National Research Centre
"Kurchatov Institute"

EXPERIENCE AND PROSPECTS

Ignalina Nuclear Power Plant, Lithuania 25 October 2018

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History

- In 1946 the first uranium-graphite reactor in Europe, named F-1, was started up at the Kurchatov Institute.

- The Decree of the USSR Council of Ministers No. 800-252 of 29.09.1966 on the design development and construction of the 1st phase of the Leningrad and Kursk power plants defined main organisations that should develop the plant and reactor design, and Kurchatov Institute of Atomic Energy was appointed as Scientific Supervisor for the Design.

- In 1968 a uranium-graphite test facility for development of production reactors was started up at the Kurchatov Institute. The facility was decommissioned in 2017.

- On 15.11.2012, Order No. 1/1049-P was issued to confirm the role of the Kurchatov Institute as Scientific Supervisor for RBMK-1000 reactors.

F-1 – the first uranium-graphite reactor in Europe

RBMK uranium-graphite critical facility
is the only facility of the kind in the nuclear industry for experimental research in physic of uranium-graphite reactor cores

National Research Centre “Kurchatov Institute”
Main areas of activity and unique competences

- Basic and applied research based on unique mega facilities (mega complexes) in priority areas of science, engineering and technology development in the Russian Federation.
- Scientific supervision of construction, operation and decommissioning of nuclear facilities.
- Kurchatov Institute fulfills scientific supervision functions and holds Rostechnadzor’s licenses for commissioning, operation and decommissioning of nuclear power plants with VVER and RBMK-1000 reactors.
- Kurchatov Institute took an active part in decommissioning of uranium-graphite production reactors.
- During activities aimed at mitigation of the consequences of the Chernobyl accident, along with the direct participation in this work, Kurchatov Institute performed calculations of activity of the power unit components for foreign customers.
- Kurchatov Institute developed a unique software system for calculation of neutronics characteristics, temperatures, strength and seismic resistance of reactor system components.
- Kurchatov Institute is carrying out decommissioning and remediation of nuclear- and radiation-hazardous facilities, including the MR research reactor located at the KI site.
- Kurchatov Institute is developing spent nuclear fuel and radioactive waste management technologies.
- Kurchatov Institute is designing and engineering nuclear materials and radioactive substances storage facilities and radwaste storage facilities.

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Experience in working with European partners

- Energiewerke Nord (EWN), STEAG, KAH, Flottwerg, Schnider Electric, AKB, Petra, IMG, ABREX, Fuchtenkotter, AREVA (Germany), 2003-2016
- Saida Regional Centre for Radioactive Waste Conditioning and Long-term Storage

- Commissariat a'l Energie Atomique (CEA) – France
- AREVA Group, Sogin S.p.A, European Bank for Reconstruction and Development (EBRD)
- environmental remediation of the SNF and RW temporary storage facility in Gremikha

- Nuvia Limited – UK
- improvement of radiological conditions at DSU 3A in Andreeva Bay

- Lawrence Livermore National Security, LLC (LLNS) – USA,
- National Nuclear Security Administration (Department of Energy) – USA,
- Commissariat a'l Energie Atomique (CEA) – France
- decommissioning of radioisotope thermoelectric generators (RTGs) and replacing with alternative power sources

- U.S. Department of Energy and National Laboratories,
- Nuclear Services Ltd (VTNS),
- Babcock Nuclear Limited, Battelle Memorial Institute (USA)
- enhancement and maintenance of nuclear material control, accounting and physical protection systems at Kurchatov Institute and RosRAO sites.

Kurchatov Institute is willing to take part in the optioneering, Conceptual Design and EIAR development to achieve the objectives and fulfill the tasks identified for Project R3 “Optioneering, Conceptual Design and EIAR development of D&D of Unit 1 and Unit 2 reactor Zone R3 equipment and RWS storage”, acting in consortium with the following Russian and Lithuanian organisations:

- JSC NIKIET (Joint Stock Company “N.A. Dollezhal Research and Development Institute of Power Engineering”) – one of the Russia’s largest research centres in the field of nuclear engineering and technology. It develops power and research reactor systems, and carries out extensive R&D in the field of utilisation of nuclear energy.

- JSC “Atomproject” – a Russian company that carries out integrated designing of nuclear power facilities, research and development of new power technologies for the nuclear industry.

- SE Ignalina Nuclear Power Plant – direct involvement is advisable, including for the purposes of submission of design solutions and EIAR to government agencies, supervisory authorities and non-governmental organisations.

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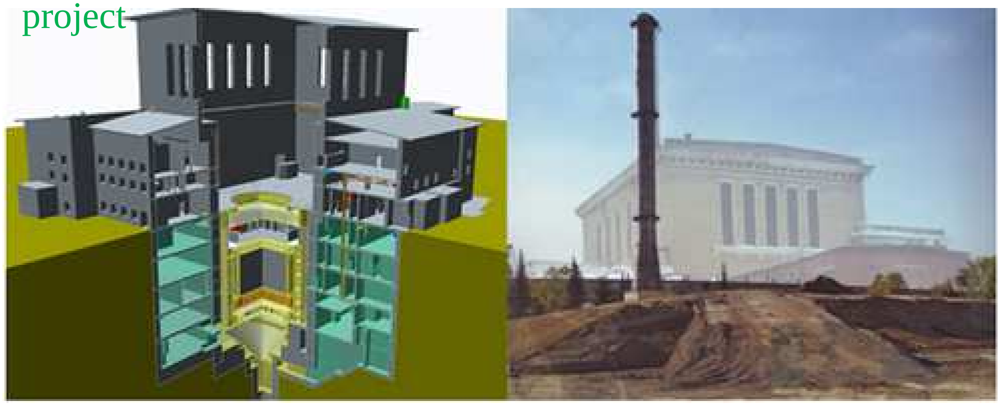
EI-2 uranium-graphite production reactor decommissioning project



Pilot installation for decontamination of graphite

Pilot plant for oxidation of reactor graphite in molten salts for removal of contamination due to spent fuel debris

In the field of spent nuclear fuel (SNF) and radwaste management, decommissioning of nuclear facilities (nuclear power plants, uranium-graphite production reactors, SNF and radwaste storage facilities) and remediation of contaminated sites **NIKIET** performs the following activities:

- R&D, design and engineering, and technical and economic support, including development of individual designs;
- development of scientific and technical, engineering, process, design and organisational documentation to ensure nuclear and radiation safety;
- development of prototypes of equipment and introduction of advanced technologies;
- project management, R&D organisation and performance;
- R&D and engineering support, assistance in partners’ activities for computational and experimental justification of equipment designs;
- technical support and designer’s supervision at the stages of fabrication and testing of SNF and radwaste management equipment and facilities, their installation, setting to work, operation, and preparation for decommissioning;
- exploratory studies aimed at improvement of efficiency, reliability and safety of processes;
- fulfillment of General Designer functions during development of design and estimate documentation for new construction, reconstruction, retrofitting, upgrading and decommissioning of nuclear facilities;
- technical support and designer’s supervision of the construction process during implementation of projects in order to maintain or improve design process parameters, schedule and implementation costs;
- reviews of design, engineering and process documentation to ensure compliance with rules and regulations in force in the field of nuclear power.

JSC "ATOMPROJECT" is an engineering company that pooled resources and competences of two major design institutes in St.-Petersburg:

- OJSC "Lead Institute VNIPIET", and
- OJSC "SPAEP".

The company designs nuclear power plants with all reactor types, and provides design support for nuclear facilities at all stages of their life cycle.

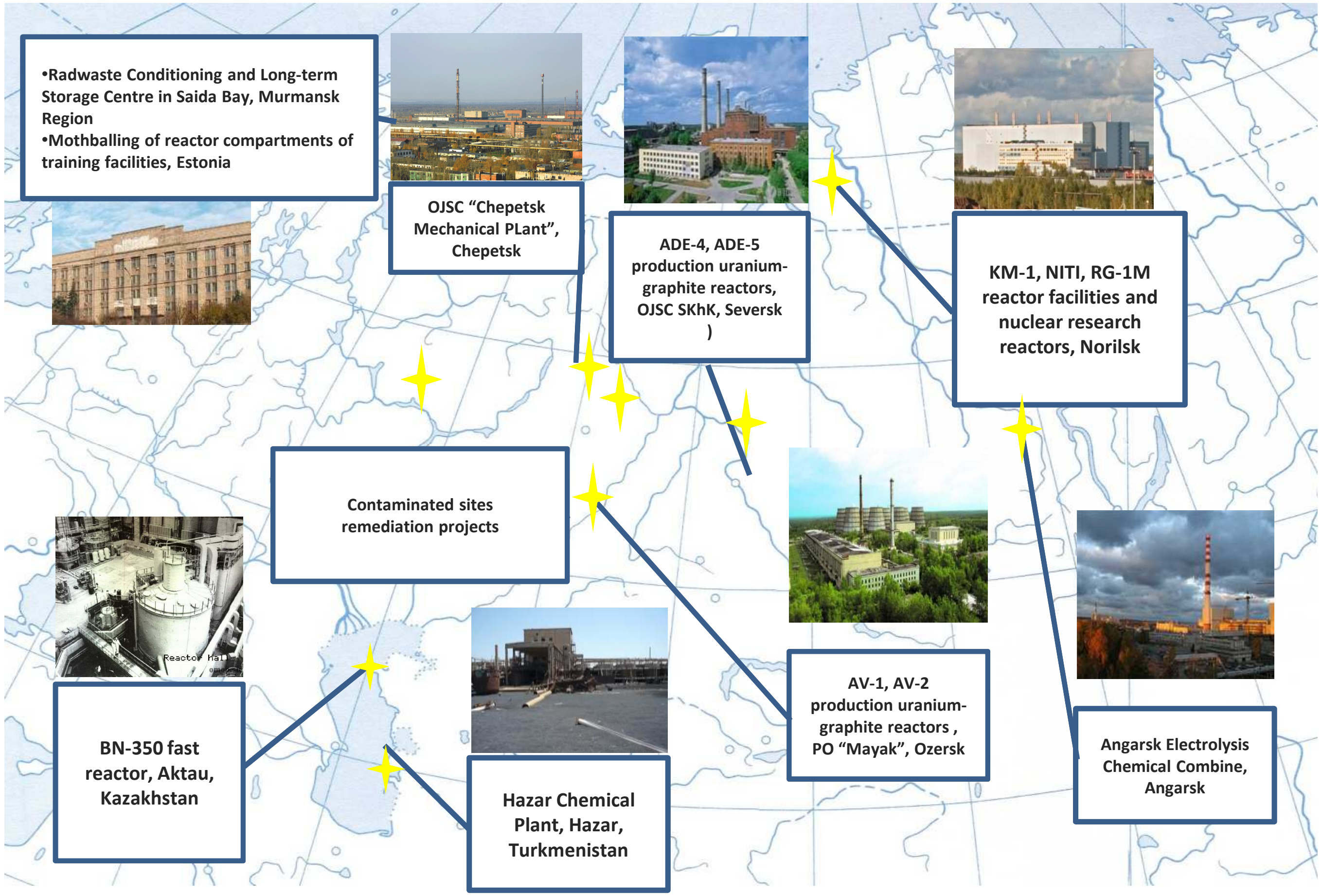
Since December 2015, JSC "ATOMPROJECT" has been a member of the JSC ASE Engineering Company Group.

Current decommissioning activities of **JSC "ATOMPROJECT"**:

Preliminary decommissioning plans were developed in recent years in accordance with national requirements and IAEA requirements for the following plants:

- Hanhikivi-1 NPP (Unit 1, VVER-1200)
- Paks-2 NPP (Units 5-6, VVER-1200)
- El-Dabaa NPP, Egypt (Units 1-4, VVER-1200)

Geography of ATOMPROJECT’s decommissioning and radwaste management activities



АТОМПРОЕКТ

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CCLS RW construction manager, general designer and contractor

The Saida Regional Center for Radioactive Waste Conditioning and Long-term Storage (CCLS RW) is a topical prototype of enterprises for management of radioactive waste from nuclear power plants. The CCLS RW is located in Murmansk Region and is designed to receive, process and store radwaste arising from the operations of the nuclear-powered fleet. In basic properties, such as material, radionuclide composition and activity, this waste is similar to radwaste generated during operation of VVER and RBMK power reactors.

Radwaste processing and conditioning operations carried out at the CCLS RW:

- decontamination of surface contaminated metallic waste,
- compacting of solid waste,
- vacuum drying of solid waste,
- sorting of intermediate-level solid waste,
- tight stowage of sorted solid waste,
- waste grouting,
- solidification (grouting) of secondary liquid waste,
- radiation control for clearance of solid waste from regulatory control / waste recycling.

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CCLS RW construction manager, general designer and contractor

Assurance of CCLS RW operational safety and reliability

Biological protection system:

- Homogeneous base
- Slipway slab
- Fencing around storage areas
- Laboratory building
- Water collection, control and treatment system
- Biological treatment system
- Absorption fields
- Liquid waste processing area

Physical protection system:

- Passive perimeter fence
- Active perimeter fence based on 2 physical principles
- Security and guard structures (checkpoints, watchtowers etc.)
- Access monitoring and control system
- Alarm call signaling system
- Security alarm system
- Security and standby lighting system
- Instant communication and alert system
- CCTV system

Radiation safety system:

- Automated radiation monitoring system
- Individual dose monitoring system
- Periodic and casual radiation control system
- Radioactive substance and radwaste accounting and control system
- RUMMSIS
- Radiochemical laboratory
- Local civil defense and emergency warning system
- Groundwater monitoring wells
- Final radiation measurements area

General engineering systems:

- Water supply
- Sewerage
- Heat supply
- Fire alarm
- Communications
- Radio broadcast system
- Instrumentation and controls
- Industrial lighting
- Automatic fire extinguishing system
- Ventilation
- Air supply
- Structured system for monitoring and control of building engineering systems
- CCTV system for monitoring of processes
- Automated remote control system

Power supply system:

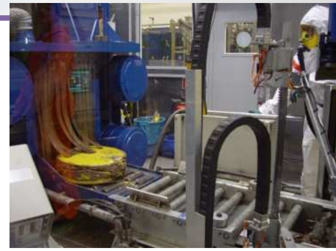
- Substation PS-308
- Distribution systems
- Transformer substation – 2 plants
- Standby electric station
- Power unit

Heavy load transfer system:

- Hydraulic facility
- Turnout and cross-over tracks
- Floating dock PD-42
- Ship-carrying equipment (power machine, keel blocks)
- Lifting and handling equipment (cranes, lifting beams, hoisters)
- Demag mobile crane

Radwaste management system:

- Sorting of radwaste containing intermediate-level waste
- Repacking of flammable low-level waste
- Cutting of low-level metallic waste
- Compacting of metallic and nonmetallic low-level waste, and drying of compacted waste
- Liquid decontamination of low-level metallic waste
- Liquid waste processing



Improvement of radiological conditions at the Gremikha radwaste temporary storage site

Kurchatov Institute, along with the development of the Environmental Impact Assessment Report (EIAR), has practical experience in carrying out the work to improve radiological conditions. Activities aimed at improvement of radiological conditions at the Gremikha radwaste temporary storage site in Murmansk Region were completed in September 2018.

- Radwaste was retrieved, sorted and loaded in containers for transportation from the site to the CCLS RW in Saida Bay for long-term storage.
- The “sarcophagus” was removed.
- The radiation safety of the personnel was ensured by the following high-level waste handling technologies developed by the Kurchatov Institute and used during the operations at the site:

- remotely controlled equipment and machines,
- video system,
- diagnostic and measuring tools,
- special ventilation and dust suppression systems,
- additional personal protective equipment.

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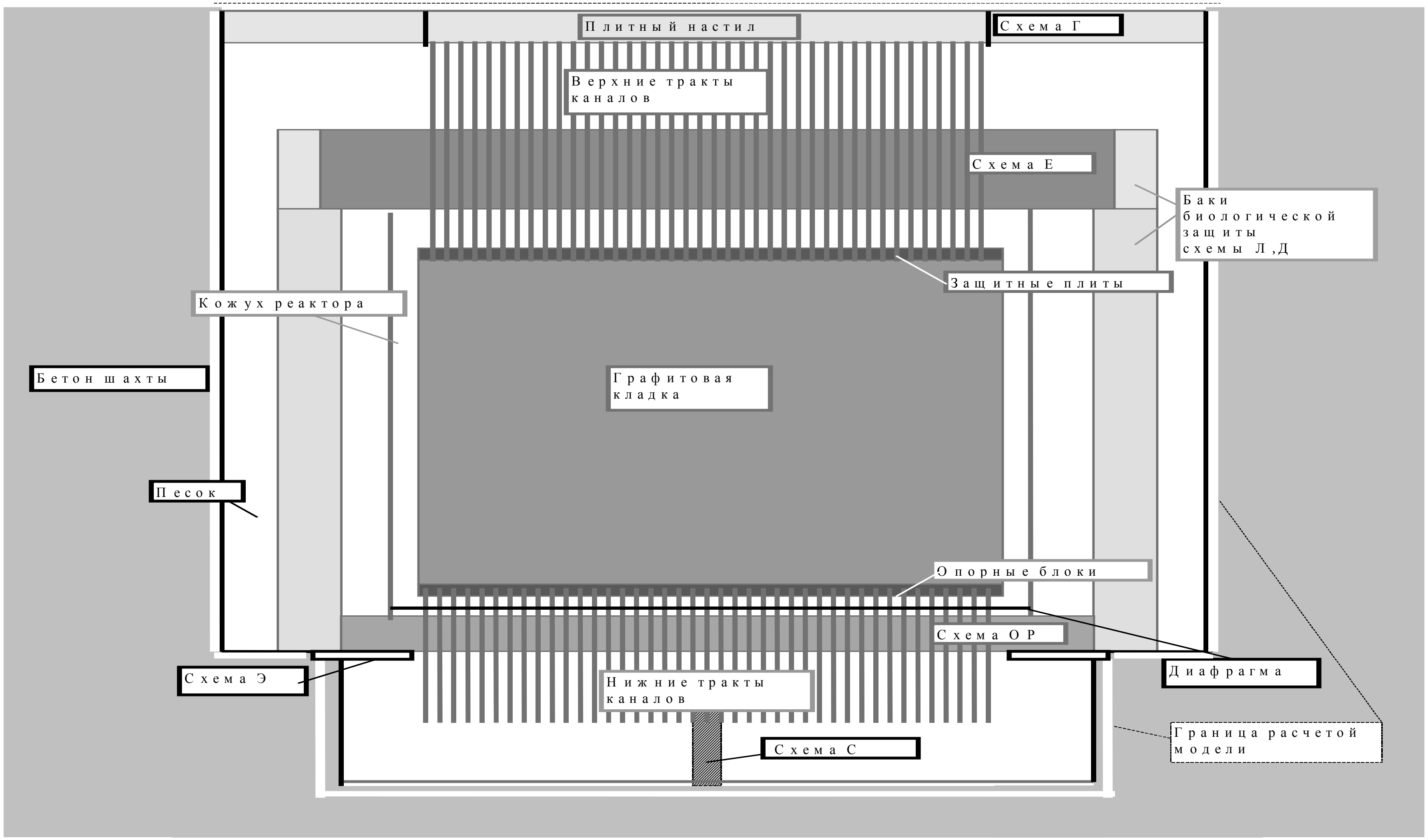
Calculation of activation of RBMK structural components: computational model, general view



List of main structures of the RBMK-1000 reactor and their masses

Reactor structural components	Mass, t
1. Reactor graphite stack:	1905.0
1.1. Graphite stack columns in the reactor core	1327.0
• within the central part	921.5
• within the first peripheral area	297.2
• within the second peripheral area	108.3
1.2. Graphite stack columns in the reflector:	484.0
• in the first row	246.3
• in the second row	128.0
• columns with cooling channels	109.7
1.3. Graphite sleeves	94.0
• within the central part	65.3
• within the first peripheral area	21.0
• within the second peripheral area	7.7
2. Channel tubes in the reactor stack:	106.5
2.1. Process channels	98.0
2.2. CPS and fission chamber channels	8.5
3. Reflector cooling channels (together with the Field tubes)	38.6
4. Protection plates	254.1
5. Support slabs	250.0
6. Reactor casing (scheme KZh)	76.0

List of main structures of the RBMK-1000 reactor and their masses (continued)

7. Inner wall of the water-filled tank (scheme L)	135.6
8. Metal structures of scheme E:	1451.6
8.1. Upper plate	71.2
8.2. Lower plate	71.2
8.3. Stiffening ribs:	270.5
• above the reactor stack	192.1
• above the space between the stack and radial shield	78.4
8.4. Serpentinite filling (γ = 1.7 t/m^3):	1007.0
• above the reactor stack	401.0
• above the space between the stack and radial shield	606.0
8.5. Shell	38.0
9. Metal structures of scheme OR	692.2
9.1. Upper plate	51.8
9.2. Lower plate	51.8
9.3. Stiffening ribs:	148.5
• under the reactor stack	114.3
• under the space between the stack and radial shield	34.2
9.4. Serpentinite filling (γ = 1.7 t/m^3):	440.1
• under the reactor stack	170.0
• under the space between the stack and radial shield	270.1

Average specific activity of the graphite stack in the central part after the final shutdown of the power unit, and activity variation with time, Bq/g

Average neutron flux in the layer:
total fluence - 4.464E+22;
thermal neutron fluence - 2.280E+22.

Радио-нуклид	Длительность выдержки, лет						
	0	5	10	20	50	100	150
H-3	4.3176+7	3.2603+7	2.4619+7	1.4038+7	2.6023+6	1.5684+5	9.4533+3
C-14	4.9974+4	4.9944+4	4.9913+4	4.9853+4	4.9673+4	4.9373+4	4.9075+4
Ca-41	1.6949+2	1.6948+2	1.6948+2	1.6947+2	1.6943+2	1.6937+2	1.6932+2
Fe-55	1.1919+5	3.3518+4	9.4258+3	7.4541+2	-	-	-
Co-60	6.7462+4	3.4972+4	1.8130+4	4.8721+3	9.4558+1	-	-
Ni-59	1.9428+1	1.9427+1	1.9426+1	1.9425+1	1.9419+1	1.9410+1	1.9401+1
Ni-63	3.4563+3	3.3388+3	3.2252+3	3.0096+3	2.4454+3	1.7302+3	1.2241+3
Сумма	4.3415+7	3.2725+7	2.4699+7	1.4096+7	2.6547+6	2.0813+5	5.9771+4

Relative contributions of main structural components of the Chernobyl NPP Unit 1 reactor into the total activity after its final shutdown, and their variation with time, %

Элементы конструкций	Длительность выдержки, лет						
	0	5	10	20	50	100	150
1. Графитовая кладка	9.93	40.68	53.14	71.90	85.00	38.22	15.21
2. Канальные трубы	84.06	49.57	42.12	26.77	13.37	54.95	77.25
3. Защитные плиты	1.43	2.18	1.11	0.27	0.19	0.47	0.79
4. Опорные блоки	2.41	3.68	1.89	0.47	0.33	0.80	1.33
5. Кожух реактора	1.47	2.76	1.18	0.39	0.73	1.88	3.15
6. Внутренняя стенка схемы Л	0.64	0.98	0.50	0.14	0.23	0.58	1.29
7.Металлоконст-рукции схемы Е	0.02	0.06	0.02	0.02	0.04	0.07	0.12
8. Металлоконст-рукции схемы ОР	0.04	0.09	0.04	0.04	0.08	0.16	0.25
Сумма 1+2, %	93.99	90.25	95.26	98.67	98.40	96.04	93.07
Сумма 1÷8, Бк	8.53+17	1.57+17	9.07+16	3.81+16	6.00+15	1.01+15	6.55+14

Total activity of the structural components is 20 MCi
Fuel activity at the time of shutdown was 2*104 MCi

Major contributors to the total activity:

- channel tubes - 84%
- graphite stack - 10%

Major dose-forming nuclides:

- for the metal structures and graphite stack - *Co-60*
- for the process channels - *Co-60, Nb-94*
- for the sepentinite filling - *Co-60, Eu-152, Eu-154*