EXPERIMENTAL RETRIEVAL OF INTERMEDIATE-LEVEL SOLID WASTE FROM SSC RIAR'S STORAGE COMPARTMENT FOR INTERMEDIATE- AND HIGH-LEVEL SOLID RADIOACTIVE WASTE

Mamonov A. V., Davydov V. V., Mamonova Yu. A., Razzhivin S. G., Lyubchenko M. L., Gordeev V. P.

JSC SSC RIAR, Dimitrovgrad, Ulyanovsk region, Russia

Article received on October 21, 2021

Adapted from the Proceedings of the Third International Scientific and Practical Conference on the Environmental Protection and the Management of Radioactive Waste from Scientific and Industrial Centers, FSUE RADON, September 22—23, 2021.

This article briefly describes the efforts on the experimental retrieval of intermediate-level solid waste from a storage compartment for intermediate- and high-level solid radioactive waste. It presents the characteristics of the retrieved radioactive waste and the radiation control indicators.

Keywords: *radioactive waste, solid radioactive waste, experimental retrieval, packaging, radionuclide composition, gamma radiation dose rate, specific activity.*

Along with other types of radioactive waste, research and production activities of JSC SSC RIAR's subdivisions result in high-level solid waste (HSRW). Waste accumulation rate was evaluated. It was shown that if the rate of SRW generation in the departments of the Institute remains the same, the free capacity of intermediate- and high-level SRW storage facilities (hereinafter referred to as the SRW SF), intended for their storage, can get exhausted by 2025—2026.

The HSRW storage facility operated by SSC RIAR was commissioned in 1986. Since 2006, the free compartments of the storage facility have been accepting solid intermediate-level waste (hereinafter, ISRW) for storage. HSRW facilities had to be used to store ISRW since SRW storage facility designed for ILW storage was almost full.

In 2006—2020, due to industrial estate reconstruction and modernization at the site, most of the HSRW storage capacity was filled with ILW.

In keeping with the requirements of modern norms and rules, Container Storage Facility (CSF) for solid low- and intermediate-level waste was constructed to provide safe management of SRW [1—3] generated at SSC RIAR site. The project titled Reconstruction of SSC RIAR's Storage Facilities and Safe Storage of Solid Radioactive Waste was implemented under FTP NRS 2008—2015 and resulted in a solid radioactive waste storage facility fitted with process units designed for waste segregation, processing, conditioning and certification.

CSF useful capacity amounts to 3,000 m^3 with a design service life of 30 years.

However, further storage of annually generated HSRW inventories and its prospects was still a pending issue.

To support scientific and production activities of SSC RIAR's subdivisions resulting in HSRW generation, it was decided to empty a large-sized compartment of the HSRW storage facility: ISRW would be removed from it within 3—5 years to accommodate high-level waste.

Different RW retrieval options were considered. It was decided to perform the work using SSC RIAR's own resources avoiding labor-intensive and costly production and engineering chains, but at the same time providing compliance with relevant safety requirements.

To implement the engineering solutions intended for waste retrieval, the following efforts were implemented:

- compartment to be emptied from ISRW was chosen;
- feasibility of a method selected to handle the retrieved SRW was evaluated;
- regulatory and engineering documentation was developed;
- necessary equipment was purchased;
- necessary preparations were implemented at the site;
- the stuff got necessary training;
- amendments were made to the terms of the license (TL) for radioactive waste management at JSC SSC RIAR site.

Based on the radiation survey and the analyzed characteristics of ISRW stored in the HSRW storage facility, a compartment was selected: it was characterized with the lowest equivalent dose rates at a distance of 1 m from the SRW and contained federally owned waste (the waste had been emplaced into the storage facility before the Federal Law No. 190-FZ On Radioactive Waste Management and Amendments to Certain Legislative Acts of the Russian Federation of July 11, 2011 was enacted [4]).

In terms of ISRW radionuclide composition, it includes alpha and beta emitting radionuclides. As for its morphology, the composition of the waste in the storage compartment is quite varied: rags, paper, film, personal protective equipment, glass, metal shavings, rubber, dismantled equipment (heat exchangers, pumps, devices, D-23 type filters). Most of the RW in the compartment was packaged into primary packaging (polyethylene or kraft bags).

Under the work program approved, ISRW retrieval flowchart included the following:

- barrier fencing of the work site and a sanitary barrier fitted with all devices and personal protective equipment (PPE) necessary to provide radiation monitoring and protection of the personnel at the work site were arranged;
- required number of containers was supplied, a stainless-steel pallet required to accommodate the retrieved RW packages was installed;
- RW packages were gripped in the compartment using a grapple, moved to the upper part of the compartment for preliminary measurements of SRW radiation parameters, shipped to the control site in compliance with the work time limits depending on the actual parameters of the radiation situation;
- survey was performed to identify alpha-active SRW and packages with the highest gamma dose rates;
- RW packages were segregated according to gamma dose rate levels at a distance of 0.1 m from the RW surface to separate them into LLW and ILW categories;
- SRW was packaged into containers;
- containers were sealed, decontaminated and shipped to the container storage facility for solid low- and intermediate-level waste.

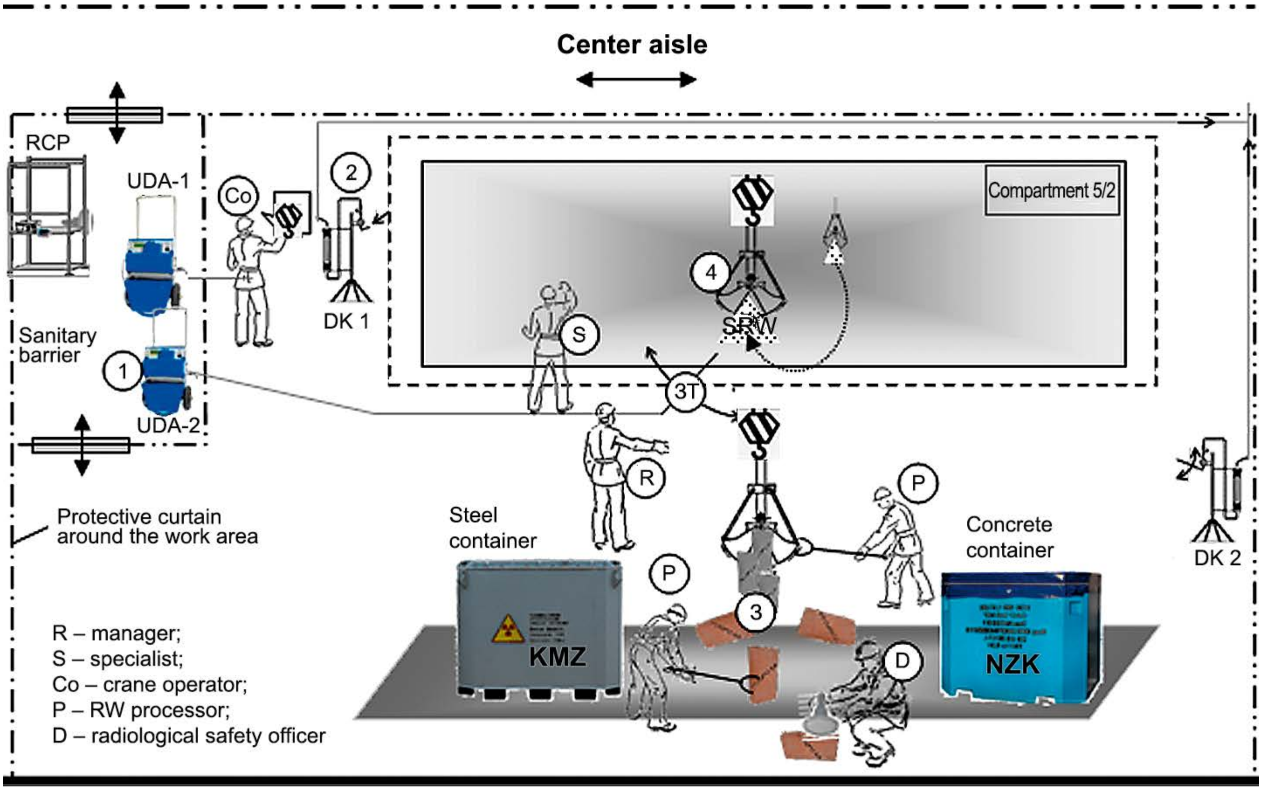
Figure 1 shows the general flowchart for the experimental RW retrieval from the compartment of building 143.

Figure 1. RW management flowchart for the experimental waste retrieval from the compartment of building 143

Solid low-level waste (LSRW) removed from the compartment was packaged into KMZ-M containers, and ISRW — into NZK-150-1.5P containers [5]. During the waste segregation stage, ISRW packages were not expected to be opened.

During ISRW retrieval from the compartment, the volumetric activity of aerosols was monitored continuously using automated UDA-1AB installations. Personnel access to the unloading area was provided on condition that the aerosol volumetric activity that did not exceed the established control level for temporary residence premises. Before the packages were loaded into containers, the radioactive contamination level with alpha-emitting radionuclides at their surface was measured. Particular attention was paid to damaged primary packages: they were emplaced into secondary packaging (PVC film, bag).

Constant radiation monitoring (RM) of personnel workplaces was in place during work execution: a remote tool was used for these purposes allowing to specify the required restrictions on the distance from the radiation sources. Grab bars were used to



RCP — radiometric control point; 1 — UDA-1AB installation with a pumping unit; 2 — mobile unit for air sampling to the AFA filter connected by a hose to the vacuum line; 3 — SRW package; 4 — grab; 5 — sampling line (silicone); IP — Smog-type intake pipe

Figure 2. Layout of equipment, technical tools for radiation monitoring and workplaces at RW retrieval sites

load SRW packages into containers. Figure 2 presents the layout of RM technical means and the workplaces at the site of experimental SRW retrieval.

Gamma radiation field from RW and the volumetric air activity at work sites were considered as radiation hazard factors for the experimental site. Gamma dose rate measured directly inside the compartment amounted to 4—6 mSv/h, whereas at the border of the compartment it was ranging from 12 to 40 µSv/h. Waste retrieval operations involved issuance of permits for radiation hazardous work with a planned individual exposure dose of 375 µSv for personnel.

SRW activity was calculated based on the gamma radiation dose rate measured at a distance of 0.1 m from the outer surface of the package according to the reference literature [6]. In these calculations, a characteristic SRW radionuclide composition was used: ^{137}Cs, ^{60}Co, ^{241}Am, ^{152}Eu. The bulk density of SRW was taken equal to 0.1 to 0.2 g/cm^3.

In terms of morphological composition, most of the retrieved RW consisted of rags, PPE, PVC film and metal items (engine elements, buckets, valve assemblies, etc.). A total of 6 aerosol filters type D-23 was removed.

The SRW activity in the containers was calculated based on the measured gamma radiation dose rate at a distance of 1 m from the side surfaces at nine points evenly spaced over the active part. Therefore, the heterogeneity of activity distribution could be accounted for in the estimated average dose rates. Under the calculation procedure, the radionuclide composition of SRW found in the containers was refined based on the data from spectrometric measurements focused on the side surface of the KMZ containers (the thickness of steel walls accounted for 5 mm) and those performed through an access hole (for cement supply) penetrating the upper lid of KMZ containers (thickness of concrete walls of 180 mm). For these purposes, MKS-AT6101D ATOMTEH spectrometer was used.

Gamma radiation dose rate at a distance of 1 m from the side surface (maximum levels) of KMZ-M containers ranged from 60 to 300 µSv/h, and the one from the NZK containers — from 20 to 300 µSv/h. MKS-AT6101D spectrometer was used to identify the main radionuclides.

For ILW packages, the maximum gamma radiation dose rate was found to be ranging from 4 to 5 mSv/h (process filters). Radioactive contamination of individual items found in damaged RW packages exceeded 20,000 alpha particles/(cm^2·min).

The total activity of all RW removed amounted to 10^7 kBq.

The individual exposure dose of the personnel during the work on admission did not exceed 30 % of the daily quota (60 µSv).

As a mean of personal respiratory protection, Lepestok-200 respirator was used assuming a time limit for continuous operation from 30 minutes to 1 hour. Respirators were promptly checked for radioactive contamination (inside and outside). According to the measurements, no radioactive contamination with alpha-emitting radionuclides over 1 $cm^{-2}\cdot min^{-1}$ was detected.

Experimental RW retrieval, excluding the preparatory period, took 12 working days. As a result, a total inventory of 24 m^3 of LSRW and ISRW was removed from the storage compartment and packaged into 8 NZK-type containers and 4 KMZ-type containers.

SRW retrieval from the storage compartment has proved to be beneficial in terms of the experience gained from the testing of the selected ILW retrieval method. Its efficiency and safety were demonstrated. It also helped to gain data on further improvement and optimization of the RW retrieval technology, including relevant technical means and managerial measures.

A large-size compartment was emptied providing free capacity for HSRW acceptance by the storage facility for a period of more than 10 years. During this period some optimal solutions for further HSRW management could be developed for SSC RIAR. ISRW retrieval from the compartments of HSRW storage facility is considered a key task under the local RW management strategy of JSC SSC RIAR for 2021–2025.

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Information about the authors

Mamonov Alexey Vladimirovich, head of Service-RWMC, JSC SSC RIAR (9, Zapadnoye Shosse, Ulyanovsk region, Dimitrovgrad, 433510, Russia), e-mail: avmamonov@niiar.ru.

Davydov Vladimir Vladimirovich, chief engineer of Service-RWMC, JSC SSC RIAR (9, Zapadnoye Shosse, Ulyanovsk region, Dimitrovgrad, 433510, Russia), e-mail: vvdavidov@niiar.ru.

Mamonova Yulia Aleksandrovna, chief specialist of the analytical group of Service-RWMC, JSC SSC RIAR (9, Zapadnoye Shosse, Ulyanovsk region, Dimitrovgrad, 433510, Russia), e-mail: yuademina@niiar.ru.

Razzhivin Stanislav Gennadievich, leading engineer of the analytical group of Service-RWMC, JSC SSC RIAR (9, Zapadnoye Shosse, Ulyanovsk region, Dimitrovgrad, 433510, Russia), e-mail: yuademina@niiar.ru.

Lyubchenko Mikhail Lvovich, head of the radiation safety department of Service-RWMC, JSC SSC RIAR (9, Zapadnoye Shosse, Ulyanovsk region, Dimitrovgrad, 433510, Russia), e-mail: vvdavidov@niiar.ru.

Gordeev Viktor Petrovich, head of the solid radioactive waste management department of Service-RWMC, JSC SSC RIAR (9, Zapadnoye Shosse, Ulyanovsk region, Dimitrovgrad, 433510, Russia), e-mail: vpgordeev@niiar.ru.

Bibliographic description

Mamonov A. V., Davydov V. V., Mamonova Yu. A., Razzhivin S. G., Lyubchenko M. L., Gordeev V. P. Experimental Retrieval of Intermediate-Level Solid Waste From SSC RIAR's Storage Compartment for Intermediate-and High-Level Solid Radioactive Waste. *Radioactive Waste,* 2021, no. 4 (17), pp. 38—43. DOI: 10.25283/2587-9707-2021-4-38-43. (In Russian).