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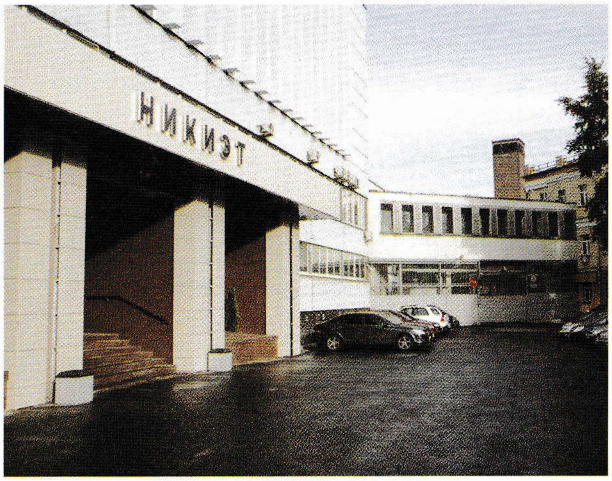
The history of the Research and Development Institute of Power Engineering begins in 1946 when, following a decree of the Council of People's Commissars, a special design bureau (referred to as the Hydraulic Equipment Sector) was set up under the direction of N.A. Dollezhal at the Research Institute of Chemical Engineering.

Academician
N.A. DOLLEZHAL,
first Director of NIKIET



Entrance to OJSC NIKIET

It is this bureau that designed the first domestic plutonium production reactors required for creation of nuclear weapons. In 1952, it was extended to form the Research and Development Institute of Power Engineering (NIKIET). In 2009, the institute was reorganised into an open joint-stock company (OJSC NIKIET).

NIKIET is one of Russia's largest nuclear engineering and technology centres, a multidisciplinary institute engaged in a number of major areas of nuclear power engineering.

The Institute has substantial manufacturing and experimental capabilities, including a pilot production shop, nuclear research reactor IR-50, subcritical facility FS-2, thermal physics rigs, facilities for testing reactor control and protection systems, and other assets.

The activities of NIKIET cover various fields, such as defence industry; demonstration of safe

YU.G. DRAGUNOV,
Corresponding Member of RAS
Director – General Designer

operation of RBMK reactors and justification of their life extension; development of integrated control and protection systems and their supply to NPPs; design of research reactors (RR) and manufacture of their components; field supervision of RR operation and extension of their service life.

Major areas of NIKIET activities

- Nuclear power systems for the Navy.
- Space nuclear power and propulsion systems.
- Nuclear power reactors for NPPs.
- Nuclear facilities for cogeneration and water desalination.
- Research and isotope reactors.
- Decommissioning of nuclear facilities.
- International Project ITER.
- State-of-the-art control systems for nuclear power facilities.
- Conversion programmes.

NIKIET is making preparations for large-scale studies to support development of a nuclear power technology which will rely on heavy metal-cooled fast neutron reactors operating in a closed fuel cycle.

NIKIET hosts the industry expertise centres for strength, reliability and service life of nuclear equipment, for non-destructive examination and diagnostics of metal components in use at NPPs.

The manufacturing capabilities of NIKIET are designed for fine tuning of the manufacturing processes and testing of the reactor components developed at the Institute.

NIKIET is the only institute in the nuclear sector that has a special division for development of nuclear research reactors and facilities working since 1957.

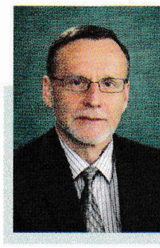
More than 20 research reactors were designed by NIKIET and built with its participation in Russia and beyond. These include reactor facilities such as SM, ARBUS, IVV-1, IVV-2M, MIR.M1, IRT-MIFI, IRT-T, IVG-1, IBR-2, IBR-2M, DRR (Vietnam), IRT-1 (Libya), etc. Some of them are unique in the world practice.

Construction of another unique high flux reactor PIK is nearing completion by NIKIET design.

The achievements of NIKIET staff in development of a wide spectrum of research reactors placed the Institute in the well-deserved leading position within this branch of nuclear engineering. NIKIET acts as chief designer of the multipurpose fast-neutron research reactor MBIR whose construction is provided for by the Federal Target Programme "Nuclear Power Technologies of a New Generation for the Period of 2010-2015 and to 2020".

OJSC NIKIET is the Operator of two nuclear research facilities.

P.I. FAKEEV
Chief Engineer



I.T. TRETIYAKOV
Chief Designer of research and isotope reactors

NIKIET's nuclear research facilities

Type	Name	Thermal power, kW	First criticality year	Status	Operation period, years*
RR	IR-50	50.00	1961	Safe storage	33
SCF	FS-2	0.20	1972	Safe storage	26

* *To shutdown*

RESEARCH REACTOR IR-50

IR-50 is a pool-type water-cooled and water-moderated research reactor of the IRT line, built in 1959–1960. It reached first criticality and power of 50 kW on February 20, 1961.

The reactor was designed by NIKIET for research in physics and technologies of reactor facilities, development of various materials and components of biological shielding against neutron, gamma and beta radiation, as well as for tests of various sensors and absorbers for CPS control members.

Safety of the reactor facility during its operation is provided by a 3-circuit system for heat removal from fuel assemblies. The primary cooling circuit appears as a reactor tank with an axial flow built-in pump and an intermediate

Main performance of IR-50

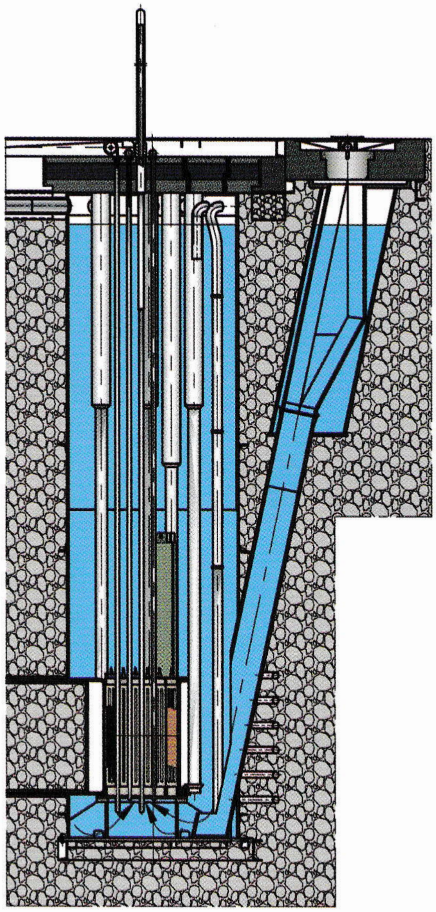
Thermal power .... 50 kW
Neutron flux, max.
thermal .... $1.7 \cdot 10^{12}$ $cm^{-2} \cdot s^{-1}$
fast .... $7.4 \cdot 10^{11}$ $cm^{-2} \cdot s^{-1}$
Moderator .... Water
Coolant .... Water
Forced cooling .... 3-circuit cooling system
Coolant flow rate .... 100 m^3/h
Coolant velocity in the core .... ~1 $m \cdot s^{-1}$
Reflector .... Water, graphite, and beryllium oxide blocks
Coolant temperature in the core, max.
inlet .... 33 °C
outlet .... 33.4 °C

heat exchanger. The secondary (closed) circuit serves for heat transfer from the primary circuit to the tertiary one. The tertiary (open) circuit is a pipeline of the community waterworks with gate valves, which delivers water to the secondary heat exchanger and then on to the sewer.

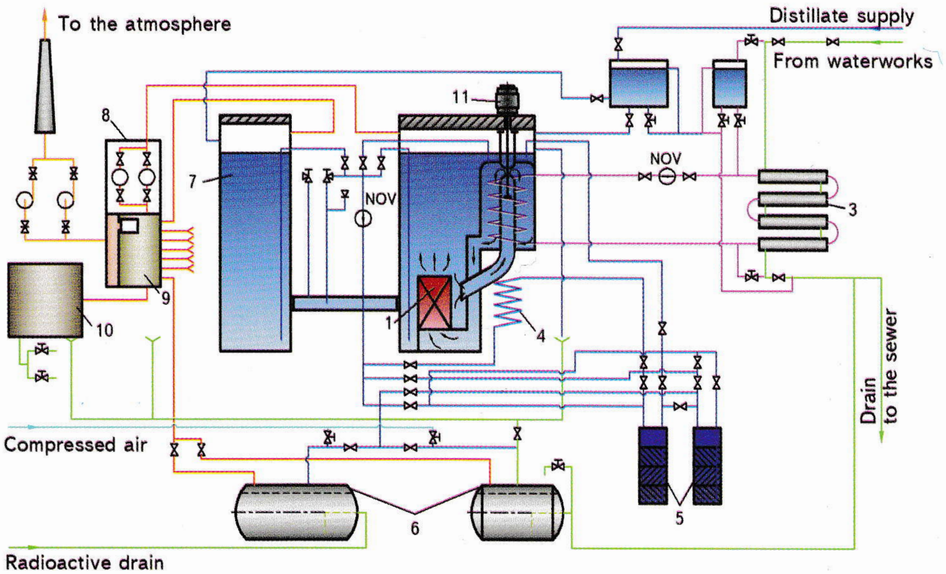
An auxiliary circuit is designed for cooling the biological shield of the reactor, cleaning the primary coolant and draining it from the reactor tank. The spent fuel assembly storage tank is also connected to this circuit.

The IR-50 fuel assembly comprises a bundle of fuel rods arranged in the holes of the upper and lower grids, a head and a tail-piece connected by a shroud of square cross-section with the flat-to-flat dimension of 68 mm.

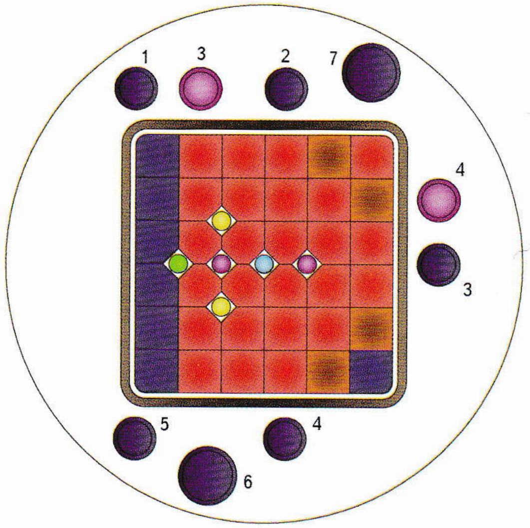
The EK-10 fuel elements appear as cylindrical rods in aluminium claddings with the outer diameter of 10 mm and thickness of 1.5 mm. The active part of an element is 500 mm long. The fuel meat is UO_2 of 10 % enrichment blended down with magnesium. Every fuel element contains 8 g of ^{235}U.



Vertical section of IR-50

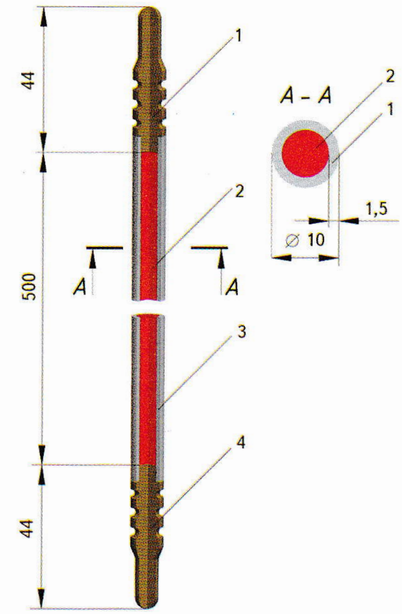


Basic diagram of the IR-50 core cooling system:
1 – reactor core; 2 – primary heat exchanger; 3 –secondary heat exchanger; 4 – heat exchanger of the biological shield; 5 – ion exchanger filters; 6 – montejus of special drainage system; 7 – SFA storage tank; 8 – filters; 9 – ventilation chamber; 10 – hot cell; 11 – axial flow pump

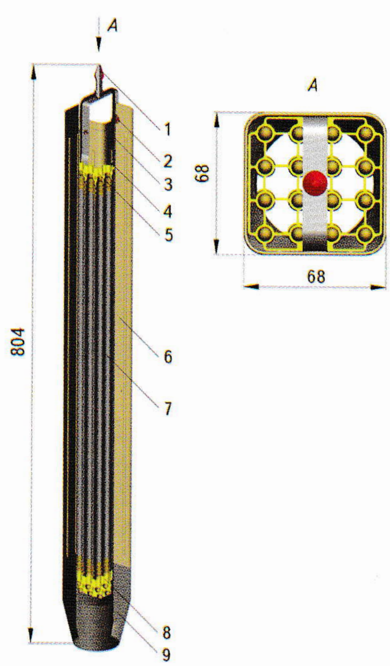


IR-50 core map:

- *Cell with water (H_2O)*
- *Fuel assembly (FA)*
- *Beryllium oxide (BeO) block*
- *Ionisation chamber (IC_{1-7})*
- *Automatic control rod (AR)*
- *Vertical experimental channel (VEC_{1-4})*
- *Manual control rod (MC)*
- *Emergency protection rod ($EP_{1,2}$)*



IR-50 fuel rod:
1 – end-piece; 2 – fuel; 3 – cladding; 4 – end-piece



IR-50 fuel assembly:
1 – assembly tip; 2 – screw M6; 3 – cramp; 4 – screw M4; 5 – grid; 6 – shroud; 7 – rod; 8 – grid; 9 – tail-piece

Experimental capabilities of IR-50

The key experimental features of the reactor include:

– a niche in the reactor shield with a rolling duct and a protective sliding door for study of the biological shield materials, compositions and mockups;

– vertical experimental channels running through the core (VEC-1, -2 of 23 mm in diameter) and reflector (VEC-3, -4 with diameters of 52 mm and 67 mm, respectively), in use for various studies in reactor physics and engineering;

– horizontal experimental channel No. 1 (HEC-1) 100 mm in diameter and an experimental water loop for testing, calibration and adjustment of various instruments (spectrometers, radiometers, etc.), an inclined experimental channel, horizontal experimental channel No. 3 (HEC-3) 50 mm in diameter;

– a hot cell with a manipulator and a system of mirrors, in use for fuel cladding leak checks;

– an experimental tank for studies with scattered reactor radiation.

The vertical experimental channels and the niche with the experimental cavity (duct) made it possible:

– to study the shielding properties of materials and their compositions, to test various mockups of real components in use at NPPs and proposed for future reactors;

– to test and calibrate in-core sensors, various instruments and CPS components;

– to study coolant radiolysis and radiation resistance of various materials;

– to study, calibrate and tune spectrometers, instruments for radiation monitoring at NPPs and other operating reactors.

Main areas of studies

Shielding physics:

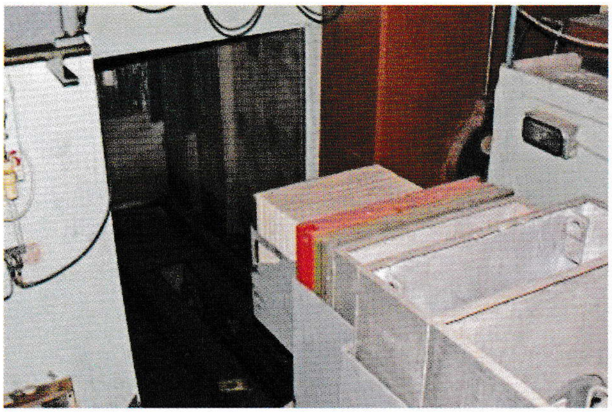
– in-niche studies on shielding properties of new materials based on titanium hydride, low-inflammability polyethylene, polyamide-based high-temperature plastics, and their compositions;

– studies to reduce the yield of capturing γ-radiation from metal-water compositions with the use of boron-containing liner materials;

– study of shield mockups with the use of a compensation space;

– study of radiation shield fragments for propulsion systems, research and power reactors;

– development and improvement of methodology for measurement of neutron and gamma-quantum fluxes and spectra.



Experimental niche with a rolling duct and a shielding sliding door

Fuel cycle support:

– study/tests of fuel samples;

– measurement of actinide fission and capture cross-sections for better understanding of transmutation rates involving thermal and resonance neutrons in a prospective burner reactor;

– investigation of ^{99}Tc and ^{129}I capture cross-sections in thermal and resonance neutron spectra;

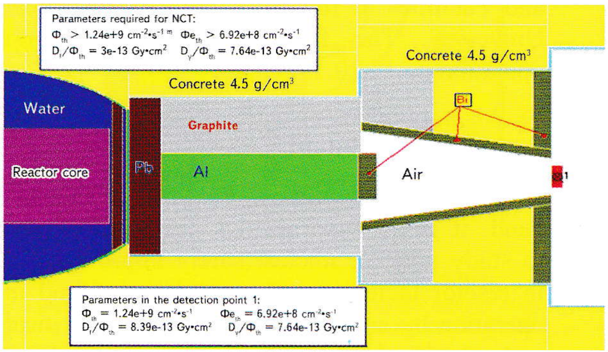
– study of transmutation compositions stability and their compatibility with structural materials;

– neutronic tests of structural components of irradiation devices in use for transmutation;

– study of mockup and pilot detectors, calibration of IC delivery specimens and suspensions for power and special-purpose reactors.

International cooperation

The IR-50 reactor is undergoing physical protection upgrades in the framework of cooperation with the UK company VT Nuclear Services.



Medical channel in IR-50 experimental niche for neutron capture treatment of malignant tumours

Recent activities

– An automated fire-fighting system was brought into pilot operation at the IR-50;

– a vessel-type thermomechanical rig KSI has passed acceptance tests in a hot cell;

– the physical protection system of IR-50 was brought into pilot operation.

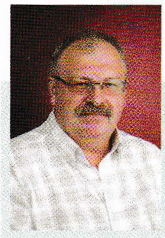
A feasibility study was carried out by NIKIET specialists for the project named “Traditional and Non-traditional Applications of Nuclear Technologies at the IR-50 Facility of NIKIET". The study identified Neutron Capture Therapy (NCT) as one of the promising work areas.

Actions planned:

– measures to extend the service life of IR-50 systems and components;

– provision of a medical channel for NCT studies in the experimental niche of the reactor.

Contact persons



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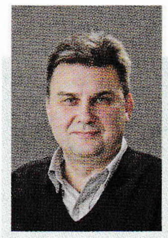

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SUBCRITICAL FACILITY FS-2

The FS-2 subcritical facility is an experimental and training rig designed and built by NIKIET on the basis of the Branch Nuclear Reactor Laboratory, Department of Nuclear Reactors and Facilities at the Bauman State Technical University. The facility was brought into operation on 17.10.1972.

FS-2 is a subcritical multiplier operating with an invariable fuel load in the core.

FS-2 is a double-purpose facility. On the one hand, it is an experimental device employed to study possible nuclear safety improvements in reactor facilities under development and in operation by enhancing their control in critical and subcritical states. On the other hand, FS-2 can be a useful aid in up-to-date training of personnel for nuclear power industry.

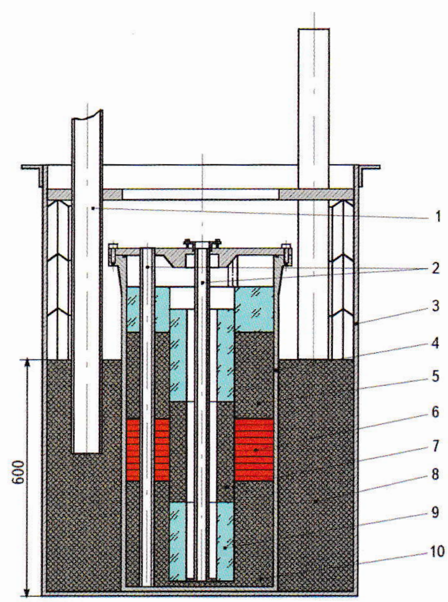
Today, FS-2 is in a state of prolonged shutdown because of the need to replace old components and upgrade the CPS.

The facility comprises:

– a subcritical multiplier;

– instrumentation, control and protection systems.

Its solid homogeneous core is surrounded by the graphite reflectors: the side one 200 mm in thickness; the bottom one 265 mm high; and the top one 230 mm high. Biological shielding is provided by a 700 mm deep water layer.



Vertical section of FS-2:
1 – vertical channels in the reflector; 2 – vertical channels in the reactor core; 3 – intermediate steel tank; 4 – aluminium tank of the reactor core; 5, 8, 10 – graphite reflector; 6 – reactor core; 7 – graphite sleeve; 9 – polyethylene

The intermediate tank with all the core and reflector components inside is placed in the biological shielding tank. The latter is made of stainless steel sheets. The core with the bottom and top reflectors is found in a cylindrical vessel made of aluminium alloy sheets.

The facility is equipped with a control and protection system which monitors the chain reaction intensity and the process parameters, controls the chain reaction intensity and its quick suppression (intensity decrease) in the core. Process control is carried out remotely from the operator's panel. For its operation, the system relies on two emergency protection rods: EP-1 and EP-2. Power is regulated by moving the suspension with an external neutron source.

The core is built of uranium-polyethylene segments consisting of uranium dioxide dispersed in the polyethylene matrix. The fuel load contains 1069.6 g of ^{235}U.

Main dimensions of the reactor core components:

- outer diameter of 370 mm;
- inner diameter of 170 mm;
- segment corner angle of 120°;
- segment thickness of 20, 10 and 5 mm;
- core height of 210 mm.

Experimental capabilities of FS-2

The core houses four vertical channels, each 26 mm in diameter: central channel (CEC) and 3 channels (I-1, I-2 and I-3) at an angle of 120° to the axis, placed at 270 mm from the centre. The central channel is an experimental device. Channels I-1 and I-2 accommodate the emergency protection rods, while channel I-3 houses the suspension with an external neutron source.

The side graphite reflector has one vertical experimental channel (VEC-1) 60 mm in diameter and four channels of the same diameter for the ionisation chambers of the CPS.

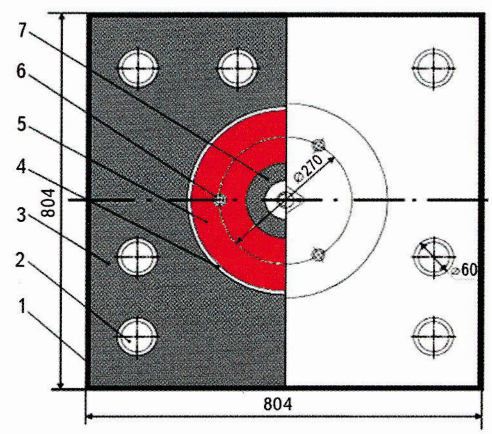
Given the neutron source capacity of 108 s^{-1}, the channels provide for the following neuron flux values at the core centre level:

	CEC	VEC-1
Thermal neutron flux, $cm^{-2} \cdot s^{-1}$	$2.55 \cdot 10^6$	$0.65 \cdot 10^6$
Fast neutron flux, $cm^{-2} \cdot s^{-1}$	10^5	10^3

The FS-2 facility allows testing neutron sensors together with the monitoring and emergency protection instrumentation in the startup and subcritical operation modes of various reactors. The tests can be staged in static or dynamic conditions, with neutron flux variations simulating quick introduction of positive reactivity as high as 0.9 β (by moving the neutron source in the core or reflector following a special algorithm). Such tests on a subcritical multiplier are safe and representational enough, as neutron fluxes in FS-2 are 100 times as high as those from a source of the same capacity in a diffusion medium.

Main performance of FS-2

Thermal power	0.2 kW
Thermal neutron flux in the central hole with the neutron source, max.	$2.5 \cdot 10^6$ $sm^{-2} \cdot s^{-1}$
Effective multiplication factor	0.990
Maximum effective multiplication factor	0.995
Moderator	Polyethylene
Reflector	Graphite
^{235}U load in the core	1069.6 g
Enrichment in ^{235}U	36.7 %
Design capacity of the isotope neutron source	$2.5 \cdot 10^8$ s^{-1}
Effective delayed neutron fraction	0.8 %
Emergency protection efficiency	2.0 %
Temperature coefficient of reactivity	$2 \cdot 10^{-2}$ %/°C



Horizontal section of FS-2:
1 – steel intermediate tank; 2 – vertical channels in the reflector; 3 – graphite reflector; 4 – aluminium tank of the reactor core; 5 – reactor core; 6 – vertical channels in the reactor core; 7 – graphite sleeve

Experimental objectives:

– to try out activation measurement procedures;

– to test sensors of new design for the CPS and systems for monitoring in subcritical and startup ranges to be used in various reactor facilities;

– to try our physical reactivity measurement techniques.

Recent activities

Examination of the FS-2 building, with its findings presented in a technical statement.

Manufacture of modules for hardware cabinets of the upgraded CPS and the control panel.

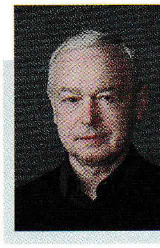
Development of an upgraded control and protection system.

Generation of an experts' report on refurbishment of the FS-2 facility at the Branch Nuclear Reactor Laboratory of the Bauman University.

Upgrades of the control and protection system.

Preparations for repairs in the facility building.

Contact person



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