Removing of Core Constructions of the MR and RFT Reactors in NRC "Kurchatov Institute" – 16054

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ABSTRACT

In frame of the FTP "Providing nuclear and radiation safety of Russia in 2008 and for the period till 2015" works of a decommissioning of the MR and RFT research reactors are carried out in National Research Center "Kurchatov Institute". Within these works, the equipment of 9 loopback facilities of the MR reactor was dismantled. In the conditions, which are most approached to natural, one researched a heat, hydrodynamic and strength characteristics of elements of cores and the capital equipment of the majority of power reactors at these facilities.

In 2014-2015 dismantle of core constructions of the MR reactor was carried out and dismantle of a graphite laying of the RFT reactor is begun. The beryllium blocks, which were constructional elements of the core, and the graphite blocks playing a reactor reflector role were also taken, packed into cases or containers and removed: part on an accumulative platform, and part are placed in storage of high level radioactive waste of the Center for decay and further sending for long storage. Works were performed by remote controlled mechanisms, control of their performance was exercised by means of remote diagnostics: gammavizor, the scanning spectrometer systems.

The following methods and the organizational principles were applied to providing of radiation safety of these works:

- the constant radiation control including individual control of a dose of external radiation, control of volume activity of radionuclides in air, annual control of internal radiation doses of the personnel;
- dust suppression and fixing of radioactive contamition by dispersion of polymeric structures;
- carrying out decontamination on a shift basis rooms with use of detergents;
- use of the remote controlled mechanisms equipped with hydraulic scissors, nippers, application of the diamond are sharp that allowed to perform the majority of technological operations remotely, using "cold" methods of fragmentation;
- development on each type of works of the operation project and schedules.

As a result, of works of 2011-2014 of the decommissioning of the MR and RFT research reactors more than 630 t of the equipment were dismantled. From them more than 455 t of radioactive waste was. The total activity of radwaste exceeded 300.0 GBq. From the pool of the reactor, about 160 channels of loopback installations and near 230 beryllium and graphite are taken, fragmented and packed. The total activity on radionuclides ^{60}Co and ^{137}Cs of them was near 55 TBq. From the territory of the center about 2550 m^{3} of firm and 4600 m^{3} of liquid radwaste are removed.

INTRODUCTION

From 2011 to 2015 the decommissioning of research reactors MR and RFT carried out at the National Research Centre "Kurchatov Institute". In 2011, a license for this work was obtained and dismantling of the equipment and cooling piping of loop facilities and the auxiliary reactor equipment began. In 2013-2014, the equipment of all 9-loop facilities was dismantled, the equipment released from 47 basement premises. Dismantling of equipment allowed reducing of the equivalent dose rate (EDR) in rooms from 5-20 mSv/h to 0.01-0.03 mSv/h [1]. Removing of core constructions was started in 2014. First of all, the main grid of the reactor, which represented a main structural element on which are mounted all the major units of the reactor was removed. Then the blocks were removed from the beryllium ones from the core (76 beryllium blocks) and graphite ones from the reactor reflector (106 graphite blocks). In 2015, the body of the MR and the reactor graphite stack of RFT reactor were removed. About 34 tons of irradiated graphite was removed from the RFT reactor stack in total. Low- and intermediate-level radwaste is packaged in concrete and metal containers for transferring them to long-term storage items. High-level waste were packed in sealed canisters and placed in the high-level waste repository of the Center for the decay.

EQUIPMENT DISMANTLE OF THE LOOP FACILITIES

Loopback facilities of the MR reactor settled down in basements of the building of the reactor 37/1 and were used for thermal and materials research of experimental SFAs of the majority of the power and transport reactors created in Soviet period. Feature of dismantling works was the arrangement of the building of the reactor near perimeter of the Center that demanded application of the technologies of dismantle which aren't leading to essential radioactive contamination of the environment air.

Works of the decommissioning were included:
- dismantle of the equipment of loopback facilities and core elements of reactors;
- removal of pipelines of the old special sewerage of MR and RFT reactors;
- decontamination of walls and ceilings of rooms;
- rehabilitation of the territory adjacent to buildings of reactors.

Dismantle of the equipment of reactors consisted of:
- cutting of the equipment and pipelines with the colorant;
- dismantle and removal of electric equipment and cables, both power, and diagnostic;
- packings of RW in containers, measuring of specific and total activity of RW in the container;
- removals of the packed RW to long storage in the specialized organization.

For reduction of contamination of the environment air all works were carried out with the use of binding and dust suppression materials.
Fragments of the dismantled equipment and pipelines generally represented radioactive waste of low level of specific activity, the part from them after decontamination was returned in a production cycle in the form of scrap metal.

During performing of separate types of works the dose rate of γ-radiation reached:
- at dismantle of pipelines of cooling systems of loops – (1–10) mSv/h;
- at dismantle of the equipment of loopback facilities – to 20 mSv/h.

So high dose power levels of a in zones of works demanded preliminary survey of the equipment by means of radiometric and spectrometer means of remote diagnostics [2]. Rooms before works were scanned by "Gamma locator" and "Gammavizor" for identification of the most intensively radiating parts of the equipment. Measurements showed existence of non-uniform contamination of the equipment, the main γ - the radiating radionuclides which are present in the equipment were ^{137}Cs and ^{60}Co. Thus the most contaminated sites by ^{137}Cs radionuclide, generally, didn't coincide with sites of the greatest activity ^{60}Co [3]. During the works in technological rooms of loopback facilities the technology of consecutive dismantle of the equipment by means of remotely-controlled Brokk mechanisms was applied [4]. However in some rooms strong contamination of the equipment had local character, and removal of the contaminated sites reduced significantly dose rate in this room. In compliance with the received activity distribution dismantle was begun with these sites, passing further to less contaminated equipment.

For access of Brokk mechanisms to basement premises by means of systems of the diamond cutting in construction designs the apertures providing pass of such powerful tools as "Brokk-400" were cut out. After expansion old and the organizations of new apertures, the weakened concrete constructions reinforced by a metalwork and were framed by protection coverings. The same apertures were used for removal of containers with the RW. Use of a set of mechanisms from "Brokk-90" to "Brokk-400" allowed to carry out a wide set of operations. Dismantle of the equipment was carried out, generally by methods of the cold cutting. Remotely controlled mechanisms had a big set of easily replaceable hinged equipment with various cutting tools. Operators of remotely controlled mechanisms settled down in the external previously decontaminated rooms, and all operations in technological rooms carried out by robotic means. The cutting of zirconium covers of loopback channels was carried out by hydroscissors under water at specially equipped stand. For decrease in volume activity of aerosols in working zones a polymeric coverings of walls, floors and ceilings of the room that interfered with formation of radioactive aerosols were used.

The Brokk-330 mechanism by means of hydraulic scissors consistently fragmented the pipelines and cable routes located indoors. Fragments of the equipment and pipelines were sorted by radiometric methods according to the activity level and were placed in containers. The metal easily decontaminated parts went on a decontamination site, and the filled container with RW went on point of output radiometric control for measuring of nuclide structure, total and specific activity of waste.
The large-size low level active equipment was removed from the room entirely robotic means of "Brokk-400".

REMOVAL OF HIGHLY ACTIVE CONSTRUCTIONAL ELEMENTS OF THE REACTOR

After completion of works on dismantle of communications and the equipment of coolant circle of the reactor and its nine loopback facilities dismantle in case designs of the MR reactor was carried out. The arrangement of MR and RFT reactors, and also the main storages and radiation objects in the MR reactor hall is presented in Fig. 1. The vertical cross section of the MR reactor is given in Fig. 2.

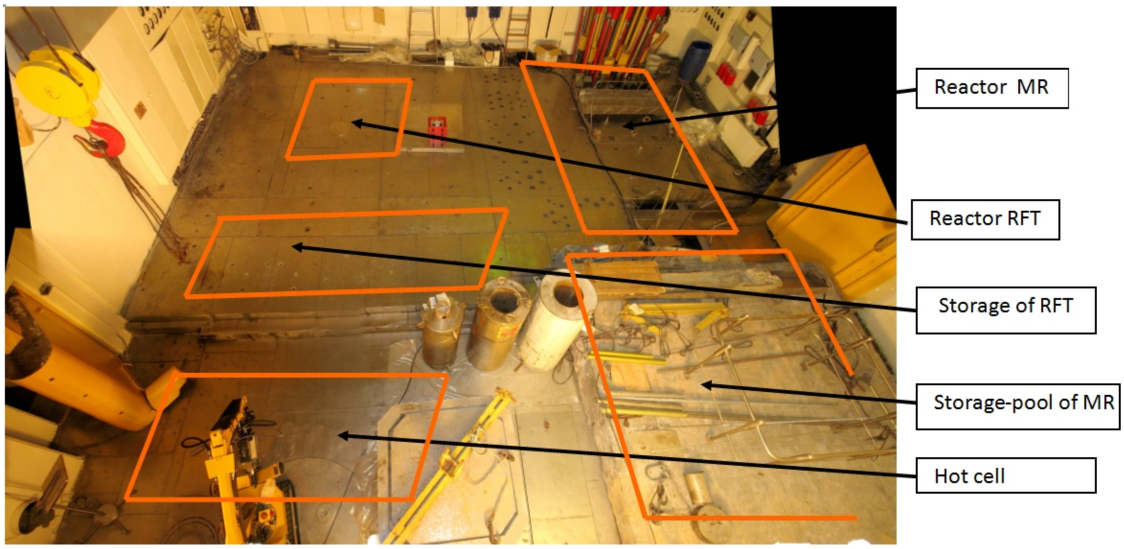
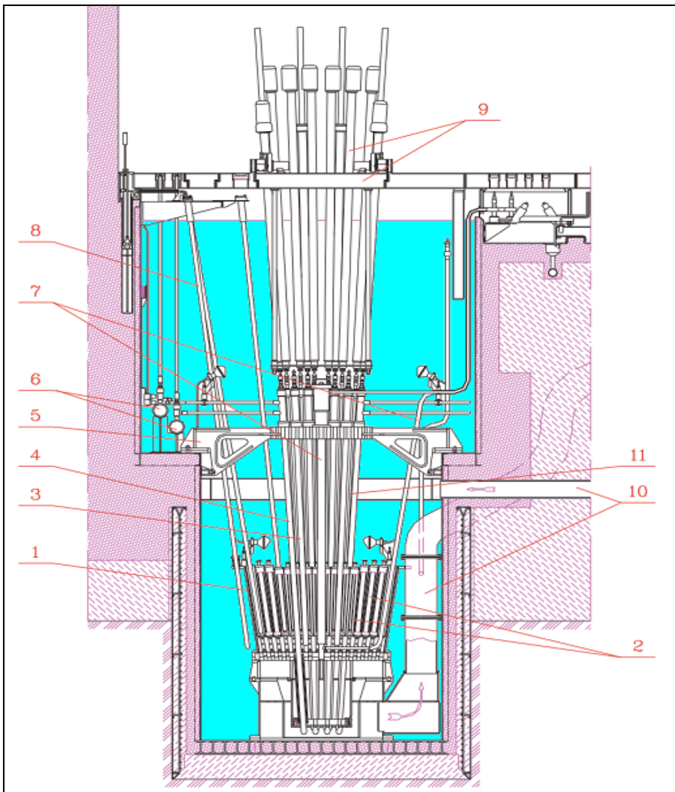


Fig.1. Arrangement of reactors and mail radiation objects in reactor hall of the MR.



1. – case of the reactor laying;
2. – beryllium and graphite blocks;
3. – working channel with stationery FA;
4. – working channel with removing FA;
5 – support grid of working and loop facility channels;
6. – collectors of cooling circle of TFA;
7. – direct-flow U – the figurative loopback channel;
8. – channels of detecting blocks of SCP;
9. – the cart with drives of cores of SCP and mobile FA;
10. – pipelines of a cooling circle of a laying;
11. – the channel with a core of SCP.

Fig. 2. Vertical cross section of the MR reactor

The ring from stainless steel is established on the bottom of the reactor pool. Diameter of the ring is 2,1 m, thickness of the ring is 40 mm, weight is 221,16 kg. On the ring, the lower support of the reactor is installed.

The lower support represented the cylinder with a diameter of 1,8 m, height – 0,985 m, made from stainless steel, thick - 35 mm. Gross weight of a design - 2635 kg. On the lower support, the lattice is established. The lattice represented two feedwells connected among themselves by 12 edges manufactured of stainless steel. The external feedwell - with a diameter of 1,8 m, internal - 0,85 m, lattice height – 0,3 m.

Gross weight - 1910 kg. From below to a support the round plate 90 mm thick made of SAV-1T alloy fastens. On the top flange of a lattice, the plate of a protector and the case of a laying of the reactor core with the lower plate is established. The plate of a protector was made of an alloy the AD-1. The protector sizes were 2,0×2,0 m, thickness - 35 mm.

The lower plate is executed from SAV-1T alloy with sizes of 2,0×2,0 m, thickness - 90 mm, the weight of a plate was 700 kg. The case of a laying of the reactor core was manufactured of an alloy the AD-1 and consisted of 3 knots: bases, case and top flange. The weight of the case of the reactor was 1485 kg. The basis of the case represented a square flange of 2,0×2,0 m in size with thickness of 40 mm. The case of a laying of the reactor core presented itself an octahedral glass in the form of the truncated cone expanding up at an angle some degrees to a vertical with thickness of a wall of 20 mm. The graphite-beryllium laying of the reactor was arranged in the case. It consisted in 216 blocks (76 beryllium, 140 graphite and aluminum ones). Characteristic sizes of blocks 130×130×1000 mm. Blocks were installed in the lower plate by means of shafts.

Results of spectrometer measurements in case designs showed that the main γ-radiating radionuclide is ^{60}Co. Activity of ^{137}Cs was 10 times less then activity of ^{60}Co. Activity of the blocks taken from the core was in the range from 7,0 to 30,0 GBq. The rate of an equivalent dose at distance of 1 m from the center of the block was in the range from 5 to 20 mSv/hour. Activity on length of blocks was distributed inhomogeneous, the maximum of radiation was the share of the central zones of the block [5, 6].

Low - and medium-active waste was packed into concrete and metal containers and went for a long storage to NPO Radon. Part of graphite and beryllium blocks as high radioactive waste were packed into tight cases and placed in high active waste storage of the Center for decay.

The standard tool – captures, tweezers, collet captures for systems extraction and movements of blocks were used for an extraction of radioactive beryllium and graphite blocks from the reactor pool. Zones of works under water lighted by underwater lamps. Control remotely of the carried-out operations and the course of measurements of radiation characteristics of the objects drawn from the pool were carried out by means of a stationary videosystem, the measuring Gamma pioneer, Gamma locator systems and the stationary dosimeter [2,3].

After extraction of beryllium and graphite blocks of a laying the basic lattice of the reactor, the representing massive design on which all main parts of the reactor were mounted was removed (see item 5 in Fig. 1). Then the case of the reactor was dismantled.

Management of the radiation-hazardous objects which were in the pool of the reactor was carried out from a special platform.

Dust suppression was carried out by means of WAGNER facility, which was established so that the direction of water dispersion at a taking by the crane and extraction of radioactive object from pool was directed to water.

For all radioactive objects, except beryllium blocks, the equivalent dose rate (EDR) of gamma radiation from the drawn object at distance of 1 m and availability of uranium as a part of object were measured. For beryllium blocks EDR was measured only. After measurement the irradiated beryllium block or other object depending on their total activity were loaded into the transport containers NZK-150-1.5P, KRAD-1.3 and KRAD-3.0 or into cases for moving to storage of high active waste of the Center. After extraction from the reactor pool for decreasing of volume of medium and high level radwaste beryllium blocks were fragmented in the same sequence, as during the works in a storage pool [7]. First of all, the shaft from aluminum having significantly lower activity separated. Depending on activity of the block it was fragmented and treated according to the technology which is presented in detail in [7].

Transport containers before sending for long storage to the special enterprise were placed on temporary storage at an accumulative site.

Finally more than 210 beryllium and graphite blocks taken from the reactor core were loaded into transport containers and cases:

- about 40 of them are placed in the cases loaded for temporary storage into cells of storage No. 7;
- 70 beryllium blocks are loaded into the containers NZK-150-1.5P, for additional protection a low level radioactive waste in the form of pig-iron fraction and sand were used. Graphite and aluminum blocks belonged to low-active waste and were packed into KRAD-3.0.

After removal of constructional elements, the lower support of the reactor representing a massive design from stainless steel (Fig. 3) was dismantled and removed.

Fig.3. Removing of the low support of the MR reactor

As a result, the capacity of the pool of the MR reactor is exempted from the equipment completely (see Fig. 4). Within further works, it is supposed to remove concrete elements in which reactor designs were placed.

Fig.4. Final condition of the MR reactor pool after dismantle of intra case elements

DISMANTLE OF THE GRAPHITE LAYING OF THE RFT REACTOR

In the reactor hall besides the MR reactor pool, a storage pool and storages of high active RW also the case and a graphite laying of the RFT reactor shut down in 1962 settled down (see Fig. 1). Constructional elements of the reactor core for protection of the personnel of the MR reactor during its operation were concreted and spread with steel plates. After removal of the main designs of the MR reactor works of decommissioning of the preserved RFT reactor began in spring of 2015. The top steel plates of protection were dismantled for this purpose and the top concrete layer over a graphite laying of the RFT reactor is removed (Fig. 5).

Fig.5. Graphite laying and top concrete covering of the RFT reactor.

Then medium-active graphite blocks of the reactor were removed. In total about 34 tons of the irradiated graphite are removed. Blocks were packed into concrete containers NZK and went on point of radiometric control. In total laying contained 19×40 blocks and 4×37 plugs, and their specific activity varied in range from 10^6 to 10^8 Bq/kg of ^{137}Cs.

ORGANIZATION OF WORKS AND PROTECTION OF THE PERSONNEL

For protection of the personnel the following methods and the principles of the organization of works were provided:

- the constant radiation control including individual control of a dose of external radiation, control of volume activity of radionuclides in air, annual control of internal radiation of the personnel by measurement of activity of the gamma radiating radionuclides in a body of workers;
- dust suppression and fixing of radioactive contamination by dispersion of polymeric structures that on 3-4 orders reduces a deflation of radioactive particles from surfaces of the dismantled equipment;
- maintenance at perhaps low level of contamination of surfaces of a floor, walls, the equipment by carrying out decontamination on a shift basis the room with use of detergents;
- use of the remotely-controlled mechanisms equipped with hydraulic scissors, nippers, the cutting tool with diamond a wire, allowing to perform the majority of technological operations remotely and applying of "cold" cutting methods;
- carrying out diagnostics of a radiation condition of object, before each type of works on dismantle, fragmentation of the equipment and removing of radioactive waste;
- development on each type of works of the project of works and operational schedules in which duties of responsibility of contractors for observance of the production technology of works and safety are defined.

RADIATION OF THE PERSONNEL AND IMPACT ON ENVIRONMENT

The organization of decommissioning, application of remote methods of a radiation situation diagnostics, remotely-controlled mechanisms, systems of dust suppression, constant radiation control, promoted decrease in radiative effects on the personnel and environment. At each worker the dose of external gamma radiation was daily fixed. In zones of works volume activity of aerosols in air was measured. The dose of internal radiation of the personnel was measured on the Spectrum of human body radiation facility in the specialized organization annually.

The volume activity of air in working zones didn't exceed standard values, the average individual dose of the personnel in 2014 was not more than 4 mSv/year, and the collective dose was estimated in 0,14 man×Sv/year. The maximum annual individual dose of internal radiation of the personnel didn't exceed 50 μSv/year.
During works of a decommissioning at perimeter of the National Research Center Kurchatov Institute it wasn't recorded any case of excess of control standards.

CONCLUSIONS

Decommissioning of the MR and RFT research reactors was carried out within the frame of the FTP "Providing of nuclear and radiation safety for 2008 and for the period till 2015". Dismantle of the equipment and decontamination of rooms of reactors was carried out by remotely-controlled mechanisms with application of technologies of dust suppression for reduction of activity of radioactive aerosols in air of working rooms that allowed reducing influence of radiation on the personnel and environment considerably. As a result, of the decommissioning more than 900 tons of the equipment were dismantled and removed for a long storage and processing. 1400 m^3 of solid RW and about 650 m^3 of liquid radioactive waste are removed. In total within all actions of the program from the territory of National Research Center Kurchatov Institute more than 3000 m^3 of SRW and 5000 m^3 of LRW are removed. The total activity of removed waste reached of 113 TBq.

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