Removing of Equipment of Loop Facilities and Preparation for Dismantling of Core of MR Reactor – 14083

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ABSTRACT

Since 2011 works on a decommissioning of the MR and RTF research reactors are carried out in the National research Center "Kurchatov Institute". These works are performed according to the project of a decommissioning approved by government authorities in frames of the Federal Target Program "Nuclear and radiation safety for 2008 and for the period till 2015". Besides the MR reactor 9 loopback facilities entered into its structure. These facilities were differed both as the nuclear fuel assembles so and systems of their cooling. In 2011-2012 the equipment of 3 loopback facilities was dismantled, it is supposed that the equipment of remained 6 ones will dismantle during this year.

According to the decommissioning project, dismantle of an equipment in underreactor premises of MR and RFT and equipment of the MR reactor itself have to be completed in 2013-2014. To start dismantle of an active zone of the reactor it was necessary to remove from the pool of the reactor and the pool of storage all loopback channels which were stored there (in total about 200 pieces), and beryllium and graphite blocks (about 80 pieces), also. All equipment stated above was used in experiments during the operation of the reactor and was contaminated by Cs-137, Co-60, etc. radionuclides.

Activity distribution on length of channels and blocks has non-uniform character. For the purpose of decrease in volumes of high level radwaste all this equipment was fragmented and sorted on activity levels. All operations on fragmentation, sorting and packing of this waste were carried out by remotely operated mechanisms under control of systems of remote diagnostics. Application of these technologies allows significant reducing of individual and collective doses of the personnel performing these works.

Dismantle of the equipment of loopback facilities was carried out by robotic means also, and sorting of radioactive waste was carried out by means of such systems as a gammavizor, gamma locator, etc. All operations on radwaste management were carried out with use of systems of dust suppression. Use of connecting and localizing materials allowed reducing of volume activity of air in zones of works significantly and limited contamination of radionuclides in environment and internal radiation of personal.

INTRODUCTION

During last year, works on a decommissioning of the MR and RFT research reactors are carried out in National Research Center Kurchatov Institute. In operation time for performing of programs of tests and researches of various types of fuel elements, fuel and constructional materials the MR reactor was equipped with 9 loop-type facilities providing possibility of research of heat physical, hydrodynamic and strength characteristics of active zones and the main equipment of different power reactors. The MR reactor power together with loop-type facilities reached 50 MWt [1-2].

The equipment of loop-type facilities was located in basements of the building of the MR reactor and had rather high levels of contamination – the equivalent dose rate in some rooms reached up to 20 mSv/h. Last year a dismantling of the equipment of loop-type facilities was begun, and 3 of them were liquidated [3]. This year elimination of the remained 6 facilities was completed.

In addition within preparation for dismantling of an active zone of the reactor works on removal from the storage pool of high active elements of the reactor and beryllium blocks were performed. The beryllium blocks which were constructive elements of an active zone, were packed and removed: part of them on an accumulative platform, and other part was placed in storage of highly active waste of the Center for decay and further delivering for long storage. Operations on dismantle of the equipment and radwaste management were carried out by the remotely operated mechanism (ROM) "Brokk", identification of most intensively radiating parts carried out radiometric and spectrometer methods by means of such systems, as "Gamma-pioneer", "Gamma locator" and "Gammavizor" [4-6]. Sorting of waste according levels of activity and choice of transport containers were carried out with application of special techniques in point of output control by means of semiconductor spectrometer measuring systems. Use of robotic means allowed reducing significantly doses of the personnel involved in works since it placed behind protective constructions out of zones of high radiation fields. For decrease in volume activity of aerosols in air of working zones technologies of dust suppression and continuous radiation control were used. It gave the possibility to avoid environmental contamination and considerable emissions of radionuclides into air at fragmentation and equipment dismantle.

TECHNOGIES OF DISMANTLE OF LOOP-TYPE FACILITIES EQUIPMENT

Loop-type facilities of the MR reactor, which main characteristics are given in Tab. 1, placed in basements of the building of the reactor 37/1.

Table 1. Main characteristics of loop facilities of MR reactor

Loop facility	Coolant	Power of facility, kW	Flow rate of coolant, m^3/h	Pressure of coolant, MPa	Maximum temperature of coolant, °C	Maximum number of experimental channels
PVC-1	Water and steam-water mixture	2000	30	10	310	3
PVC -2	–“–	1000	–“–	–“–	–“–	2
PVK	–“–	3000	150	10	330	6
PBU	Water	1000	30	20	330	2
PVO	–“–	2000	30	20	330	2
PV	–“–	1000	30	20	330	2
POV	–“–	1000	30	10	330	2
PVM	Liquid metal	1000	2,5	0,5	620	1
PG	Heluim	100	7	10	900	1

Each of loop-type facilities had the specific features, at the time of the beginning of decommissioning of MR reactor; pipelines of some facilities were fulfilled with the coolant. Dismantle of facilities had a number of features, which have essential impact on a course of works:

- a large-size equipment which can weight up to 5 tons;
- a high γ-radiation levels inside (to 20 μSv/h);
- complexity of routes of removal of containers with fragments of the dismantled equipment.

- technological rooms of loop-type facilities of the reactor were characterized by a large number of units of equipment inside;
- into the structure of facilities both the large and small-sized equipment were included;
- levels of γ-radiation in technological rooms of facilities changed over a wide range from several μSv/h up to 20 μSv/h;
- from rooms of loop-type installations it was necessary to organize special routes of transportation for removal of the dismantled equipment and to do technological passes in construction designs of the building of the reactor;
- the arrangement of the reactor building near perimeter of the Center demanded application of dismantle technologies not producing an essential radioactive contamination of the air environment.

At a preparatory stage, apertures of doors and hatches of basements of the reactor building were expanded, additional passes between rooms and floors for delivery of special equipment and containers, and also removal of the packed radwaste were organized.

Dismantle of the equipment included:

- cutting of the equipment and pipelines with the coolant;
- dismantle and removal of electric equipment and cables, both power, and diagnostic. For reduction of contamination of the air environment all works were carried out with use of binding and dust suppression systems.

Fragments of the dismantled equipment and pipelines are generally presented themselves a radioactive waste, and some of them partially returned in a production cycle in the form of scrap metal.

A dose rate of γ-radiation when performing separate types of works in these rooms was characterized by the following values:

- (1–1.5) Sv/h – for channels' chopping, fragmenting and packaging into radwaste casks;
- (1–10) mSv/h – for underfloor pipelines' dismantling in the MR central hall;
- (1–10) mSv/h – for mezzanine water loop pipes' dismantling in water pipelines corridors 1–3 (pipeline corridors);
- up to 20 mSv/h – for loop-type equipment dismantling.

So high power levels of a dose in working zones demanded application of preliminary survey of the equipment by means of radiometric and spectrometric systems of remote diagnostics [7]. Before works for identification of most intensively radiating parts of the equipment the "Gamma locator" and "Gammavizor" scanned rooms. Measurements showed existence of non-uniform contamination of the equipment, the main gamma-radiating radionuclides which are present in the equipment were ^{137}Cs and ^{60}Co. More over sites most contaminated by radionuclide ^{137}Cs did not coincide with sites of the maximum activity ^{60}Co [7]. During the works in technological rooms of loop-type facilities the technology of consecutive dismantle of the equipment by means of remotely operated Brokk mechanisms [3] was applied. However in several rooms the high contamination of equipment had a local character, and a removal of the contaminated sites reduced significantly dose rate in this room. In compliance with the received distribution of activity dismantle began with these sites, passing further to less contaminated equipment.

For reasons of availability it was decided to begin with the PG, POV and PVO loop facilities, work on which elimination, were executed last year [3].

For access of Brokk mechanisms to basements, the apertures providing pass of such powerful tools as with "Brokk-400" were cut out in concrete constructions by means of systems of the diamond cutting. After expansion old and the organizations of the new apertures, the weakened concrete constructions were reinforced by metalwork and were framed with coverings. The same apertures were used for removal with radwaste. Use of a set of mechanisms from "Brokk-

90" to "Brokk-400" allowed a carrying out of a wide set of operations. Dismantle of the equipment was carried out, generally by methods of the cold cutting. Remotely operated mechanisms had a big set of easily replaceable attachments with various cutting tools. Operators of remotely operated mechanisms were in the external previously decontaminated rooms, and all operations in technological rooms carried out robotic means. For decrease in volume activity of aerosols in zones of works polymeric coverings of walls, floors and room ceilings that interfered with formation of radioactive aerosols were used.

Dismantle of the equipment of loop-type facilities was carried out according to the following sequence. Means "Brokk" through an aperture was delivered to the room, and by means of hydraulic scissors, consistently fragmented pipelines and the cable routes located indoors. Fragments of the equipment and pipelines were sorted according level of activity by radiometric methods and took place in containers. Metal easily decontaminated parts went on a decontamination site, and the filled container with radwaste went on a point of output radiometric control for definition of nuclide structure, total and specific activity of waste.

The large-size lowly active parts of equipment were removed from the room entirely by robot "Brokk-400", then load-lifting mechanisms and auto-loaders to decontamination point. Point of decontamination, output radiometric control and accumulative platform of radwaste are on a site of the former radwaste storages, adjacent directly near the reactor building.

As a result of works in 2013 the equipment of the remained 6 loopback installations was dismantled, 30 rooms were freed from the equipment, 250 cubic m (320 t) were directed on an accumulative platform, removed on long storage of 200 cubic m (280 t). Dismantle of the equipment allowed reducing of EDR in rooms from 5-10 mSv/h down to 0,01-0,03 mSv/h.

REMOVAL OF HIGH LEVEL ACTIVITY OBJECTS AND BERYLLIUM BLOCKS FROM THE POOL STORAGE

The pool storage was intended for temporary storage of the loop-type facility channels unloaded from an active zone, beryllium and graphite blocks. Documentary information on existence in the pool storage of radiation-hazardous objects was absent. Existence in the pool of a large number of highly active loop-type facility channels with bringing and taking-away pipelines did not allow conducting of its examination with identification of all radioactive objects, which were there. After unloading from it about 160 channels of loop-type facilities became possible carrying out visual inspection of the objects, which are storing at the pool bottom (see Fig. 1). Visual inspection showed that except a truss with the irradiated beryllium blocks, at the pool bottom there is a set of the objects, a different form and dimensions (see fig. 1). By results of visual inspection, the sequences of the management with radioactive objects were developed and works on removal of beryllium blocks and highly active elements from the pool storage were performed.

Fig.1. Radioactive objects at the pool bottom after uploading of channels of the loop-type facilities.

The extraction of the irradiated beryllium blocks and radioactive objects was carried out according to the scheme provided on Fig. 2. For work on removal of radiation-hazardous objects and beryllium blocks three types of containers were prepared: KRAD-1.3, KRAD-3.0, NZK-150-1.5P.

Regular tools: captures, tweezers, cullet captures for systems extraction and movements of blocks were used for extraction of radioactive objects from the pool storage. Underwater lamps on bars of 3 - 6 meters long shined zones of the work under water. A stationary videosystem was applied for remote control of operations. The Gamma pioneer, Gamma locator measuring complexes and the stationary dosimeter measured a radiation characteristic of objects drawn from the pool (see fig. 3) [5-6].

Works on the management with the radiation-hazardous objects which were in the pool storage, began with removal of a protective plate of overlapping over a lock and installations of the assembly bridge. Then personal installed lighting lamps, and placed a WAGNER dispersion facility in the pool, so that the direction of dispersion of water at a hooking and extraction by the crane of radioactive object from the pool was sent to water.

For all radioactive objects, except beryllium blocks, there was measured the equivalent dose rate (EDR) of gamma radiation from drawn object at distance of 1 m and the identification of uranium availability in the object was carried out. For beryllium blocks, the EDR was measured only. After measurement, the irradiated beryllium block took place in a free cell of a truss in a lock, number of a cell and results of radiation inspection were fixed in the operational magazine. Other objects 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 level radioactive waste of the Center.

As the scheme of Fig. 2 notes, two versions of the treatment of high radioactive beryllium blocks were provided. Blocks with activity more than 0,1 TBq were loaded into metal cases which took place on temporary storage in free cells (∅416) of storage No. 7. If activity of block was less than 0,1 TBq, it was loaded into NZK-150-1.5P containers with additional protection.

After removal from the bottom of pool the most intensively radiating fragments, the beryllium blocks were extracted from truss and fragmented for decreasing the volume of intermediate and high level radioactive waste. An aluminum shaft, which had significantly smaller activity, cut off first of all (Fig. 4).

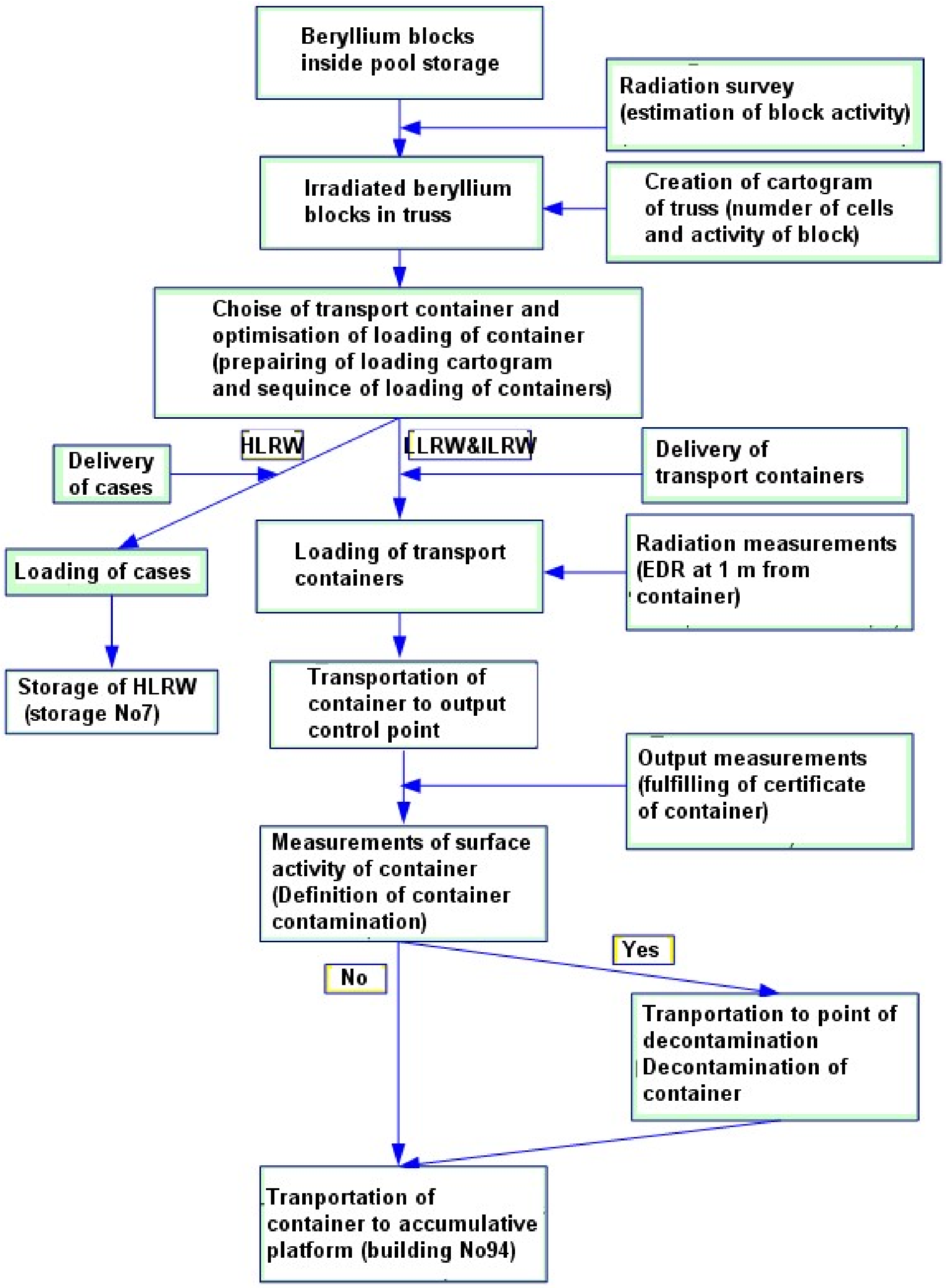

Fig.2. Sequence of management of the irradiated beryllium blocks

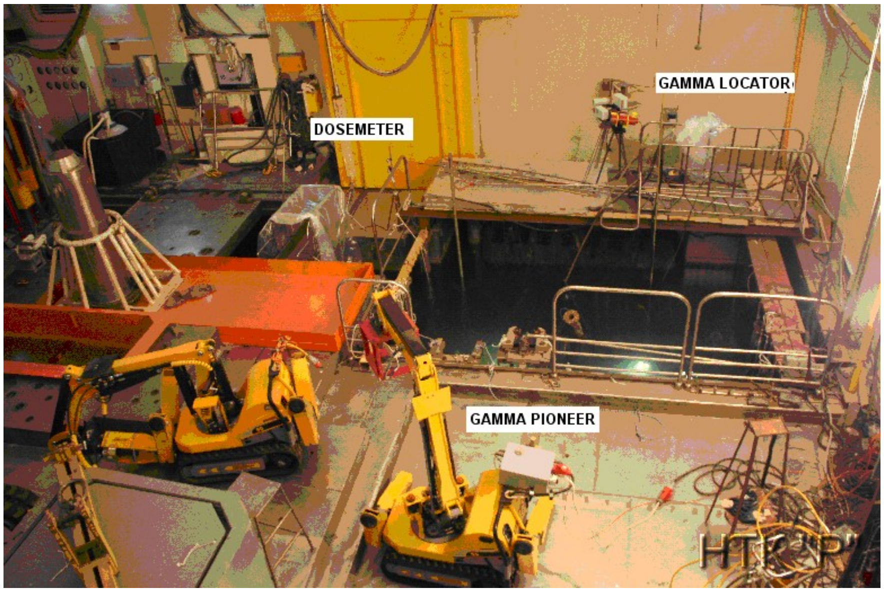

Fig. 3. Radiation survey of the objects extracted from pool storage.

By means of "BROKK-90" equipped with hydroscissors, the personal cut off the suspended arrangement from the high active beryllium blocks, and then located it in a case placed in the lead reloading container (see Fig. 5). A cover closed the case, and the container moved to storage No. 7, where the case was overloaded in a free cell (see Fig. 6).
If activity of block was less than 0,1 TBq, block was fragmented on smaller parts. For prevention of scattering of fragments during cutting, the beryllium block took place in a strong cover. In the course of fragmentation of the block, the unit of airless dispersion system of WAGNER was used for the dust suppression.
During cutting, the strong cover was put on the top part of the beryllium block remotely. The block placed in a cover was transferred to the container NZK with a concrete ring and hung out on the center of a ring (Fig. 7). The remotely operated BROKK-330 mechanism equipped by the hydroscissors fragmented the block in several places. Fragments of the block dropped in the concrete ring placed in the container NZK-150-1.5P.

Fig.4. Separation of aluminum shaft from the beryllium block

The control of volume activity of air indoor was carried out during the work constantly. In case of need, a pig-iron fraction or sand between a concrete ring and the container case was used as additional protection. After a full load, a cover closed the container and the container was transported on a site of output control. After the EDR measurement in control points on a surface of the container and measuring of its total and specific activity on point of output control, the container was transported on a platform of temporary storage of the transport containers loaded by radwaste – the building 94 (see Fig. 6). The truck crane loaded it in the building.

Fig. 5. Loading of radwaste in transport and lead containers

Fig.6. Transportation of lead case into storage No.7.

In the course of extraction and radiation inspection, all radioactive objects unloaded from the pool storage were sorted. According to total activity they were placed in the following containers:

- the low level active objects having activity ^{60}Co of no more than 0,3 GBq, were loaded into the containers KRAD-1.3 and KRAD-3.0;
- the intermedium level active objects with activity to 3,0 GBq were loaded into the containers NZK-150-1.5P;
- objects with activity in the range of 3,0 – 50,0 GBq were loaded into the containers NZK-150-1.5P with additional protection. The assessment of thickness and structure of additional protection were defined on a basis of results of EDR calculation. The calculation took in

consideration of a real geometry of the container and assumed a uniform distribution of activity inside a concrete ring;
- objects with activity 50,0 – 100 GBq were loaded as the fragments into the containers NZK-150-1.5P with additional protection.
- objects with activity more than 100 GBq were loaded into metal cases which took place for temporary storage in free cells (Ø416) of storage No. 7.

Fig. 7. Fragmentation of high active beryllium blocks and loading them into NZK-150-1.5P container.

Transport containers before sending for long storage to the special enterprise took place for temporary storage on an accumulative platform. The building 94 is provided the possibility of placement ~ 250 KRAD-2.7 containers or 230 NZK-150-1.5P containers.
The building 94 represents itself a construction which internal sizes make 13500x10000 mm. Walls are put from the concrete blocks which thickness above the earth level makes 60 cm and below earth level - 120 cm. A removable roof covered the above construction.
According to standard requirements, the dose rate at distance of 1 m from a surface of the transport container should not exceed 0.1 mSv/hr. Transport containers with radwaste filled the building almost now. A program of the EDR calculation was developed for an assessment of influence of an accumulative platform on EDR on surrounding territories taking into account dispersion of photons in air and real geometry of the building 94. Results of calculations showed that on border of a sanitary protection zone of the Center the EDR from the containers located in the building No. 94, in ~ 30 times below a natural background.
Finally, 28 beryllium blocks removed from the pool storage were loaded into transport containers and cases:
- 3 blocks from a lock of the pool are placed in the cases loaded on temporary storage into cells of storage No. 7;
- 25 blocks are loaded into five containers NZK-150-1.5P with additional protection in the form of concrete rings and the pig-iron fraction and sand as a low active waste.
The radioactive objects extracted from the pool storage are loaded into 2 containers KRAD-3.0 and 5 containers NZK-150-1.5P for transportation into the special enterprise and 7 cases for placement in storage No. 7.

CONCLUSIONS AND DISCUSSIONS

During from the end 2012 to autumn of 2013 the equipment of all 9 loop-type facilities of the MR reactor is dismantled, beryllium blocks are removed, and also high - and medium-active objects were extracted from the pool storage. The performed works will allow lowering of a water level in the pool of the reactor and the lock of pool storage connected with it. After that dismantle of an active zone of the MR reactor can start. Preliminary surveys of a pool bottom of the reactor showed that in the course of works it is necessary to face of the same problems and operations, which were carried out in the course of works in the pool storage. The main problems, which should be solved, are a removal of bottom sedimentation from the pool and identification of the objects containing fission elements. The technique of definition of presence of uraniferous objects is developed now. However, for definition of quantitative characteristics of samples it is necessary using of an active and passive neutron diagnostics of identification nuclear fuel in the contaminated masses.

In result of works, 200 cubic meters of radwaste was removed, 630 tons of equipment was dismantled. 10 cases with HLRW were placed into the storage of high active radwaste of the Center for decay. The active parts were placed into ~120 cases after fragmentation of channels.

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