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Research Article

# Dismantling and decontamination of large-sized radiation-contaminated equipment during Research Building B decommissioning at the Bochvar Institute site*

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## Abstract

The article presents the results of work on dismantling the large installation equipment of Research Building B at the Bochvar High-technology Research Institute of Inorganic Materials (Bochvar Institute). The works were carried out as part of Building B preparation for decommissioning. The purpose of dismantling the large-sized capacitive equipment was to reconstruct the large installation site for managing radioactive waste generated during Building B decommissioning. The works on decommissioning a radioactively contaminated building within a densely populated district of megalopolis were carried out for the first time.

The characteristics of the large-sized capacitive equipment are presented. Radioactive contamination of the capacitive equipment is determined by long-lived α-emitting isotopes: $^{235}U$, $^{238}U$, $^{239}Pu$. The sequence of works on dismantling the radiation-contaminated capacitive equipment includes preparatory work, dismantling the tank piping, localizing radioactive contamination of the external surface of the equipment as well as dismantling and moving it into a transport container.

Dismantling and decontamination of the large-sized capacitive equipment was carried out by the Bochvar Institute Decommissioning Department. The following tools were used during the works: (1) a mobile foam decontamination facility to perform decontamination works and (2) a mobile high pressure facility to apply localizing and decontaminating film coatings. The tanks were dismantled by means of low-spark tools, i.e., reciprocating saws. Crane runways were made in order to move the dismantled equipment into transport containers: the movement was carried out with the help of a winch.

The main results of dismantling and decontaminating the radioactively contaminated tanks are the dismantling of four units of long-length column-type equipment with heights from 4.2 to 6.4 m and 26 units of capacitive equipment (maximum capacity = 8 $m^3$) as well as decontamination of the internal surfaces of radiation-contaminated equipment (decontamination factor = 25–70). As a result, the activity of the accumulated radioactive waste was reduced (the RW class was changed from 3 to 4).

The main conclusion regarding the managment of large-sized radiation-contaminated tanks during Building B decommissioning is as follows: the works were organized and carried out at a high technical level, using modern decontamination and dismantling equipment and modern methods to ensure work safety at the Bochvar Institute site in the city of Moscow.

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## Keywords

Decommissioning, radiation-contaminated equipment, tank, extraction column, dismantling, uranium, plutonium, foam decontamination, radioactive waste

# Introduction

Successfully completed in 2015, the Federal Target Program “Ensuring nuclear and radiation safety for 2008 and for the period up to 2015” was an example of a systematic approach to ensuring the safety of nuclear facilities (Order No. 484-p 2007, FTP NRS-2 Archives). One of the FTP NRS objectives was to reduce radiation hazards of enterprises located in populated areas (Federal Law of the Russian Federation). One of such enterprises is the Bochvar High-technology Research Institute of Inorganic Materials (Bochvar Institute): works with nuclear materials and radioactive substances had been carried out in its research buildings since the late 1940s. In 2010, due to the reduction of work with nuclear materials and radioactive wastes, it was decided to decommission Research Building B, the laboratories and facilities of which had been involved in developing SNF hydrometallurgical processing technologies (Sukhanov et al. 2013a, 2013b, Kuznetsov et al. 2012, 2017).

The experimental base for research, development and testing works on SNF extraction processes, equipment and methods for managing and controlling SNF processing was a large radiochemical facility located on Building B a few decks (from the first to the forth). In 2012, LRWs previously accumulated during operation (190-FZ) were removed from the tanks of the facility and transferred to FSUE RosRAO. The capacitive equipment was also to be removed as part of the decommissioning works (Kuznetsov et al. 2014).

The paper describes the technology for managment the large-sized radiation-contaminated tanks during Building B decommissioning at the Bochvar Institute site.

# Brief description of removed equipment

The radiochemical facility had four decks. The floor of the lowermost deck was concrete and the floors of upper deck were made of corrugated metal sheeting. The facility area on the lowermost deck floor is 138.6 $m^2$. The entrance to the facility was from the second deck. The main equipment of the facility included tanks, pumps, pipelines, receivers, pulsators, electrical appliances, and instrumentation and automated control systems (Fig. 1). A list and brief characteristics of the capacitive equipment are given in Tab. 1.

A radiation survey of the internal equipment surfaces, carried out after the removal of the RW accumulated during the facility operation, showed the presence of sediments and deposits that had accumulated for a long operational period. It has been established that the radionuclides that determine the radioactive contamination of the large-sized capacitive equipment are long-lived $\alpha$-emitting isotopes: $^{235}U$, $^{238}U$ and $^{239}Pu$ (Kuznetsov et al. 2016). In the existing infrastructural and technological conditions of Building B, it was not possible to completely remove the contamination of the internal equipment surfaces; therefore, it was

**Figure 1.** Radiochemical facility equipment.

**Table 1.** A list and brief characteristics of the capacitive equipment.

| No. | Component | Overall dimensions, mm | Quantity | Weight u/kg | Wall thickness, mm | Contaminations |
|---|---|---|---|---|---|---|
| **The lowermost deck** | | | | | | |
| 1 | Tank | Ø 1000×1390 | 1 | 350 | Up to 4 mm, upper part: up to 8 mm | U-238 up to $10^3$ Bq/g |
| 2 | Tank | Ø 800×1160 | 1 | 350 | Up to 5 mm, upper part: up to 8 mm | U-238 up to $10^3$ Bq/g |
| 3 | Tank | Ø 800×1970 | 1 | 350 | Up to 4 mm, upper art: up to 8 mm | U-238 up to $10^3$ Bq/g |
| 4 | Agitation tank | Ø 1000×1500 | 2 | 1700 | Up to 10 mm | U-238 up to $10^3$ Bq/g |
| 5 | Tank | Ø 700×1390 | 1 | 235 | Up to 5 mm, upper part: up to 8 mm | U-238 up to $10^3$ Bq/g |
| 6 | Tank | Ø 800×1490 | 1 | 350 | Up to 5 mm, upper part: up to 8 mm | U-238 up to $10^3$ Bq/g |
| 7 | Tank | Ø 1000×1730 | 4 | 460 | Up to 5 mm, upper part: up to 8 mm | Two tanks: U-235 up to $10^3$ Bq/g (enriched up to 1,66%), 2 tanks: U-238 up to $10^2$ Bq/g |
| 8 | Tank | Ø 1900×2300 | 2 | 1270 | Up to 20 mm | U-238 up to $10^3$ Bq/kg |
| 9 | Pump | 500×300×400 | 1 | 50 | – | U-238 up to $10^4$ Bq/g |
| **The second and the third decks** | | | | | | |
| 10 | Tank | Ø 1000×1730 | 1 | 450 | Up to 5 mm, upper part: up to 8 mm | U-238 up to $10^3$ Bq/g |
| 11 | Tank | Ø 400×1160 | 3 | 92 | Up to 5 mm, upper part: up to 8 mm | Two tanks: U-238 up to $10^3$ Bq/g 1 tank: Pu-239 up to $10^2$ Bq/g |
| 12 | Tank | Ø 700×1390 | 6 | 235 | Up to 5 mm, upper part: up to 8 mm | 5 tanks: Pu-238 up to $10^2$ Bq/g 1 tank: U-238 up to $10^3$ Bq/g |
| 13 | Tank | Ø 800×1970 | 2 | 350 | Up to 5 mm, upper part: up to 8 mm | Pu-239 up to $10^2$ Bq/g |
| 14 | Tank | Ø 1400×2730 | 1 | 1375 | Up to 10 mm | Pu-239 up to $10^2$ Bq/g |
| **Equipment located on several decks** | | | | | | |
| 15 | Vibration absorption unit | Ø 2000×4500 | 1 | 2500 | Up to 5 mm | U-238 up to $10^3$ Bq/g |
| 16 | Pulsation unit | Ø 1300×6400 | 1 | 1980 | Up to 5 mm, upper part: up to 8 mm | U-235 up to $10^4$ Bq/g (enriched up to 1,66%), |
| 17 | Extraction column | Ø 200×4200 | 1 | 200 | Plexiglas (thickness up to 5 mm), metal – frame | U-238 up to $10^3$ Bq/g |
| 18 | Extraction column | Ø 200×4200 | 1 | 250 | Plexiglas, metal – frame | U-238 up to $10^3$ Bq/g |

decided to dismantle and subsequently transfer the radiation-contaminated capacitive equipment to contractor. To remove the capacitive equipment, it was necessary to carry out a set of measures to ensure its safe dismantling, transporting and loading into transport containers. Special attention was paid to ensuring security during the work, since the enterprise was located within the boundaries of Moscow (Vereschagin et al. 2016).

# Preparatory work

To ensure radiation safety during the work, a sanitary lock was created to separate clean and dirty areas (NP-057-04). The premises of the facility were previously divided into sections in accordance with the technology adopted in the working documentation (volumes 109001.000Б.120005-TX5 and 109001.000Б.120005-TX6 of the "Bochvar Institute Building B Decommissioning" project, JSC RAOPROEKT, 2012). The sanitary lock was equipped with radiometric control devices and plastic containers were installed to collect contaminated overalls.

The equipment and pipelines were brought to a state suitable for safe dismantling; in particular, the large installation communications were blown with compressed air to remove residual process media (Savin et al. 2013, Sukhanov et al. 2013c, Efremov et al. 2015).

Before starting the main work on dismantling the large-sized equipment, the large installation piping manifolds and process pipelines were dismantled and removed. The manifold connections were partly flanged and partly welded. The total length of the dismantled radiation-contaminated pipelines was about 1500 m (with pipe diameters from 12 to 120 mm). The pipes were made of stainless steel, rubber, plastic, and ferrous metal. The piping manifolds were removed both using a hydraulic tool and manually (the connector for mating flanges) (Fig. 2). The instrumentation of the monitoring, measuring and control systems was completely dismantled; the instrumentation and automated control cables were disconnected from the sensors and instruments of control, protection and alarm systems, and dismantled.

# Removal of the column-type capacitive equipment

The radiochemical facility included four units of long-length column-type equipment with heights from 4.2 to 6.4 m:

- one pulsation unit (surface contamination up to $10^4$ Bq/g for $^{235}$U);
- one vibration absorption unit (surface contamination up to $10^3$ Bq/g for $^{238}$U); and
- two extraction columns (surface contamination up to $10^3$ Bq/g for $^{238}$U);

To dismantle them in accordance with the design solutions, a monorail hoist was mounted and a winch was installed on the beam channels of the facility the uppermost deck. Hatches were cut into the upper deck floors and the columns were dismantled through these hatches (Fig. 3).

**Figure 2.** Dismantling the process pipelines.

Dismantling was carried out using plasma cutters and a local suction to prevent radionuclides from entering the air of the working area.

## Removal of the radiation-contaminated capacity equipment

In total, during the large installation dismantling, 26 units of capacitive equipment were to be removed. The maximum equipment capacity was 8 $m^3$.

In order to remove large-sized capacitive radioactive wastes from the large installation the lowermost deck, the window opening was expanded. The expanded opening was reinforced with welded metal structures. From the outside, the opening was sealed with two layers of polyethylene film. After the work was completed, a metal shield was installed indoors.

For the mechanized removal of the large-sized capacitive equipment, crane runways and guides were created and carts were used. The crane runways and guides were made in a mobile version to extend them beyond the building for at least one meter, to mechanize the movement of large-sized radioactive waste into the transport container (Fig. 4).

During the dismantling process, all the holes in the equipment were filled with mounting foam. Polymer coating based on polyvinyl alcohol was applied on the equipment to be removed, to localize surface radioactive contamination. To create a more stable coating, it was applied twice: the second layer was applied after the first layer was completely dried (Fig. 5).

The dismantled large-sized equipment was disconnected from the beds and stands; then, with the help of the hoist and the winch, it was moved onto a cart on the crane runways; afterwards it was fixed on the cart and moved into a transport container (Fig. 6).

The large-sized process equipment was loaded into the PU-2ETS-ST containers (Fig. 7) and sent to FSUE RosRAO for compaction, conditioning and temporary storage before being transferred to the National Operator for RW and Technological Waste Managment (Vereshchagin et al. 2017).

## Equipment decontamination

During the work on dismantling the equipment of the radiochemical facility, special attention was paid to reducing the amount of accumulated radioactive waste.

**Figure 3.** Removal of the column-type equipment.

**Figure 4.** Opening in the wall of the radiochemical facility; crane runways.

**Figure 5.** Applying polymer localizing coating.

**Figure 6.** Dismantling and removal of the large-sized capacitive equipment.

**Figure 7.** Loading of the large-sized radiation-contaminated equipment into the PU-2ETS-ST transport containers.

**Figure 8.** Foam decontamination of the internal equipment surfaces.

As mentioned above, it was not possible to completely decontaminate the internal equipment surfaces. Decontamination was carried out by treating the internal equipment surfaces with acidic foam compounds (Fig. 8). The decontamination factor ranged from 25 to 70. As a result of the decontamination works, the radioactive waste activity was reduced (for radiation-determining transuranic radionuclides, the RW class was changed from 3 to 4) (Resolution of the Government of the Russian Federation No. 1069).

# Conclusion

Totally, after dismantling the capacitive equipment of Building B radiochemical facility, 26 units of equipment were dismantled and removed, including two 8 $m^3$ tanks and and four units of long-length column-type capacitive equipment. Treating the internal equipment surfaces with foam-forming decontamination compositions made it possible to change the RW class from 3 to 4. Dismantling the large-sized equipment of the radiochemical facility was a unique task performed by the Bochvar Institute personnel, which later made it possible to reconstruct the facility site for managing radioactive waste accumulated during Research Building B decommissioning, using modern safety methods, under the conditions of the Bochvar Institute site located within a megalopolis, i.e., the city of Moscow.

# References


- 190-FZ Federal Law (2011) "On radioactive waste treatment and on amendments to certain legislative acts". http://www.consultant.ru/document/cons_doc_LAW_116552/ [accessed: October 10, 2018]
- Efremov AE, Belousov SV, Vereshchagin II, Kuznetsov AYu (2015) Managment of large-size radioactive waste during decommissioning of the research building. VII Russian Youth School of Radiochemistry and Nuclear Technology. Radiochemistry-2015, Zheleznogorsk (Krasnoyarsk Territory), 167.
- Federal Law of the Russian Federation (2011) Concerning the radiation safety of the population (as amended on July 19, 2011). http://docs.cntd.ru/document/9015351 [accessed: October 10, 2018]
- FTP NRS-2 Archives (2018) The Federal Target Program "Ensuring nuclear and radiation safety for 2016–2020 and for the period up to 2030". http://фцп-ярб2030.рф/about/archiv/ [accessed: October 10, 2018]
- Kuznetsov AYu, Azovskov ME, Antsiferova EYu, Belousov SV, Voronko GI, Kotov AL, Kukava VJ, Novoselova AP, Savin SK, Sukhanov LP, Tuzov YuV, Shirokov SS (2014) The Initial Stage of Decommissioning Research Building B at the Bochvar Institute. Yadernaya i radiatsonnaya bezopasnost Rossii 17: 73–84. http://www.fcp-radbez.ru/images/stories/FCP/materiali/sb17.pdf [accessed: October 10, 2018]
- Kuznetsov AYu, Belousov SV, Savin SK, Azovskov ME, Khlebnikov SV, Efremov AE, Vereshchagin II, Shirokov SS (2016) The Study of Precipitation and Deposits in Special Communication Systems of Building B at the Bochvar Institute. Atomnaya energiya 120(3): 162–164. https://doi.org/10.1007/s10512-016-0119-6
- Kuznetsov AYu, Belousov SV, Savin SK, Komarov EA, Udalaya MV, Sobko AA (2017) The Main Results of Decommissioning Research Building B at the Bochvar Institute. Atomnaya energiya 123(4): 210–216. https://doi.org/10.1007/s10512-018-0335-3
- Kuznetsov AYu, Savin SK, Sukhanov LP, Utrobin DV, Chernikov MA (2012) State of Affairs and Plans for Decommissioning Research Building B at the Bochvar Institute. Yadernaya i radiatsonnaya bezopasnost Rossii 13: 120–132. http://www.fcp-radbez.ru/images/stories/FCP/materiali/sb13.pdf [accessed: October 10, 2018]
- NP-057-04 (2018) Safety regulations for decommissioning nuclear fuel cycle facilities (2017) NP-057-04: Safety regulations for decommissioning nuclear fuel cycle facilities http://sudact.ru/law/prikaz-rostekhnadzora-ot-14062017-n-205-ob/np-057-17/ [accessed: October 10, 2018]
- Order No. 484-p of April 19 (2007) On Approval of the Concept of the Federal Target Program "Ensuring nuclear and radiation safety for 2008 and for the period up to 2015". http://www.alppp.ru/law/bezopasnost-i-ohrana-pravoporjadka/3/rasporjazhenie-pravitelstva-rf-ot-19-04-2007--484-r.html [accessed: October 10, 2018]
- Resolution of the Government of the Russian Federation No. 1069 of October 19 (2012) "On the criteria for categorizing solid, liquid and gaseous wastes as radioactive wastes, criteria for categorizing radioactive wastes as special radioactive wastes and disposed radioactive wastes, and criteria for classifying disposed radioactive wastes". http://base.garant.ru/70247038/ [accessed: October 10, 2018]
- Savin SK, Kuznetsov AYu, Shernikov MA (2013) Research & development and application of low waste decontamination technologies. Abstracts of the 5th International Conference Decommissioning Challenges: Industrial Reality and Prospects. Société Française d'Energie Nucléaire: 31.
- Sukhanov LP, Kuznetsov AYu, Chernikov MA, Savin SK, Belousov SV, Shirokov SS (2013a) Preparation for Practical Works on Decommissioning Research Building B at the Bochvar Institute. Yadernaya i radiatsonnaya bezopasnost Rossii 15: 61–69. http://www.fcp-radbez.ru/images/stories/FCP/materiali/sb15.pdf [accessed: October 10, 2018]
- Sukhanov LP, Kuznetsov AYu, Chernikov MA, Voronko GI (2013b) Decommissioning of the Bochvar Institute "Nuclear Legacy". Bezopasnost okruzhayushchey sredy 3–4: 95–99.
- Sukhanov LP, Kuznetsov AYu, Shernikov MA (2013c) Decommissioning of nuclear legacy facilities of A.A. Bochvar Research Institute. Abstracts of the 5th International Conference Decommissioning Challenges: Industrial Reality and Prospects. Société Française d'Energie Nucléaire, 49.
- Vereschagin II, Belousov SV, Efremov AE, Khlebnikov SV, Kuznetsov AYu (2016) Ensuring Radiation Safety During Decommissioning Building B at the Bochvar Institute. VII Russian Youth School of Radiochemistry and Nuclear Technology: Abstracts. Ozersk, 24. [in Russian]
- Vereshchagin II, Kuznetsov AYu, Belousov SV, Savin SK, Khlebnikov SV (2017) The main and final stages of decommissioning Research Building B at the Bochvar Institute. Proc. of the Conf. "Environmental, Industrial and Energy Security". Sevastopol. SevGU Publ.: 244–246.