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The origin of the Central Research Institute named after Academician A.N. Krylov (KSRI) is traced to the Ship Model Basin constructed in the central part of St. Petersburg, on the island of "New Holland" (1894), which was Russia's first facility for shipbuilding. The Institute's history has always been closely associated with the history of the Russian fleet, of national science and of St. Petersburg itself.

Institute building

The Research Institute of Naval Shipbuilding was set up around the Ship Model Basin in 1932. Construction of the Institute complex as it appears today started in 1936 on the southern outskirts of Leningrad.

In 1944, after a number of reforms, the Institute received its present-day name and the status of a multidiscipline scientific center; the same year, it was named after A.N. Krylov, one of the first managers of the Ship Model Basin (1900).

By 1960, construction of the main complex of basins and other experimental facilities of the Institute was completed. In 2000, KSRI became a State Scientific Center (affiliated to the RF Ministry of Industry).

KSRI is the leading domestic research organization in the field of shipbuilding and

A.N. KRYLOV
(1863–1945)

A. N. Krylov is the founder of the shipbuilding theory, the author of many works on the theory of magnetic and gyro compasses, on artillery, mechanics, mathematics and astronomy. In 1914, he became a Corresponding Member and in 1916 a Full Member of the Academy of Sciences. Later on, the Academy instituted the Krylov Prize which is awarded for "outstanding work with the use of computer facilities for solving problems of mechanics and mathematical physics".

V.M. PARSHIN
Scientific Leader – Director of KSRI

one of the world's largest scientific centers in this sphere. The Institute raised various schools of national fundamental and applied science related to design of watercraft, oceanic facilities and marine structures. Among the prominent personalities of the past were: Academician A.N. Krylov, Professor I.G. Bubnov, Academicians V.L. Pozdyunin, Yu.A. Shimansky, V.V. Novozhilov, and Corresponding Member of the USSR Academy of Science P.F. Papkovich.

The biggest practical achievements of the Institute include:

– the world's highest speed and seagoing qualities of ships and vessels;

– robust means of electromagnetic protection;

– engineering approaches for reducing the noisiness of submarines;

– the highest strength standards of submarines, warships and various other watercraft;

– means of protection of nuclear submarine crews against radiation and means specified against radiation fields;

– high-efficiency propellers for domestic and foreign watercraft;

– winning of a world lead for Russia in building watercraft of radically new types or with new characteristics.

Research reactor of KSRI

Name	U-3
Thermal power	50.00 kW
First criticality year	1964
Status	Safe storage
Operation time*	40 years

** Before shutdown*

Today, KSRI is a multipurpose scientific center which deals with most complicated problems of watercraft hydrodynamics and strength, it sets the course for development of ship-borne power facilities, is engaged in research and development efforts to control noise and vibrations of mechanisms, power supply systems and whole ships, as well as to reduce the levels of electromagnetic fields with their impacts on man and the environment. The sum of ongoing studies in the key areas of shipbuilding enables the Institute to predict the directions of development and to underpin the domestic shipbuilding programs.

POOL-TYPE HETEROGENEOUS REACTOR U-3

The U-3 is a pool-type water-moderated reactor cooled by natural circulation of water. The reactor reached first criticality and was brought to the power level of 50 kW on December 13, 1964.

The multipurpose nuclear research reactor U-3 of the Krylov Shipbuilding Research Institute is intended for a broad spectrum of studies related to the effect of ionizing radiation on substances, materials and products as well as to formation of specified radiation conditions in experimental positions.

The U-3 reactor allows investigating the service life of instruments and the behavior of various materials under irradiation. Together with a vessel compartment model, the reactor was involved in experiments to deal with the problems of habitability, radioactive material transport and deposition in the event of accidents at ship-borne nuclear power systems.

The view of the U-3 reactor

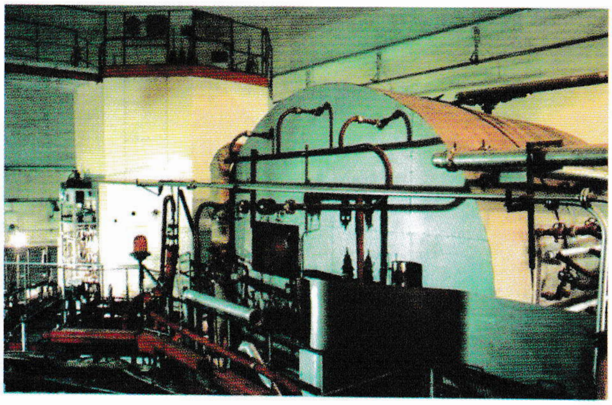
Main performance of U-3

Thermal power	50 kW
Moderator	Water
Coolant	Water
Reflector:	
top and bottom	Water
side	Graphite (GM3A)
Neutron flux, max.	
thermal (E<0.025 eV)	$4.0 \cdot 10^{11}$ cm$^{-2} \cdot$s^{-1}
fast (E>0.1 MeV)	$4.7 \cdot 10^{11}$ cm$^{-2} \cdot$s^{-1}
Cooling by natural convection	Yes
Forced cooling	No
CPS rod material	Aluminum (AMSN)
Number of CPS rods for:	
emergency protection (scram)	2
automatic control	3
manual control	1
CPS drive type	Electromechanical, reversing, multispeed, step

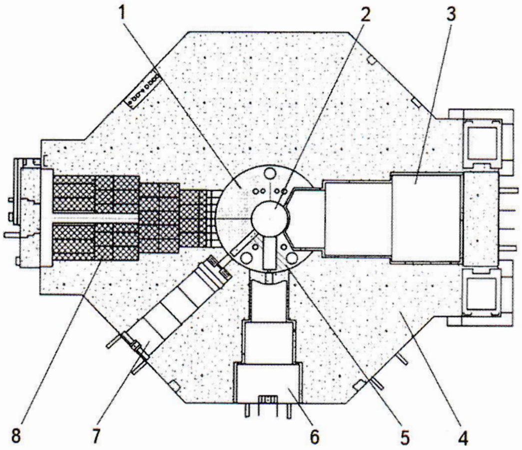
Since July 26, 2004, the reactor has been in safe storage.

In 1988–1989, the reactor equipment was upgraded, with the design and composition of the core, reflector and experimental devices left unchanged.

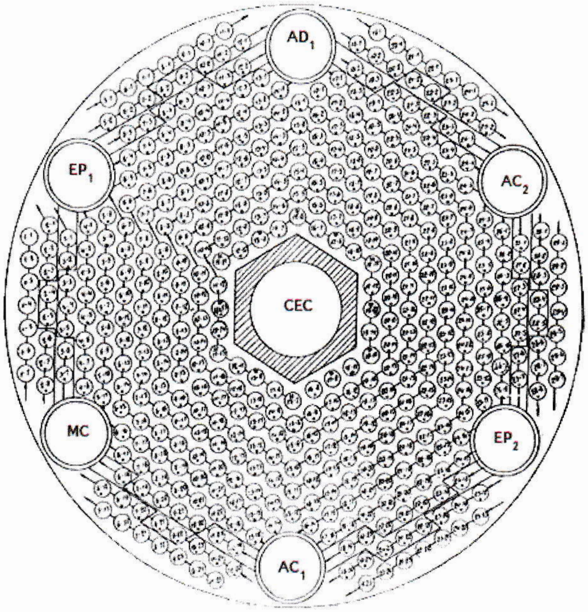
The reactor core is heterogeneous. Distilled water is used as moderator, coolant, bottom and top reflectors. The side reflector is made of graphite. The reactor operates in a fast neutron spectrum.



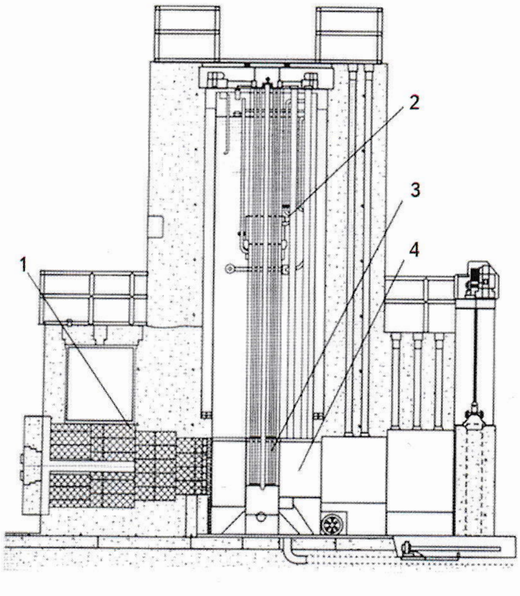
U-3 reactor hall



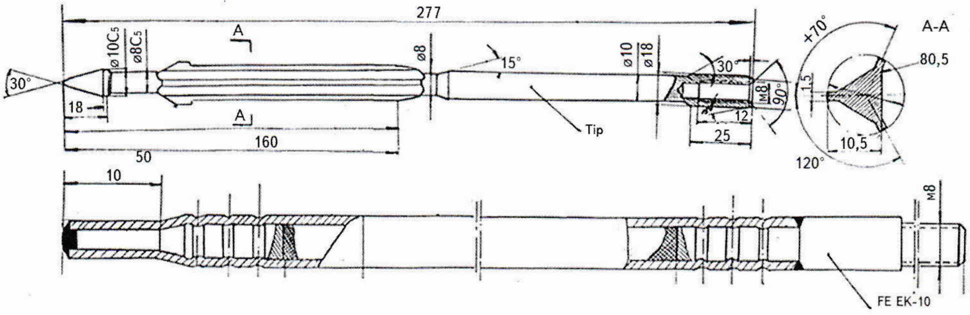
Horizontal section of the U-3 reactor:
1 – graphite reflector; 2 – reactor core; 3 – roll-out box; 4 – biological shield; 5 – tangential gate; 6 – radial gate, rolling; 7 – radial gate; 8 – thermal column



U-3 core map



Vertical section of the U-3 reactor:
1 – thermal column; 2 – heat exchanger; 3 – core; 4 – roll-out box



U-3 fuel rod

Structurally, the U-3 fuel is enclosed in 426 fuel elements (type EK-10) that are rods, with their meat located in an aluminum cladding. The meat is made of uranium dioxide cermet enriched in ^{235}U to 10 % and containing magnesium as diluent. The fuel meat is 7 mm in diameter and 500 mm in active length, and its leak-tight aluminum cladding with the outer diameter of 10 mm has a wall thickness of 1.5 mm.

The EK-10/U-3 fuel rod has special parts attached mechanically to its ends. The lower end-piece of length 44 mm is a standard component of the EK-10 fuel rod, while the upper end-piece is specially shaped to let coolant pass through the top tube plate.

The upper end-piece is made of aluminum. It has a head, to be gripped by a collet, flaring out to Ø16.5 mm, three radial ribs at an angle of 120° to be fitted to the top tube plate of the reactor core and another three similar ribs with Ø14.5 mm to go through the tube plate. The length of the upper end-piece is 277 mm in the total fuel rod length of 865 mm.

The U-3 reactor is cooled by natural circulation of primary water.

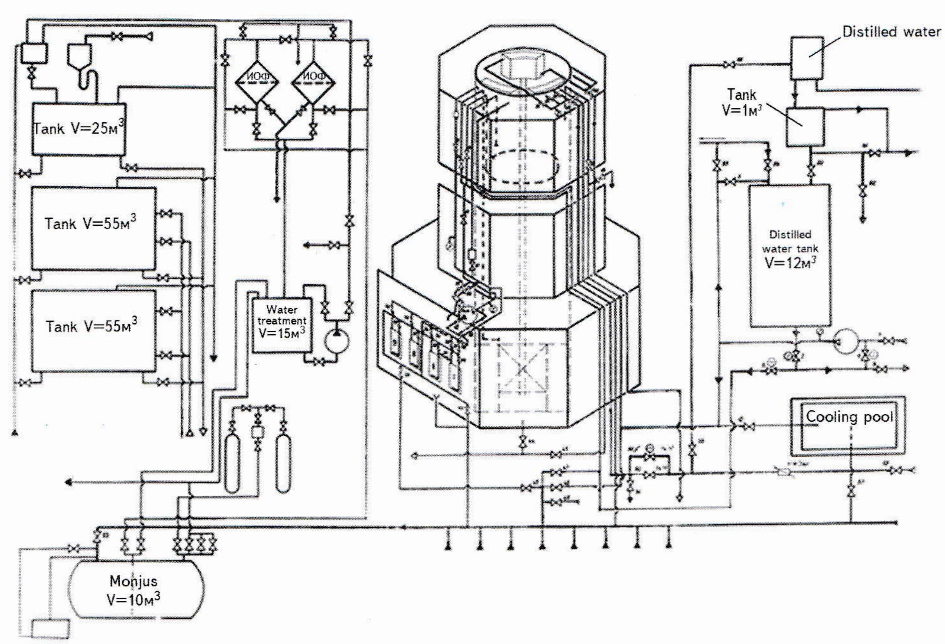
The reactor heat is transferred to service water of the secondary circuit via three intermediate heat exchangers in the upper part of the reactor vessel.

Experimental capabilities

The U-3 research reactor is located in a one-storied hall and has the following devices for experiments:

- horizontal channels:
  - gate No. 1 – tangential, Ø100 mm;
  - roll-out box, measuring 800×800×500 mm;
  - gate No. 2 – radial, rolling, Ø100 mm;
  - gate No. 3 – radial, Ø100 mm;
- vertical channels:
  - central experimental channel (CEC), Ø52×1 mm;
- irradiation devices in the core::
  - three-stage roll-out box;
  - rolling radial gate on motor-driven trolley;
- irradiation devices in the reflector:
  - tip of the tree-stage roll-out box;
  - rolling radial gate No. 2;
- 25 m³ ship compartment model.

The U-3 reactor has unique equipment, such as a three-stage roll-out box for irradiation of large instruments and devices, one tangential and two radial gates.



Flow chart of the U-3 reactor

Specific neutron flux in irradiation devices, $cm^{-2} \cdot s^{-1} \cdot W^{-1}$

Horizontal channels

Gate No. 1:

thermal .... $4 \cdot 10^{2}$

fast .... $4.4 \cdot 10^{1}$

Gate No. 2:

thermal (E>1 MeV) .... $1.2 \cdot 10^{3}$

fast .... $8 \cdot 10^{2}$

Gate No. 3:

thermal .... $1 \cdot 10^{3}$

fast .... $6 \cdot 10^{2}$

Vertical channels

thermal .... $6 \cdot 10^{6}$

fast .... $6.6 \cdot 10^{5}$

In-core irradiation devices

thermal .... $8 \cdot 10^{6}$

fast .... $8.9 \cdot 10^{6}$

Main areas of studies

– Radiation protection of ships and vessels.

– Service life of ship-borne instruments and components under irradiation.

– Mass transfer and activation of corrosion products in ship-borne water-cooled facilities.

– Formation of radiation conditions in closed compartments of ships and methods of removing radioactive substances.

– Methods to improve water treatment processes and equipment for ship-borne nuclear power systems.

– Ship-borne reactor control systems.

– Diagnostics and service life of ship-borne equipment (studies by radiation engineering methods).

– Physics of advanced reactors.

– Radiation dosimetry and metrology.

Main activities

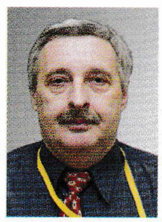
Many service life studies were carried out at the U-3 reactor for various instruments and materials. Used together with a ship compartment model, the reactor helped to solve the problems of habitability, radioactive material transport and deposition under emergency conditions at ship-borne nuclear power systems.

Power generation by the U-3 reactor over its operation time came to 310 173.7 kW·h.

In 2010, the Federal Service for Environmental, Technological and Nuclear Supervision issued a license valid till December 24, 2017, which authorized operation of the U-3 reactor in the long-term shutdown mode.

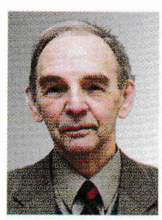
The facility life extension activities are in progress.

Personalities

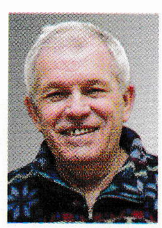


KIRILL KONDRATYEV
Manager of the Nuclear Research Reactor U-3

YURI KISILYOV
Manager of the Nuclear Research Complex.



EDUARD GOZHULENKO
U-3 Shift Leader



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