

RADIATION AND VIDEO SURVEY OF WATER CLEANUP AND VENTILATION SYSTEM OF RFT REACTOR

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Abstract. The specialists of NRC “Kurchatov Institute” have conducted the dismantling of the MR multiloop research reactor and RFT reactor. The technical start-up of the 20 MW capacity experimental graphite water cooling reactor (RFT) started in 1952. The reactor was shut down 10 years after the working period. The fuel was removed and the reactor was partially dismantled. The ventilation system and water cleanup system of the RFT reactor were located in a separate building. The upper part of the reactor vent stack was dismantled in the early 60's. The water cleanup system, which consists of 6 stainless steel tanks (4 – Ø1.5m, h=5m; 2 – Ø3m, h=5m) located around the base reactor vent stack, was mothballed. To plan the dismantling work, a radiation and video survey of the water cleanup system and the reactor vent stack was carried out. For this purpose, holes were drilled in the upper ceiling of premises with the water cleanup system and at the top of vent stack. Through these holes video recording and measurement of the exposure dose rate distribution were carried out. The measurement of the exposure dose rate distribution along the height of vent stack was also carried out. Based on the result of these surveys, the measurements of distribution of activity from radioactive waste along the height of the tank were carried out. The collimated spectrometric system on the basis of a semiconductor detector CdZnTe (volume of a crystal of 60mm³) was used. The measurements showed that the distribution of activity from radioactive waste along the height of the tank was non uniform. To measure the distribution of the contamination of the inner surface vent stack we used the spectrometric system with semiconductor detector CdZnTe (volume of a crystal of 500mm³) with circular collimator. The results of measurements are presented and discussed. The results of the survey will be used for planning the dismantling work.

Key words: Radiation survey, semiconductor CdZnTe detector, dismantling, radioactive contamination

1. INTRODUCTION

RFT reactor ventilation and water cleanup systems are located in a separate building next to the MR reactor building (Fig.1). After stopping the RFT reactor in the early 60s of the last century, the upper part of the vent stack was dismantled. Above the outlet vent stack, a concrete floor (1) is installed and the roof is mounted. The water cleanup system includes 4 metal settling tanks (Ø3m, h=5m) (2), which were used for degassing and settling of radioactive water coming from the RFT reactor. After settling the water, it was pumped into 2 metal tanks (adsorption columns Ø1.5m, h=5m) to clean it from radioactivity (3). Tanks-settling tanks and adsorption columns are located in the rooms around the vent stack: tanks-settling tanks for two in one room, adsorption columns each in a separate room. After the reactor was shut down, the access to these premises was concreted. In case of insufficient cleaning, the water is squeezed out from the adsorption column were reported in montejus (4) where the compressed air is again forced through the adsorption column.

For the planning of dismantling works, a radiation inspection of the premises of the water treatment system and the vent stack was carried out.

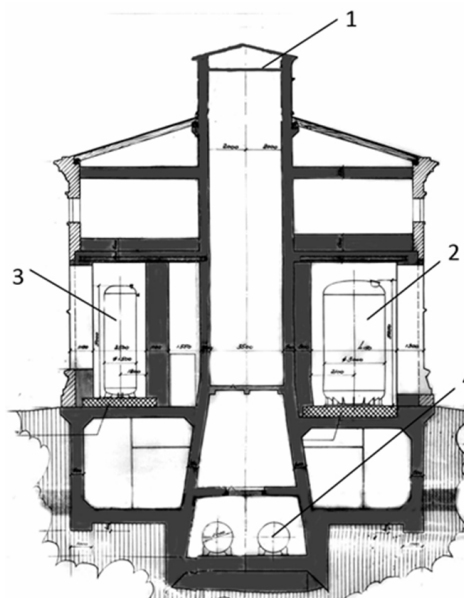


Figure 1. The building of the ventilation and water cleanup system of the RFT reactor (1 - concrete slab, 2 - settling tanks, 3 - adsorption column, 4 - montejus).

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2. RADIATION AND VIDEO SURVEY OF WATER CLEANUP AND VENTILATION SYSTEM

A survey of the treatment system included: video filming indoors, the measurement of the dose rate at the height of the rooms, measuring distribution of the specific activity at the height of the studied tanks. For the inspection in the premises of the water treatment system, the holes of $\varnothing 200\text{mm}$ in the upper floors were drilled. Video footage of the premises showed that the premises are dry, there are no leaks. In Fig. 2, the image frames in the room of the water cleanup system are presented.

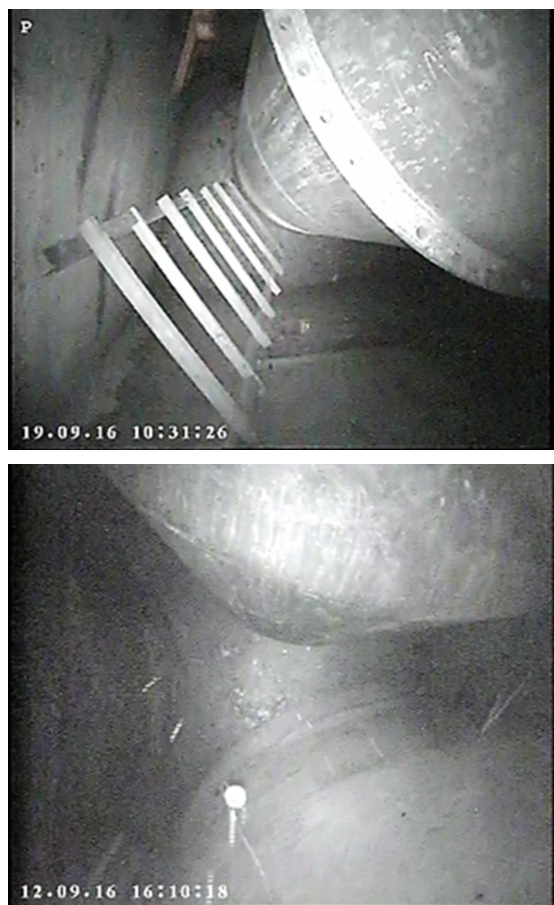


Figure 2. Video frames in the room of water cleanup system

Dose rate measurement in the premises was carried out in a standard device UIM2-2. Dose rate values are unevenly distributed in the height of the premises. The maximum dose rate in indoor settling tanks 1 and 2 - $400\mu\text{Sv/h}$, settling tanks 3 and 4 - $200\mu\text{Sv/h}$, absorption column 5 - 4mSv/h , absorption column 6 - 10mSv/h .

For measurements of the activity distribution over the height of the tanks, a collimated spectrometric system was used, described in detail in [5]. The system consists of a measuring unit, a multi-channel analyzer InSpector 2000 and a computer. Measuring unit-semiconductor detector CdZnTe with volume $V=60\text{mm}^3$ is located in a lead shielding with a

collimator. Dimensions of the measuring unit: $\varnothing 30\text{mm}$, height 80mm . The lead shielding consists of two parts: the fixed lower part and the movable upper part. When raising the top of the lead shielding, a collimation hole 1.5cm high and a horizontal angle of 60° is opened.

For measurements, the detector mounted on a metal rod was lowered into the holes drilled in the upper floor of the premises so that the collimator hole was directed to the scanned tank. At each point, two measurements of the gamma radiation spectrum from the tank were carried out: with an open and closed collimator, which allowed to take into account the effects of gamma radiation from the neighboring tank.

The analysis of the radiation spectra showed the results of measurements that the radiation from the tanks is determined by the radionuclide ^{137}Cs . The distributions of the difference (with open and closed collimator) rate of the account in the peak of the total absorption of ^{137}Cs in the height of the settling tanks are given in Fig.3.

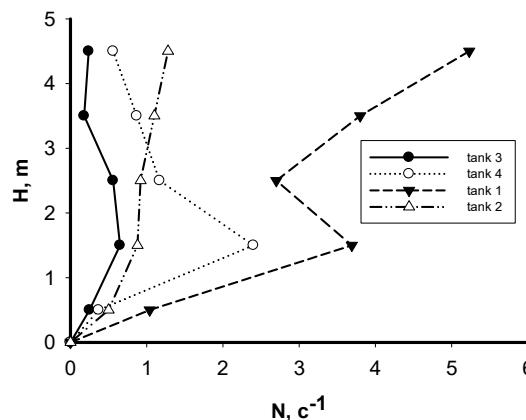


Figure 3. The distributions of the difference (with open and closed collimator) account rate at the peak of the total absorption of ^{137}Cs on the height of the settling tanks.

The distribution of radioactive contamination of the settling tanks is uneven in height. In tanks 3 and 4, the main activity is in the lower part. Activity is distributed almost evenly in it. In tank 1, the activity is located in the lower and upper parts. Without access to these rooms and opening of the upper flanges of the tanks we cannot say that these tanks are empty or filled with radioactive water. But according to the obtained distributions of activity, it can be assumed that there is no water in the tanks. The activity of the tanks is determined by the contamination of the internal surface and sediment on the bottom.

The distribution of activity in the height of the adsorption columns is presented in Fig. 4.

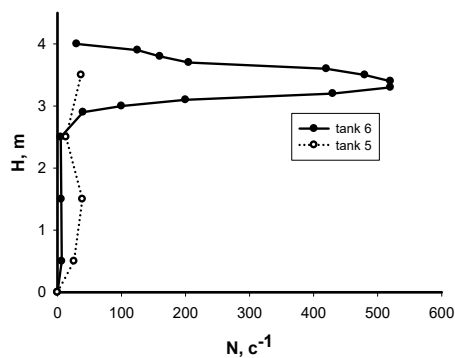


Figure 4. Distribution of activity at the height of the adsorption columns

The most radioactive contamination is in the adsorption column 6. The main activity is in the upper part of the column filled with glauconite. It can be assumed that the difference in the activity of these columns is due to different technological processes.

For the inspection of the internal volume of the vent stack in the stack wall at a height of 1.5m from the floor above the premises of the tanks, a hole $\varnothing 150\text{mm}$ was drilled. Video inspection inside the vent stack was carried out through this hole. The survey showed that inside the stack there are metal structures, at the bottom of the vent stack, partially dismantled nozzles. Also the photos were taken from the stack space under the nozzles. In Fig.5, photos of nozzles located in the lower part of the vent stack and metal structures, which are visible through the nozzles, are given.

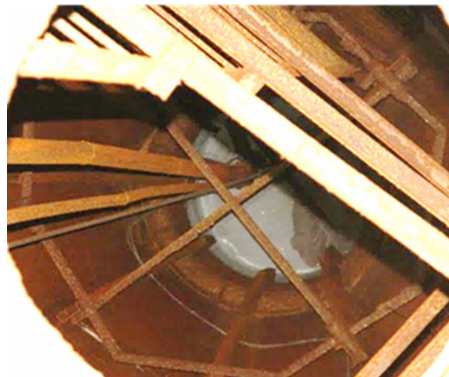


Figure 5. The photos of nozzles (upper) located in the lower part of the tube and metal structures (lower)

The measurement of the dose rate by the height of the vent stacks (see Fig.6). The highest values of gamma dose rate around the nozzle.

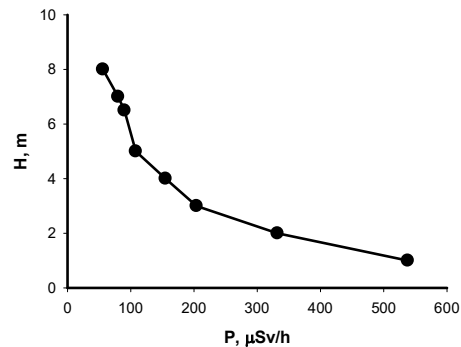


Figure 6. The distribution of the dose rate at the height of the vent stack

The measurement of the distribution of surface activity inside the vent stack by height was carried out using a collimated CdZnTe detector ($V_c=500\text{mm}^3$) with an annular collimator [6] (Fig.7)

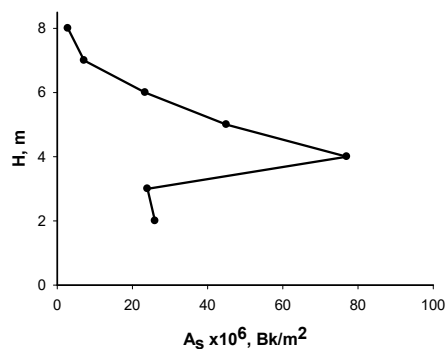


Figure 7. The distribution of surface activity inside vent stack by the height

The increase dose rate at the approach to the bottom of the vent stack (nozzles) and the uneven distribution of surface activity values along the vent stack height can be explained by the fact that the main contribution to the readings of the devices does not give a contaminated vent stack surface, but a rusty construction inside the vent stack and nozzles.

To verify this assumption, rust samples were taken from the metal structures of the nozzles. Measurements made on the Canberra spectrometric complex showed that the rust radiation is due to the radionuclide ^{137}Cs , the specific activity of rust by ^{137}Cs – $1.8 \cdot 10^6 \text{ Bq/kg}$.

To determine the surface contamination of the vent stack with concrete core from the drilled hole in the vent stack wall, concrete samples were taken. Two

layers of concrete were removed from the inner surface of the core: the first one with a thickness of 0.3mm, then the second with a thickness of 0.18mm. The measurement of the radiation spectrum of concrete samples showed that the concrete is contaminated with radionuclide ^{137}Cs . The specific activity of the first layer $4.8 \cdot 10^5$ Bq/kg, the second layer $1.52 \cdot 10^5$ Bq/kg. We can say that the activity of the surface of the vent stack is defined by a thin surface layer with a thickness of 0.5-1mm, which is important when planning the dismantling of the vent stack and quantity of radioactive waste. The surface activity inside the vent stack (a layer of 0.5mm), calculated from these data was $3.75 \cdot 10^5$ Bq/m². This value is 10 times smaller than the surface activity of the vent stack at this height, measured by a collimated detector. The data obtained confirm the assumption that the greatest contribution to dose rate inside the vent stack is made by radiation from metal structures inside the vent stack and nozzles.

Montejus 1 and 2 are at the bottom of the building in the canyon under the vent stack. These montejus merged water from the adsorption columns, the activity of which exceeded the norm. The water from these montejus came back to the adsorption column for repeated purification. Currently, the canyons are filled with water. In Fig. 8, a photograph of the canyon montejus filled with water is showed.



Figure 8. The photo of the canyon with montejus

Montejus and pipelines in the canyon are covered with a layer of rust. The gamma dose rate on surface of canyon is 0.2mSv/h.

In order to determine the activity of montejus, the measurements were conducted using collimated CdZnTe semiconductor detector with the volume $V=60\text{mm}^3$ and an angular collimator. For measurements, a thin-walled pipe with a closed lower part was lowered into the water. The detector is lowered into the pipe.

Two measurements are made. At the first point, the detector is mounted close to the surface of montejus. The collimator is aimed at montejus. The second point of the pipe is installed in the water at a distance from montejus. The collimator is aimed at the water. At each point, two measurements were made with a closed and open collimator. Differential count rate of the detector at the peak of full absorption of ^{137}Cs in the water was 0.4 count/s in the direction of montejus – 2.5count/s. Activity montejus is several times higher than the water activity. Activity montejus can be identified as external contamination – rust, which well absorbs radioactive contamination, internal contamination or the contents of montejus.

Sludge is at the bottom of the canyon in the water. Water and sludge samples were taken for the spectrometric analysis. The analysis of the water sample showed that the water activity is determined by the radionuclide ^{137}Cs . The measurements showed that the specific activity of the water was $^{137}\text{Cs} - 3.7 \cdot 10^5 \text{Bq/l}$. In the fine sediment, radioactive nuclides ^{137}Cs , ^{94}Nb , ^{141}Am , ^{154}Eu , ^{152}Eu , ^{60}Co are contained; specific activity is given in Table 1.

Table 1. The specific activity of sediment from montejus

nuclide	Specific Activity, Bq/kg
^{241}Am	$1.7 \cdot 10^7$
^{137}Cs	$2.2 \cdot 10^8$
^{154}Eu	$1.0 \cdot 10^6$
^{152}Eu	$3.6 \cdot 10^6$
^{60}Co	$1.1 \cdot 10^6$
^{94}Nb	$2.6 \cdot 10^4$

3. CONCLUSION

The main criteria for the selection of technologies for dismantling equipment and construction of the water cleanup and ventilation system of RFT reactor are the minimization of the personnel exposure and the reduction of the amount of radioactive waste.

Radiation and video inspection of the water cleanup and ventilation system of the RFT reactor showed that the optimization of dismantling operations will require additional radiation inspection of equipment, which will be available. So after the organization of access to the premises it will be possible to open the flanges of the settling tanks and conduct remote measurements and video recording inside them in order to establish the presence and activity of radioactive waste.

After the removal of metal structures inside the vent stack, it is necessary to re-measure the surface radioactive contamination of the vent stack to clarify the depth of penetration of radionuclides into the concrete [7]. Knowing the thickness of the contaminated layer can significantly reduce the amount of radioactive waste. Various technologies of removal of radioactively contaminated concrete layer from the surface of the vent stack are considered.

From the canyons, which are located in montejus, it is necessary to remove radioactive water that will allow a detailed radiological survey of canyons and montejus and the optimization of their dismantling.

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