ГОСУДАРСТВЕННАЯ КОРПОРАЦИЯ ПО АТОМНОЙ ЭНЕРГИИ «РОСАТОМ»

Joint Stock Company
“Pilot & Demonstration Center for Decommissioning of Uranium-Graphite Nuclear Reactors”

Technical approaches and main challenges of U-graphite reactors decommissioning

JSC «PDC UGR» Director General

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PILOT & DEMONSTRATION CENTER FOR DECOMMISSIONING OF URANIUM-GRAPHITE NUCLEAR REACTORS

JSC "PDC UGR" Corporate Objectives:

Provision of commercial decommissioning services for the single-type nuclear facilities based on the standardized technologies suitable for distribution at the nuclear industry enterprises and exporting.

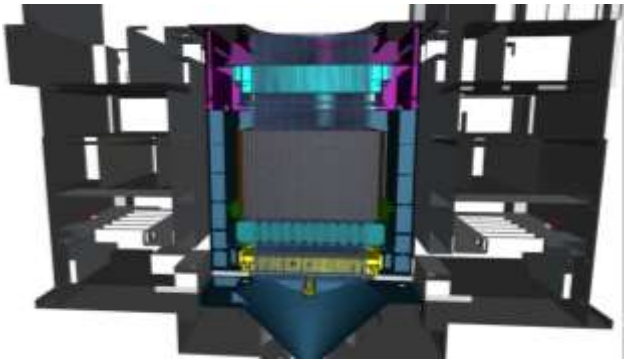
Base for the decommissioning technology development - 2 industrial sites of the Reactor Plant (5 shutdown uranium-graphite reactors).

North site (area 11) – 2 industrial reactor plants

South site (area 2) - 3 industrial reactor plants

MAIN CHALLENGES

Regulatory and legal framework



Concept of decommissioning by "on-site entombment" approach

Safety justification

Technology development

Project implementation by «on-site entombment» approach

EI-2 DECOMMISSIONING STAGES

Final shut-down, nuclear safety ensuring	Decommissioning concept development	CERS, R&D	Project development, license obtaining	Project implementation
1990-1993	2011	2011-2012	2011-2012	2012-2015

External appearance of EI-2 reactor in 2012 before D&D

Mothballing facility, 2015.

REGULATORY AND LEGAL FRAMEWORK OF EI-2 DECOMMISSIONING

2008	“Decommissioning concept of nuclear facilities, radiation sources and disposal sites” enacted from 30.01.2008 by General director of “Rosatom”.
2009	“Conception of decommissioning of uranium-graphite nuclear reactors using radiation safe on-site entombment approach” enacted from 28.12.2009 by order of General Director of “Rosatom” in 2010.
2011	Federal Law N 190-FZ from 2011 «About radioactive waste treatment …»
	“Local concept of decommissioning of uranium-graphite nuclear reactors of JSC “Siberian Group of Chemical Enterprises” (SGCE) using radiation safe on-site entombment approach finalized by the Director of Nuclear and Radiation safety Department of “Rosatom” in 2011.
	“Minutes of meeting as of 08.09.2011 about in-situ entombment of EI-2” enacted from 03.10.2011 by the Department of Nuclear and Radiation safety.
2012	Comprehensive engineering and radiation survey, decommissioning project, R&D on materials and safety validation report completed.
	Licensing for decommissioning activities.
	Practical work started.
2015	Completion of all practical works, mothballing facility for special radioactive wastes creation.

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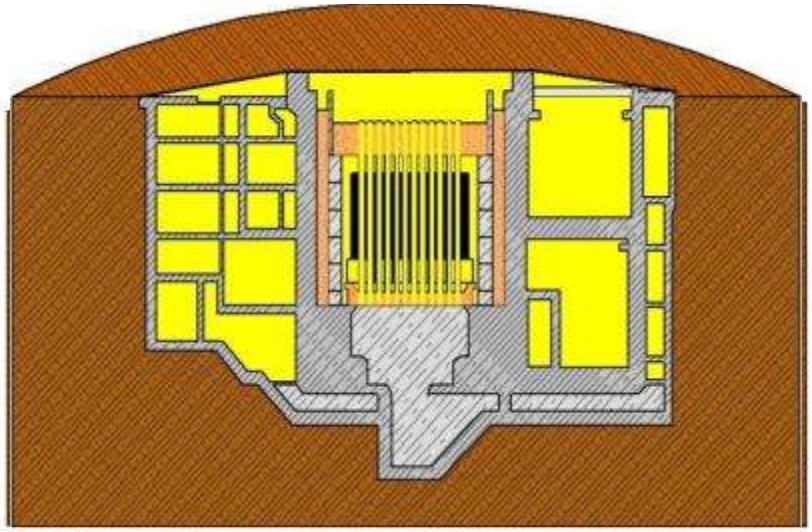
JUSTIFICATION OF EI-2 DECOMMISSION VARIANT

1. Radioactivity and radionuclide composition data of RW accumulated in shutdown commercial-scale uranium graphite reactors.
2. Calculations results of labor costs and safety radiation dose for UGR decommissioning activities for in-situ entombment and dismantlement options.
3. Location conditions. All commercial-scale uranium graphite reactors in Russia are located in zones where near surface disposal, underground disposal facilities and radioactive waste disposal sites formed during the defense program realization already exist.
4. Analysis results of the global experience and present scientific knowledge applicable to reactor graphite treatment.
5. Graphite stacks of uranium-graphite reactors located below ground level.

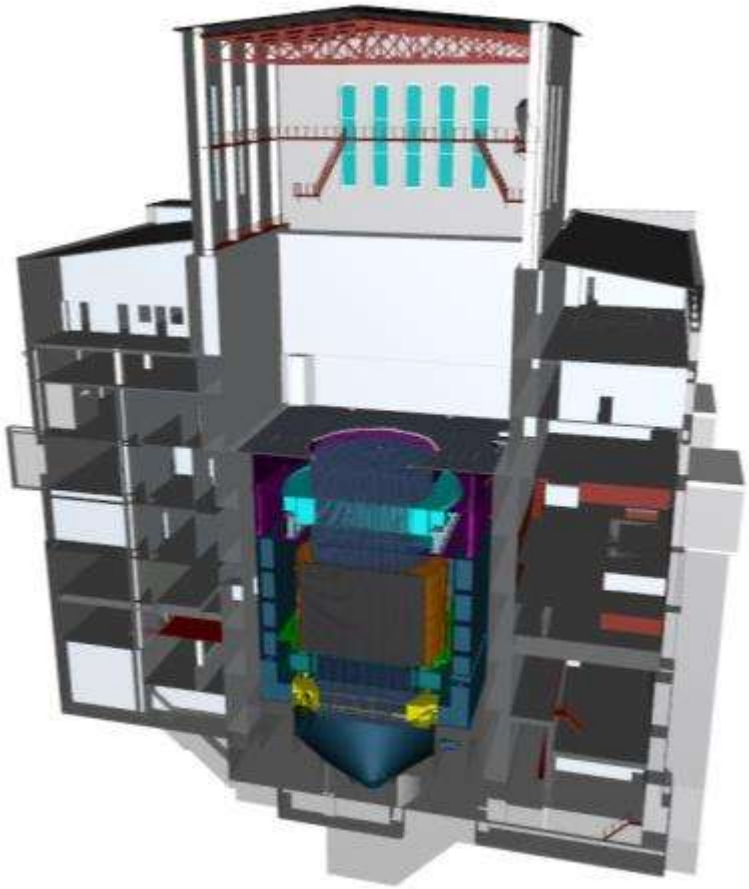
Analysis of this information proved that in-situ entombment is a well-founded option as regards to minimization of negative ecological impact on the personnel and environment as well as the economic costs for decommissioning.

CONCEPT OF EI-2 URANIUM-GRAPHITE REACTOR DECOMMISSIONING



1. Complete dismantling of support systems and equipment of the EI-2 except for reactor installation itself.
2. Concrete placement in the bottom elevation rooms and sub-reactor areas up to the bottom biological shielding.
3. Void-free filling of in-core areas using the barrier mixtures based on natural clay.
4. Decontamination of engineering structures.
5. Dismantling of superstructures of EI-2 building.
6. Setting-up a barrier for weather impact on the entombment facility.

INITIAL STATUS OF COMMERCIAL-SCALE URANIUM-GRAPHITE EI-2 REACOR



Total weight of metal structures within reactor vault is 3000 t.

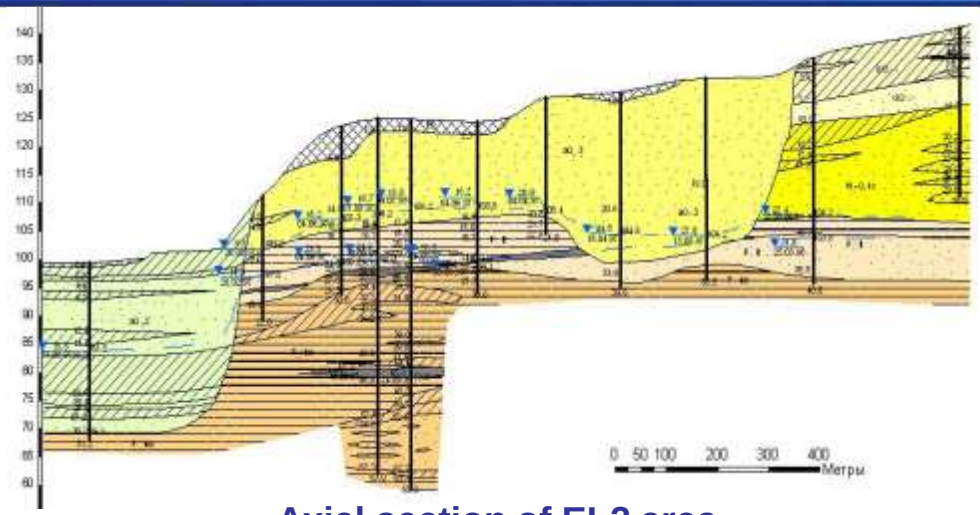
Total weight of graphite stack ~ 1400 t.

Graphite stack volume ~ 800 m^3.

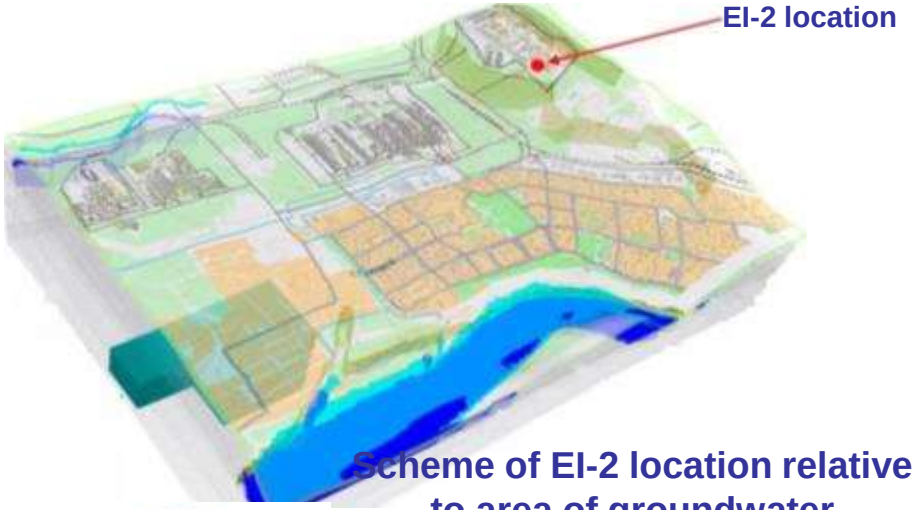
Graphite activation products – ^{3}H, ^{14}C, ^{36}Cl, ^{60}Co.

14C activity (~105-106 Bq.g) constitutes 95% of all irradiated graphite activity.

PREDEVELOPMENT ANALYSIS



Axial section of EI-2 area



Scheme of EI-2 location relative to area of groundwater discharge

1. Geological research in EI-2 zone.
2. Sorption capacity of geological environment.
3. Sorption parameters for the most significant long-lived radionuclide in massive material of aquafer.

Radionuclide	Allocation coefficient in massive material, m^3/kg
^{3}H	No sorption
^{14}C	No sorption
^{36}Cl	No sorption
^{90}Sr	0,30-0,48
Cs isotopes	6,5-9,3
U isotopes	0,14-0,21
^{237}Np	0,62-1,5
Pu isotopes	4,8-6,9
Am isotopes	5,5-7,8
^{244}Cm	5,5-7,8
^{60}Co	1,6-3,0

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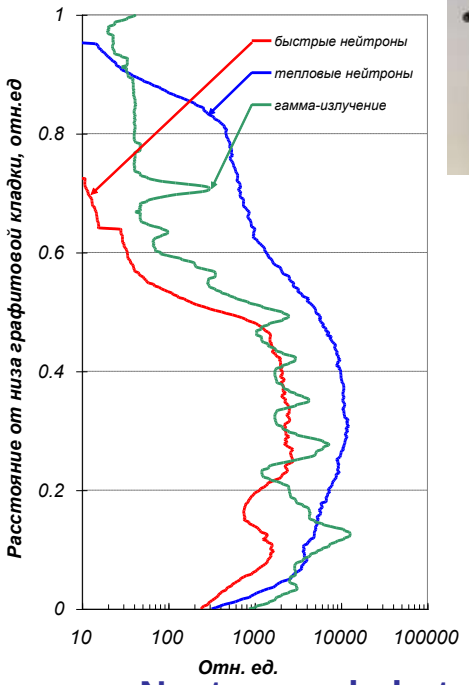
COMPREHENSIVE ENGINEERING & RADIATION SURVEY TECHNOLOGIES

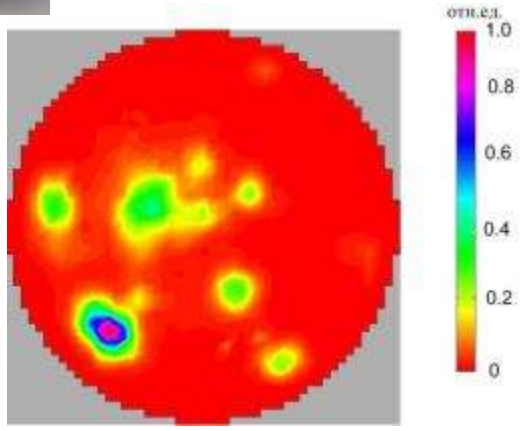
Radiation survey

Updating of content of C-14, Cl-36 and other radionuclides, its location form in graphite, constructional materials and metal structures.



Neutron and photon scanning of reactor facilities

Equipment for gamma neutron logging



Determination of fuel spillage localization areas

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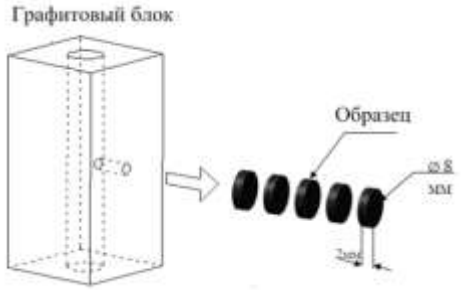
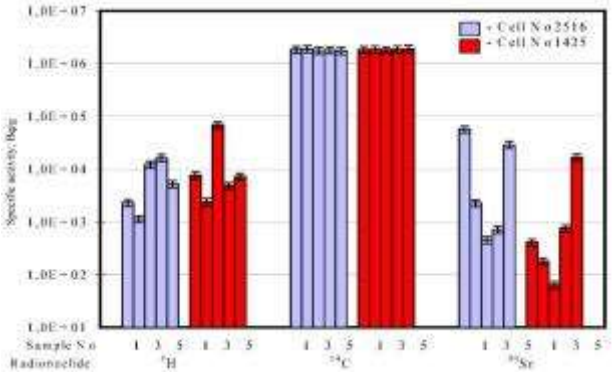
Calculation of mass of fuel spillage



Collection of samples



Determination of isotopic composition and sample activity

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R&D conduction

Barrier material choice

Criteria	Solution
Performance stability during the period of nuclear waste potential threat, ecological safety, accessibility.	Natural materials
High sorption capacity of radionuclides with different by chemical properties, plasticity	Mixture of natural materials on the base of natural clay or clay rock
Low water conductivity, natural compression, good flowability	Machine processes mixtures with definite humidity and granulometric composition

R&D RESULTS

1. The barrier material composition based on machine processed mixture of natural clay as well as void-free filling technologies were developed;

2. Calculations proved that forecasting specific activity of radionuclides is 10^{-3} Bq/kg except for C-14 and Cl-36 where underground reservoir enters Tom river (modeling timeframe – 10,000 years);

3. It was confirmed that under any events evolution scenario the most mobile C-14 and Cl-36 radionuclides will not exceed action level.

4. Based on the researches justifying safety of in-situ entombment scenario the project of EI-2 uranium-graphite nuclear reactor decommissioning was developed and license was obtained to implement this work.

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TECHOLOGIES

CLASSIFICATION OF TECHNOLOGIES APPLIED DURING OF PROJECT DEVELOPMENT AND EI-2 REACTOR DECOMMISSIONING

Technologies used for comprehensive engineering and radiation survey of the equipment, buildings, and areas

Dismantling technologies for the principal and support equipment, buildings and constructions

Technology of addition protection barriers construction during closing-down the reactor facilities and content of nuclear waste disposal facilities

Treatment technologies for radioactive waste accumulated during the reactor operation time and decommissioning

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PRACTICAL ACTIVITIES

Technological pipeline and NPP equipment dismantling

NPP first circuit pipelines dismantling

Utility systems pipelines dismantling

NPP heating equipment dismantling

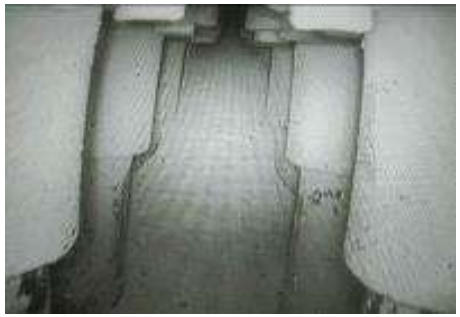
PRACTICAL ACTIVITIES

Metal constructions dismantling

Technological vault metal constructions dismantling

PRACTICAL ACTIVITIES

Technological openings performance to the difficult to access spaces for barrier materials transportation (remote visual control equipment was applied).

Technological openings performance though metal structures and filling up the cavities with the barrier material



Technological openings performance though engineering structures and filling up the space with the barrier material

PRACTICAL ACTIVITIES

Decontamination of the EI-2 reactor building

PRACTICAL ACTIVITIES

RW packages characterization

Containers with nuclear waste at the temporary storage area

PRACTICAL WORKS

Dismantling of engineering structures

Dismantling of central hall engineering structures

Construction of protective shield

RESULTS

1. **Barrier material and filling technology were developed.**
2. **Composite protective barriers system was created:**
   - Under graphite stack – 22 m;
   - Across graphite stack – 22 m;
   - Above graphite stack – 13 m.
   - Total volume filled by barrier material ~ 40 000 m3.
3. **Metal nuclear waste disassembled ~1000 т.**
4. **Volume of decontaminated and dismantled superstructures ~ 11 000 м^3.**

THANK YOU FOR YOUR ATTENTION