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The Obninsk Branch of the L.Ya. Karpov Institute of Physical Chemistry (NIFHI), which is now part of the National Research Centre bearing the same name, was set up in 1959 near the Town of Obninsk, Kaluga Region, for extensive research in radiation chemistry and solid-state physics as well as in other spheres of atomic energy uses. Its base facilities are the VVR-c reactor and a hot cell laboratory.

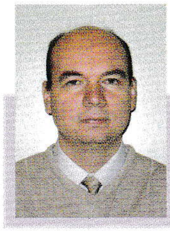
The VVR-c reactor building

The VVR-c reactor has seen numerous studies associated with various fields of science and technology, such as radiation material science, physics of semiconductors, analyses of ultrapure materials, radiation-induced polymer destruction, radiation chemistry of diluted aqueous solutions, tests of biological objects for medical purposes, simulation of severe accidents, etc.

The Obninsk Branch is a major supplier of radiopharmaceuticals – more than 20 types of which are of its own development – and medical products.

Following the Nuclear Medicine Programme, a Neutron and Neutron-Capture Therapy Complex is being built around the VVR-c reactor to NIKIET's design in cooperation with the Medical Radiological Research Centre (MRNC RAMN), IPPE, IATE, MEPhI. The idea behind this project is to set up a medical and scientific centre of neutron therapy on the basis of the Obninsk clinical facilities of MRNC RAMN.

The VVR-c reactor supports, among other studies, the activities of the Neutronography Centre where scientists analyse the structure and composition, the structural changes and

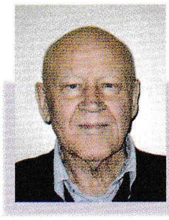


O.YU. KOCHNOV
Director of the Obninsk Branch

properties of substances and materials, as well as special-purpose products and assemblies.

The VVR-c reactor was the country's first facility where radiation processes were developed for nuclear doping of semiconductors, to be later implemented at other Russian research and production reactors. Today, the reactor produces strategic semiconductor materials of excellent quality for state-of-the-art instrumentation.

Besides, the Institute's reactor is employed in development of technologies for production of high-performance, heat and moisture-resistant, extended-life radioactive iodine sorbents for a new generation of filters to clean atmospheric emissions from nuclear reactors and radiochemical facilities.



V.V. POZDEEV
Head of Radiopharmaceutical Department

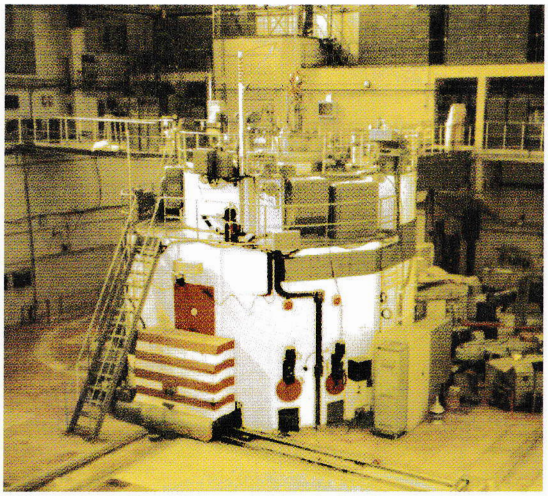
VVR-c REACTOR FACILITY

In terms of the NIFHI Branch organisation, the VVR-c reactor is an interface between a number of scientific and technological departments forming a research and production complex.

The VVR-c reactor facility comprises the research reactor proper together with storage facilities for fresh and spent fuel, components and systems for radioactive waste and nuclear material handling, as well as components and systems for research and experiments.

VVR-c is a heterogeneous tank-type research reactor which uses water as moderator and coolant.

The reactor reached its first criticality on November 4, 1964, and came to its nominal power on April 22, 1965.

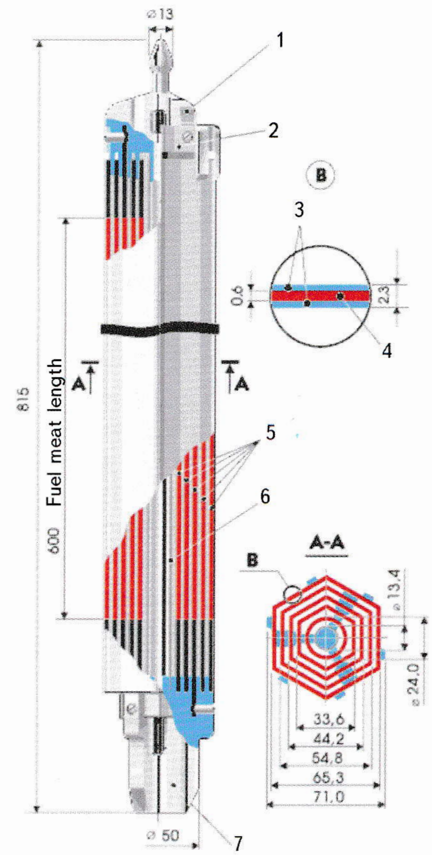


VVR-c reactor

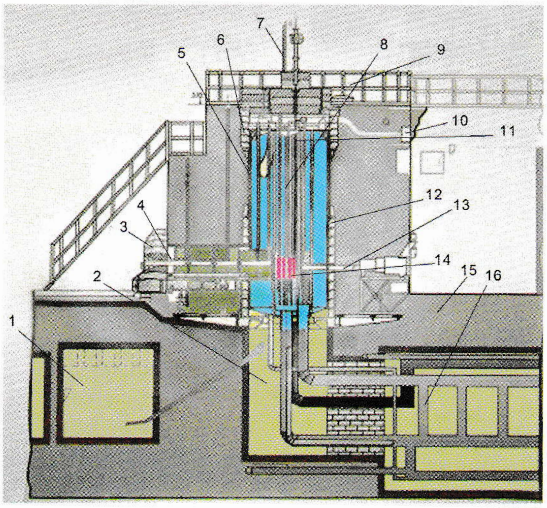
VVR-c control room

The VVR-c reactor is designed for a large variety of activities to support different spheres of science and engineering.

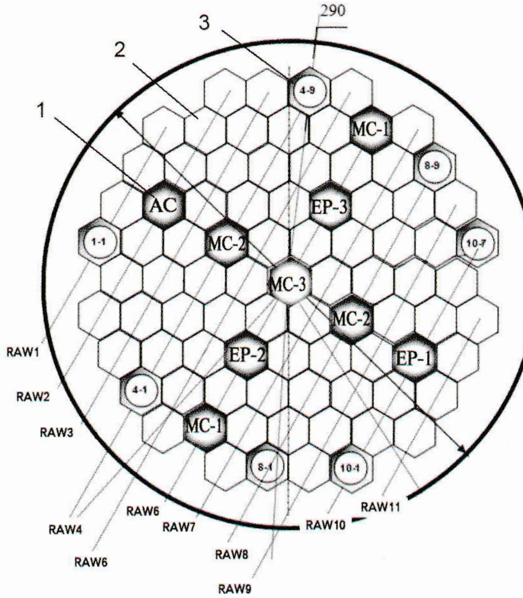
Reactor vessel is a cylindrical tank with spherical bottom. The tank is 2268 mm in diameter and 5340 mm high. The tank and in-tank elements are made of aluminum alloy. The core is housed in the centre of the lower part of the tank. The tank is plugged with the lid, on which vertical channels are attached and elements of CPS member drives, experimental devices, etc. are placed. The tank lid has openings to make it possible access to the core during its maintenance.



VVR-c fuel assembly:
1 – head; 2 – ring; 3 – cladding; 4 – fuel core; 5 – fuel elements; 6 – tube; 7 – end-piece



VVR-c reactor (vertical section):
1 – dispensing chamber; 2 – under-reactor room; 3 – thermal column; 4 – movable shield block; 5 – reactor vessel; 6 – support ring; 7 – optical device; 8 – CPS rod; 9 – handling mechanism; 10 – ventilation lines; 11 – vertical experimental channels; 12 – thermal shield; 13 – horizontal experimental channel; 14 – reactor core; 15 – concrete shield; 16 – primary pump chamber.



VVR-c core map:
1 – CPS rod; 2 – FA cell; 3 – experimental channel

The reactor core comprises 70 fuel assemblies of the VVR-c type arranged in a cylindrical separator (vessel). The bottom of the separator is a support grid, with its openings accommodating the end-pieces of fuel assemblies. To prevent radial movements of fuel assemblies, restraining segments are provided at the separator's inner periphery. Every VVR-c fuel assembly contains five tubular fuel elements of hexahedral cross-section.

The reactor core contains CPS rods whose location is shown in the core map.

The reactor has a two-circuit cooling system.

The primary circuit includes: 5 reactor coolant pumps (RCP); 3 heat exchangers; pipelines and valves. The circuit volume together with the reactor tank is 40 m^3. The structural material of primary pipelines and components is stainless steel.

The secondary circuit includes: circulation pumps; pipelines and valves; a mechanical-draft tower.

The secondary pipelines are made of stainless steel, with cast-iron valves in them. The reactor heat is removed by the secondary coolant to the atmosphere through a 4-section mechanical-draft tower.

The primary circuit is filled and made up from tanks. In the event of leakage, water would be collected in a special drainage reservoir. In such a case, the core would be sprayed with water from the makeup tanks, which would have been returned from the special drainage reservoir by emergency cooling pumps.

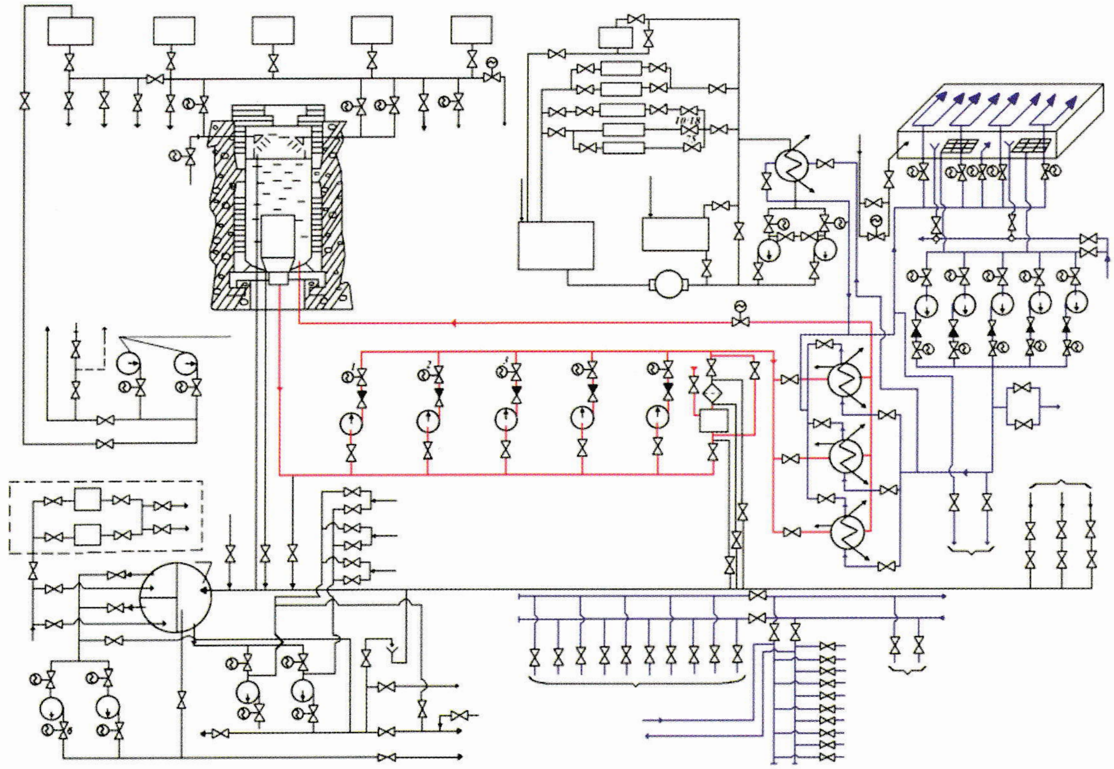
The cycle of the reactor operation at nominal power without refuelling (reactor campaign) is ~100 hours long. At the end of the campaign, the reactor will be partially refuelled, with one or two spent fuel assemblies removed to the storage facility and replaced with fresh assemblies. The planned reactor outages will be used for equipment maintenance and preparations for experiments.

The primary heat exchangers, the secondary pumps and, partly, valves were replaced, and a spent fuel storage facility was built in line with the VVR-c Reactor Upgrading Programme. Tank internals with beryllium and zirconium alloy components were manufactured; the tank is going to be redesigned. The upgrades are expected to be completed by 2015.

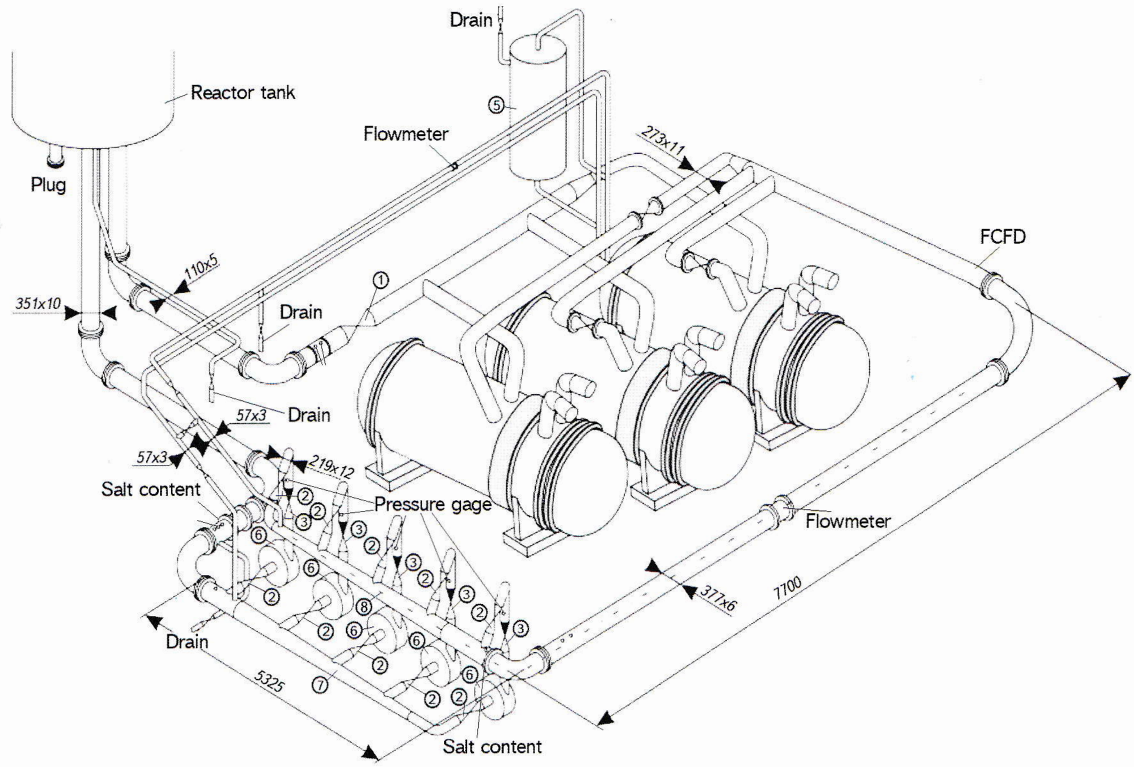
Experimental capabilities of VVR-c

The VVR-c reactor is designed for a broad range of experiments and applied research.

The reactor tank accommodates 28 vertical experimental channels passing through the tank bottom and thimbles. Six vertical channels are located in the core separator.



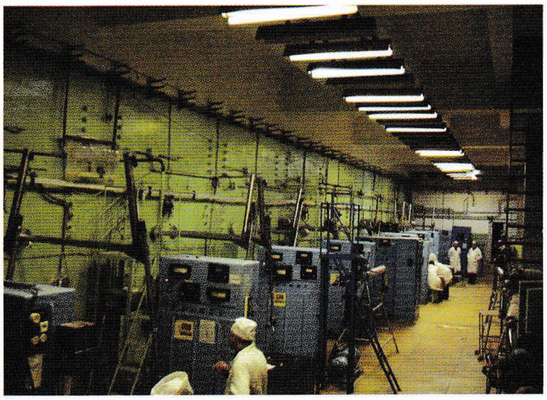
VVR-c cooling system topology



VVR-c cooling system after upgrades:
1 – gate valve, D300; 2 – gate valve, D200; 3 – check valve; 4 – heat exchanger T-2342; 5 – ion-exchange filter; 6 – centrifugal pump; 7 – suction header; 8 – pressure header

Main performance of the VVR-c reactor

Thermal power	15 MW
Neutron flux, max.:	
thermal	$1.02 \cdot 10^{14}$ $cm^{-2} \cdot s^{-1}$
fast (E>0.8 MeV)	$4.86 \cdot 10^{14}$ $cm^{-2} \cdot s^{-1}$
Heat flux:	
maximum	0.396 MW/m^2
average	0.165 MW/m^2
Core volume	206 l
Core height	0.6 m
Core diameter, effective	0.64 m
Number of fuel assemblies in the core	70
Moderator	Water
Coolant	Water
Coolant parameters:	
temperature:	
at the core inlet	≤ 50 °C
at the core outlet	≤ 60 °C
primary coolant flow rate	1400 t/hr
RCP head	0.35 MPa
primary coolant flow velocity	2.5 m/s
Number of CPS rods:	
automatic control	1
shim	5
emergency protection	3



Hot cells

Five horizontal experimental channels are brought to the separator, which also has a niche for a mobile experimental device attached to it.

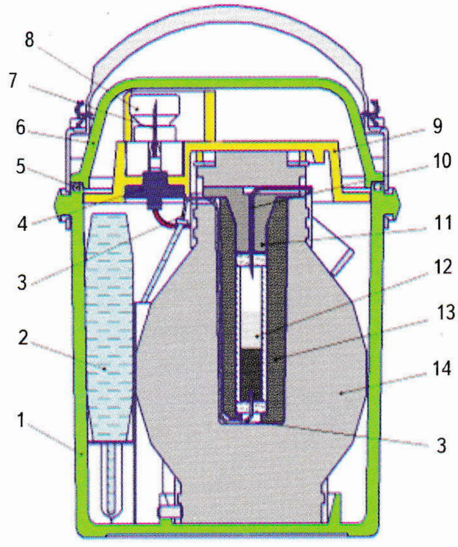
The experimental channels can house various devices: loops, irradiation capsules, rabbits, etc. The capsules are inserted and removed by handling devices through special channels in the shielded lid of the reactor.

Apart from the reactor, the complex includes 9 heavily shielded and 10 lightly shielded hot cells, as well as a distributed transport system provided with biological shielding, a radwaste treatment station, a radwaste storage facility, and a mechanical repair department.

Since 1980, the reactor has been producing medical radioisotopes and their associated

a

b



^{99m}Tc generator as prepared for transfer:
a – general appearance; b – sectional view: 1 – safeguard vessel; 2 – KOMPOPLAST-300 container; 3 – eluent line; 4 – hydrophilic filter Millex; 5 – rubber ring; 6 –cover; 7 – injection needle LYER; 8 – safety flask; 9 – panel; 10 – top needle; 11 – plug; 12 – column; 13 – shell; 14 – shielding container

radiopharmaceuticals on an increasing scale. The greatest advancement has been shown by diagnostic and therapeutic radiopharmaceuticals based on molybdenum-99, iodine-131, samarium-153 and other radionuclides. These preparations are supplied to more than 200 patient care institutions on a regular basis.

An innovative technetium-99m generator developed on the basis of the reactor is distinguished by its improved ergonomics and modern style. The generator charging area set up to support this process allows producing technetium-99m in compliance with the GMP requirements.

The VVR-c reactor saw pioneer work on neutron transmutation doping (NTD) of single crystal silicon, which laid the groundwork for domestic development of this technology. An NTD line with a Topaz-2 irradiation facility is in operation, producing doped silicon for manufacture of power semiconductors in a wide range of resistivity ratings.

International cooperation

The VVR-c reactor is a scene of long-term cooperation with companies of Czechia and Germany in neutron transmutation doping of silicon which meets the world standards of quality and is being produced in annually increasing quantities.

Main activities

In 2011, the reactor utilisation factor was estimated at 0.28.

The reactor has been put to many uses in research activities, in production of radiopharmaceuticals, semiconductor materials, etc.

NIFHI plans:

– to develop and produce diagnostic and therapeutic radiopharmaceuticals and medical products;

– to provide continuous neutron and neutron capture therapy services to cancer patients at the medical complex;

– to develop further and to produce neutron transmutation-doped and radiation-modified semiconductors;

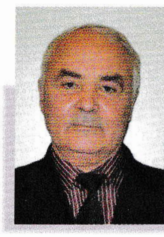
– to conduct neutron diffraction analyses of atomic and defected structure of various materials;

– to conduct neutron activation analyses of materials;

– to develop and produce filters for capture of radioactive aerosols (iodine, etc.);

– to test materials and products for radiation resistance.

Contact person



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