessel. In this case excessive reactivity is controlled by limiting the level of pulse rod removal from the core.

General view of IGRIK reactor

IGRIK main performance

Fuel	$UO_2SO_4+H_2O$
Enrichment in ^{235}U	90 %
Core volume	54 l
Number of fissions per pulse	$2.0\cdot10^{18}$
Total power density per pulse	60 MJ
Specific power density in the solution	1.1 MJ/l
Minimum pulse width	2.5 ms
Neutron fluence in the central channel	$1.1\cdot10^{15}$ cm^{-2}
Neutron fluence in the lead shielding window	$2.2\cdot10^{14}$ cm^{-2}
Gamma dose rate in the central channel (in water)	$1.3\cdot10^{4}$ Gy
Gamma dose rate in the lead shielding window (in water)	150 Gy

Using a dosing pump the solution is supplied from the storage cylinder to the core vessel immediately before pulse generation. Pulse is generated in the absence of personnel in the reactor hall. Right after operation is completed the solution is drained to the storage cylinder. Device for cooling solution between fission pulses is mounted on the outer surface of the main storage reservoir. Water in this device circulates around a closed loop.

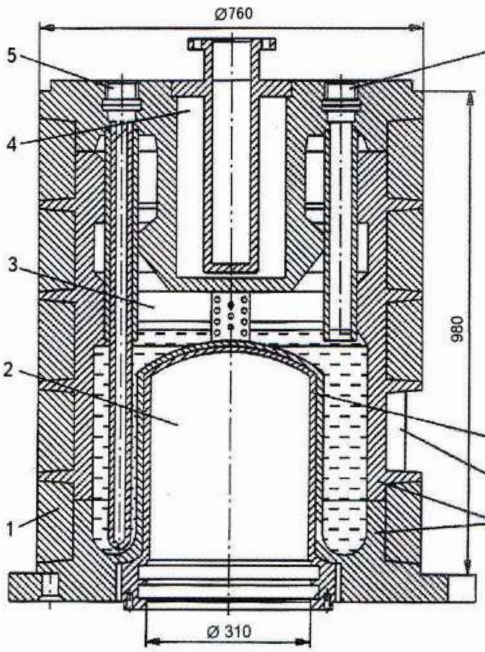
Core vessel is the main design element. It is a thick-wall hollow cylindrical vessel which has one central and peripheral channels for housing irradiation samples and control elements.

There are two chambers in the core vessel. The upper chamber is used as a receiver for mechanism of pulse rod control element; the lower one, which is the 51 cm-high central channel, Ø31cm, is designed for housing irradiation samples. Thickness of cylindrical layer of the solution is 8.5 cm in cylindrical part of the core vessel. Vessel is made of acid-resistant steel forgings. The lead shielding is attached to its 5 cm-thick outer wall.

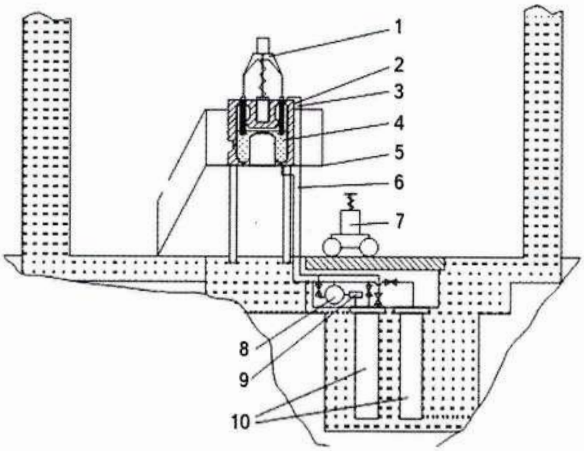
Vessel weight is with lead shielding is more than 50 times as much as fuel weight. Such weight relation promotes a reduction of the vessel travel range if solution disperses and hits on the upper lid after fission pulse has been generated. To damp vessel travels the rubber shock absorbers are used. These shock absorbers tolerate vessel travels within the limits of ±0.5 cm of normal position.

IGRIK experimental capabilities

The reactor was designed due to the necessity of studying radiation resistance of various objects. Therefore, its design was selected to provide as high neutron fluence and gamma-quantum dose rate as possible and as large volume available for housing irradiation samples as possible.



IGRIK core:
1 – lead shielding; 2 – main experimental channel; 3 – fuel solution; 4 – upper experimental channel; 5 – pulse rod channels; 6 – load-carrying barrel; 7 – irradiation window; 8 – core vessel



IGRIK layout in the reactor hall:
1 – pulse rod mechanism; 2 – core vessel; 3 – gas pipeline; 4 – fuel solution; 5 – support; 6 – solution supply and drain pipeline; 7 – loading device; 8 – dosing pump; 9 – filter; 10 – storage cylinders

Irradiation samples can be housed in the central channel and/or outside the reactor near the side surface of the core vessel, e.g. opposite to lead shielding window, where neutron fluence is the highest. Samples are loaded into the central channel by special mechanism mounted on the trolley.

During reactor operation it was often required to change its radiation field, i.e. to harden or soften neutron spectrum or change gamma-neutron component ratio in conducting various irradiation tests. To solve such tasks various devices were developed and commissioned at different times:

- gamma and neutron converters designed for being housed in the central channel and near the core vessel;
- neutron filters;
- devices which compensate reactor reactivity disturbance introduced by converters, filters and other devices.

Use of the mentioned devices made it possible to enhance reactor experimental capabilities significantly.

Main areas of studies

– Development, modernization, study of performance, commissioning (decommissioning), operation of solution-type research reactors.

– Radiation resistance studies of electronics and its hardware components.

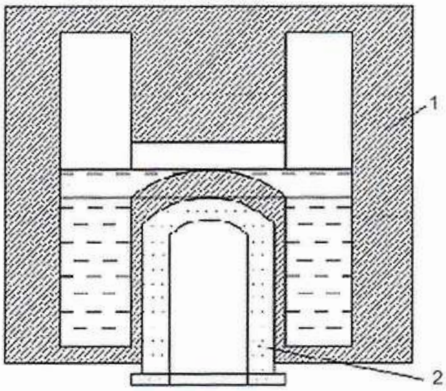
– Study of thermal, physical and mechanical properties of fissionable materials.

– Neutronic studies of systems where fissionable material solutions are applied.

Main activities

About 1700 pulses have been generated and 300 startups have been performed in the static mode at the reactor during its operation.

It is planned to modernize all reactor systems and develop IGRIK-2 reactor with extended experimental capabilities on its basis.



Layout of converters in IGRIK central channel: 1 – core vessel, 2 – converter

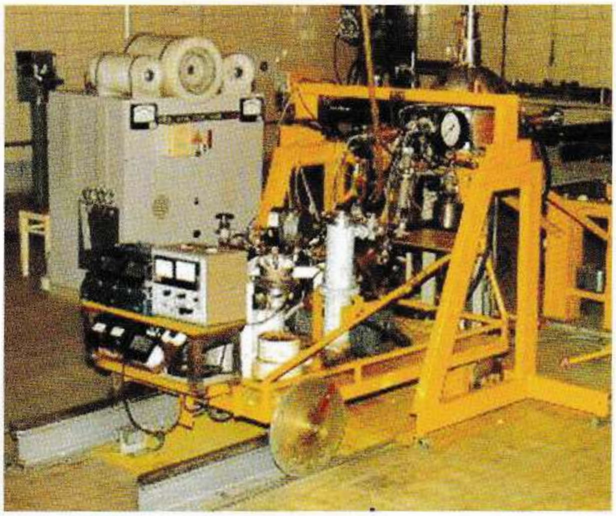
EBR-L PULSE REACTOR–LASER

EBR-L research reactor, experimental fast reactor-laser, is a fast pulse reactor with (U+Mo) metal fuel. Reactor is fast aperiodic self-quenching pulse reactor designed for studying nuclear pumped lasers.

For these purposes, EBR-200M reactor was modernized in the following way. Horizontal walk-through channel which goes through the central copper reflector was developed. EBR-L reactor reached critical state with delayed neutrons in March, 1981 and was commissioned in the same year.

EBR-L reactor-laser is housed in the reactor hall with dimensions of 12×12×6 m.

The core consists of two hemispheric assemblies made of uranium-based alloy (enriched to 90% uranium and 3% of molybdenum) surrounded with the copper reflector.



View of EBR-L reactor

EBR-L main performance

Loading of the central channel	Unloaded	Loaded*
Maximum number of fissions per pulse	$1.5\cdot10^{17}$	$1.5\cdot10^{17}$
Rated number of fissions per pulse	$1.2\cdot10^{17}$	$1.2\cdot10^{17}$
Minimum pulse time, μs	60	140
Maximum core temperature, °C	450	450
Neutron fluence in the central channel, cm^{-2}	$3.5\cdot10^{14}$	$5.8\cdot10^{13}$ (thermal)

* *Polyethylene unit in cadmium casing; a polished aluminum casing is mounted on the inner surface of the channel*

Lower assembly with part of reflector (safety unit) and stop unit housed together with pulse rod is flexible. Cylindrical copper reflector is housed between the assemblies. This reflector has horizontal cylindrical channel with 12.5 cm in diameter.

Usually this channel houses ~60 cm-long moderating unit with axial channel designed for laser cell, Ø6 cm. To prevent moderating unit against overheating which can occur in case of its contact with laser cells filled with metallic fumes a polished aluminum casing is mounted on the inner surface of its channel. The unit is cooled with air blown through annular gap between the cell and aluminum casing.

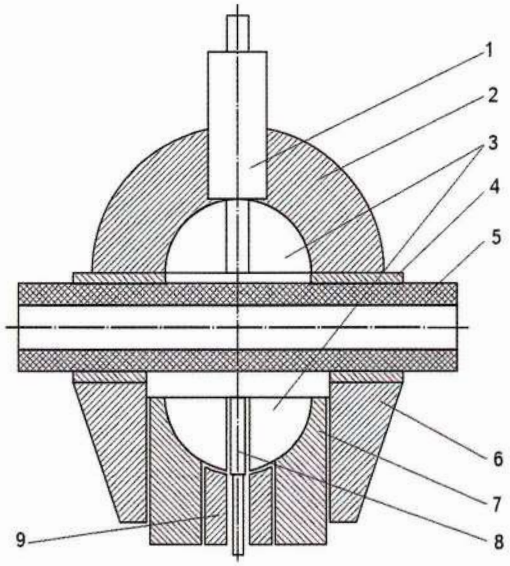
To reduce the influence of delayed neutrons on reactor performance a shielding, i.e. 0.4 mm-thick disks made of natural boron in steel casings is installed in the upper and lower parts of the middle reflector. In addition, a moderator unit installed into the reactor channel is encircled by cadmium casing.

EBR-L experimental capabilities

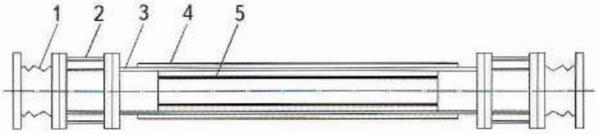
At present, EBR-L reactor includes the reactor itself, a set of laser cells, exhaustion system, laser (gas) media preparation systems, filters for additional gas cleaning, light emission extraction and recording system.

Main areas of studies

- Nuclear exited plasma physics and nuclear pumped laser physics.
- Physics of pulse reactor with metal core.



EBR-L core:
1 – fine reactivity controller; 2 – upper reflector; 3 – semi-spherical assemblies; 4 – middle reflector; 5 – moderator unit; 6 – lower reflector; 7 – safety unit; 8 – pulse rod; 9 – stop unit



Heated laser cell layout:
1 – alignment device; 2 – extension; 3 – central part of the cell; 4 – electric heater; 5 – U_3O_5 layers

YAGUAR APERIODIC SELF-QUENCHING PULSE REACTOR

YAGUAR research reactor is a uranium-fuelled homogenous aperiodic pulse reactor with solution core designed for studying U and Pu fuel behaviour during the pulse heating and further loading.

The first stage to reach first criticality at YAGUAR reactor commenced in the end of 1988. The reactor was commissioned in June, 1990.

YAGUAR general arrangement involves a core vessel with radiation shielding, a process system with separate gamma-irradiator loop and CPS. Reactor vessel with pulse rods actuator is installed in the reactor hall where gamma- and neutron radiation units, air-driven actuator control unit and auxiliary equipment are housed.

YAGUAR process system consists of solution and gas loops separated from each other to prevent solution from leaking to gas loop.

Solution is filled into the core before reactor startup. It is done via pipeline and valve system by increasing air pressure in the cylinder. To produce gauge pressure a membrane pump and cylinder for pressurized air are provided in the process system.

Closed loop process cycle is provided by a regeneration system for water radiolysis products generated in reactor operation. To regenerate explosive mixture a spark igniter, which ignites the mixture directly within the vessel, was included in the gas pipeline. Generated water goes to the storage cylinder and mixes with the solution.

Reactor control room and automated fission pulse data recording system are housed in a separate building.

While generating a fission pulse the control system and air-powered drives simultaneously move two pulse rods using the special connection circuits for electrical and pneumatic valves which are envisaged in an air-powered drive system. The drives are designed to provide the possibility to move rods independently from each other.

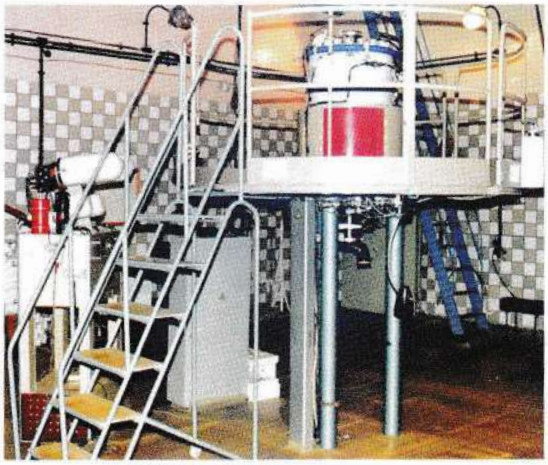
Fuel composition of YAGUAR core is highly concentrated uranyl sulphate solution in light water with small content of cadmium salt. Core vessel is designed to make it possible for fuel solution to flow both vertically and horizontally during a fission pulse. It allowed inertial pressure to be reduced in the fuel down to a tolerable level and a fission pulse which is the longest-lived one for solution systems to be obtained (its half-width came to ~ 700 μs).

When YAGUAR reactor reached first criticality in 1990 the following parameters were specified:

- power density in the fuel solution and normalization of control equipment in terms of this value;
- neutron energy spectra and 3-D fluence distribution in the areas designed for housing irradiation samples;
- fluence energy spectra and 3-D distribution of gamma-quantum dose rates around the reactor and gamma-irradiator.

YAGUAR experimental capabilities

The main experimental facility is the central experimental channel, Ø144mm, which walks through the core and goes as a 2.5 m-deep well into the concrete bottom of the reactor.



General view of YAGUAR

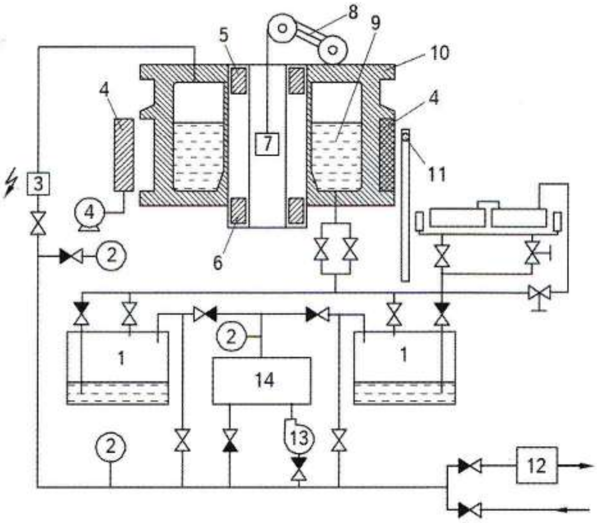
YAGUAR main performance

Fuel	$UO_2SO_4+H_2O+CdSO_4$
Enrichment in ^{235}U	90 %
Core volume	38 l
Number of fissions per pulse	$1.0 \cdot 10^{18}$
Total power density per pulse	32 MJ
Specific power density in the solution	0.85 MJ/l
Minimum pulse width	720 μs
Neutron fluence in the experimental channel	$1.2 \cdot 10^{15}$ cm^{-2}
Gamma-quantum dose rate in the experimental channel (in water)	$0.8 \cdot 10^3$ Gy
Maximum power in the static mode	4 kW

Use of activated fuel solution as delayed gamma source turned out to be beneficial. For this, a radiation loop (gamma-irradiator) was added to the reactor process system.

The gamma-irradiator consists of four (~5 cm-thick) identical flat reservoirs-modules, each of which is parallelepiped with overall dimensions of 54.0×54.0×5.0 cm.

Inner volume of the module which can be filled with fuel solution is ~10 l. Thickness of solution flat layer is 4 cm; its width and length are 50 cm each. The module consists of two parts, each one being milled from solid titanium plate. It has box shape with 0.5 cm-thick bottom, side walls and reinforcing ribs between them. Two such boxes are connected to each other and welded along the perimeter, that generates a parallelepiped with inner chamber. Such a design has required



⋈ – *normally opened valve;*

⧓ – *normally closed valve;*

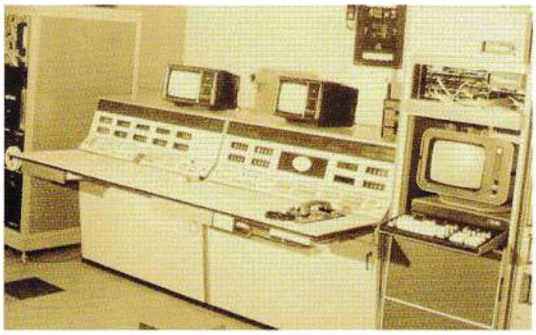
⋈ – *manual valve*

YAGUAR process system:
1 – cylinders for storing fuel solution; 2 – pressure sensors; 3 – spark igniter; 4 – radiation shielding with drive; 5 – upper pulse rod; 6 – lower pulse rod; 7 – sample in irradiation position; 8 – sample loading drive; 9 – core; 10 – core vessel; 11 – neutron source; 12 – gas cleaning filter; 13 – membrane pump; 14 – gas cylinder

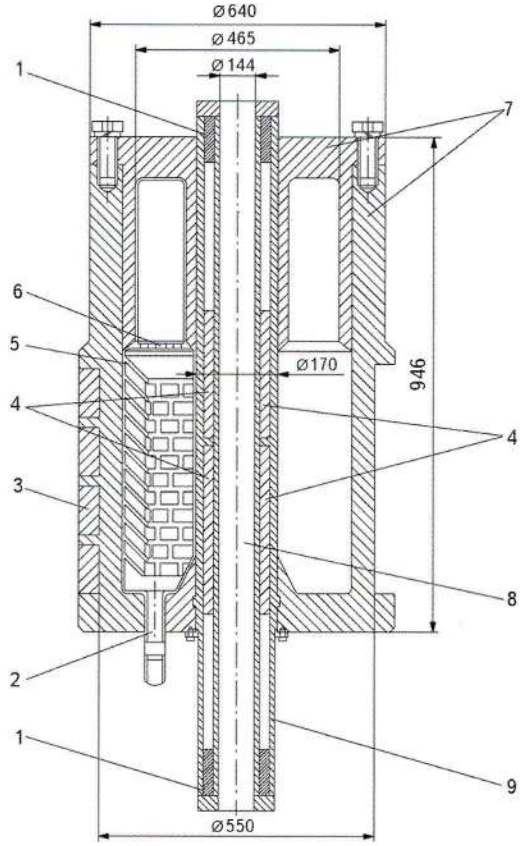
leaktightness and rigidity; it withstands inner pressure of up to 5 MPa.

Various gamma-quantum source configurations are produced by changing a relative position of the modules. The most usable gamma-irradiators were 3-D well-shaped gamma-irradiator, 50×50×50 cm, and the flat one, 100×100×5cm.

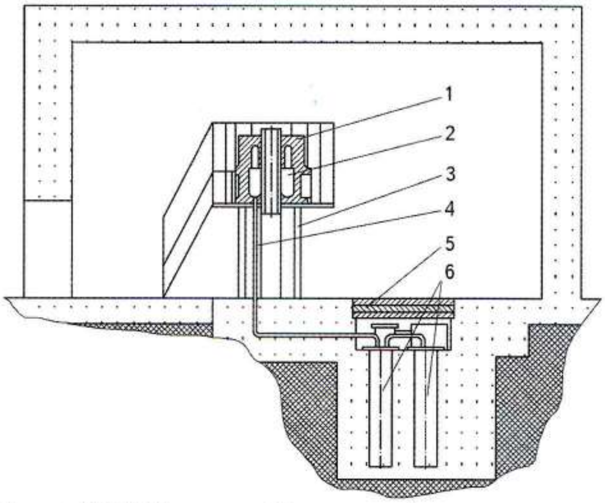
Radiation solution can be supplied to the chambers of gamma-irradiator modules a few minutes after the pulse or after the solution has been cooled in the vessel or storage cylinder depending on irradiation test conditions. After completion of works, where gamma-irradiator is used the solution comes back to a storage cylinder.



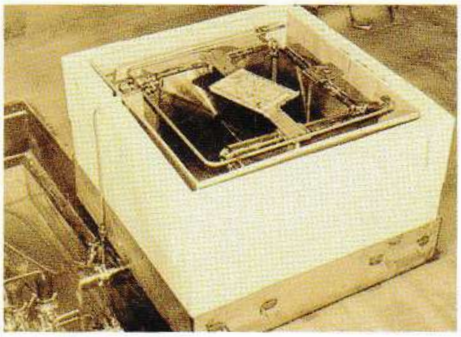
YAGUAR control room



YAGUAR core:
1 – shock-absorbers; 2 – drain pipeline; 3 – lead biological shielding; 4 – pulse rods; 5 – ampoule; 6 – reinforcing flange; 7 – load-carrying case; 8 – central experimental channel; 9 – inner load-carrying shroud (thimble)



Layout of YAGUAR reactor and its process equipment:
1 – core vessel; 2 – fuel solution; 3 – supports; 4 – pipe to supply solution to the core vessel; 5 – radiation shielding of storage cylinders; 6 – storage cylinders



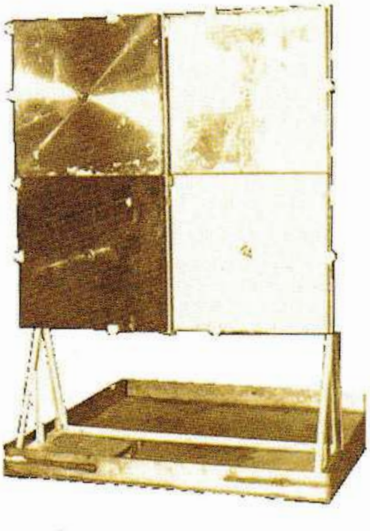
3-D gamma-irradiator

Main areas of studies

– Development, modernization, study of performances, commissioning, operation and decommissioning of solution-type research reactors.

– Radiation resistance studies of electronics and its hardware components during irradiation tests.

– Study of thermal, physical and mechanical properties of fissionable materials.



Flat gamma-irradiator

– Neutronic studies of systems where fissionable material solutions are studied.

– Basic studies of nuclear and elementary particle physics.

CRITICAL FACILITY – FBKN-2 FAST NEUTRON PILE

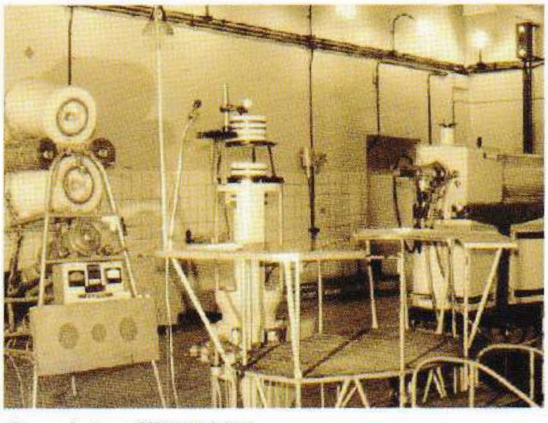
FBKN-2 critical facility (CF) was designed and manufactured with respect to state-of-the-art organizational and technical choices using modern electronic and hardware components. FKBN-2 CF reached first criticality in October, 2000.

The first facility for measuring critical mass – fast neutron pile (FKBN) was commissioned at VNIITF in March, 1958. In 1970, it was modernized during its transfer to a new building. This facility was named FKBN-M and operated up to the end of 1998, when it was fully worn out.

By early 2000 a new CF named FKBN-2 was manufactured for critical mass measurements. It differed from FKBN-M in the following:

– enhanced mechanical precision in manufacturing CF parts and units;

– automation and computerization of neutron flux recording system by logging and saving measurement protocol on a magnetic carrier;



General view of FKBN-2 CF

– computer-aided audio and video surveillance of assembling and data logging on a magnetic carrier.

In addition, all the machine units and hardware included in the facility set were qualified. Building, control room and test hall are equipped with the state-of-the-art security means.

FKBN-M modernization was aimed at increasing its reliability and safety of conducted works, enhancing accuracy and repeatability of results of criticality tests, replacing worn-out and obsolete equipment.

CF mechanisms were replaced by the new ones with a better movable part centering mechanism design. Electronic equipment was also replaced by the new one which used up-to-date electronics and hardware components as well as contactless automatic control and protection circuits. The main focus was on introduction of systems enhancing safety during nuclear hazardous works.

Among them are:

- system which monitors personnel access to the reactor hall and makes it impossible for one worker to carry out operations in the hall;
- automatic system for measuring neutron multiplication coefficient and power;
- system which prohibits assembling of multiplying system if neutron multiplication coefficient exceeds 30;
- system which prohibits operation of the facility in the static mode if core power is more than 100 W;
- automatic system which records multiplying system assembly process.

The facility was modernized at the design stage in three main areas, namely: modernization of electromechanical test bench, recording system and CPS.

To install FKBN-2 CTB a new foundation bed was constructed in the test hall.

As of now, FKBN-2 CTB includes 5 sets of parts made of fissionable materials. Sets 1–4 consist of hemispherical layers which, when assembled, form spherical systems made of HEU and Pu. Set 5 (ROMB) involves HEU and Pu disks as well as disks and rings made of various non-fissionable materials.

Assembling of multiplying system at FKBN-2

FKBN-2 CF main performance

Allowable power in the static mode	100 W
Allowable temperature at the hottest point	100 °C
Maximum input electrical power	15 kW
Travel of CF movable part at emergency discharge (backup discharge)	10 mm
Scram rod response time	0.2 s
Maximum load on mechanical test bench support	65 kN
Maximum load on movable part of mechanical test bench	5 kN
Travel speed of movable part of mechanical test bench:	
“fast”	0.5 mm/s
“average”	0.1 mm/s
“slow”	0.02 mm/s
Error in measurement of clearance between movable and fixed parts of mechanical test bench	0.1 mm
Maximum travel of movable part of mechanical test bench	500 mm

Main areas of studies

– Development, modernization, study of performances, commissioning, operation and decommissioning of facilities, critical assemblies and research reactors.

– Nuclear physics research at SCF to justify nuclear safety, specify nuclear physical constants and verify mathematical models and calculations.

– Determination of physical and radiation characteristics of nuclear materials and components of subcritical systems.

Contact person

ALEXANDER LUKIN
Head of Division
Tel. (35146) 5-11-00
Fax (35146) 5-11-01
dep5@vniitf.ru