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CURRENT STATE AND PROSPECTS FOR THE DEVELOPMENT OF RW MANAGEMENT SYSTEM IN THE FAR EASTERN REGION OF RUSSIA

Sidenko K. S., Ponomarenko I. N., Trofimov V. V.

Far East Centre for Radioactive Waste Management — a Subsidiary of FSUE "RosRAO Enterprise for Radioactive Waste Management" (FEC "DalRAO" — subsidiary of FSUE "RosRAO"), Vladivostok, Russia

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The paper describes the practice of radioactive waste management in the territory of Primorskiy Krai. It presents the applied methods, equipment and installations used for decontamination and decommissioning of FEC "DalRAO" facilities. The paper summarizes the results of completed radioactive waste management efforts.

Keywords: *radioactive waste, spent nuclear fuel, radioactive waste processing*

Federal State Unitary Enterprise "Far East Federal Enterprise for Radioactive Waste Management" FSUE "DalRAO" (currently transformed into FEC "DalRAO" — a subsidiary of FSUE "RosRAO") was established in accordance with the order of the Government of the Russian Federation of February 9, 2000 220-r [1] (order of the Atomic Energy Minister of the Russian Federation as of May15, 2000 No. 276).

The enterprise was established to perform operations in the Far Eastern Region of the Russian Federation associated with the management of spent nuclear fuel, solid and liquid radioactive waste, both resulting from naval fleet operations and disposition of nuclear submarines, surface ships with nuclear power units and nuclear maintenance ships (ATO), as well as environmental remediation of nuclear sites.

In accordance with the terms of nuclear licenses, as well as relevant contracts and agreements concluded, the following services are provided by FEC DalRAO being a subsidiary of FSUE RosRAO:

- safe afloat storage of reactor units removed from decommissioned nuclear submarines and nuclear maintenance ships (ATO) withdrawn from naval service;
- safe storage on a solid ground of reactor compartment units removed from dismantled nuclear submarines and ATO packaged units;
- storage of spent nuclear fuel and radioactive waste in storage facilities of the enterprise;
- taking part in the transportation of spent nuclear fuel, its temporary storage and shipment for reprocessing to FSUE PA Mayak;
- processing of solid and liquid radioactive waste resulting from the dismantlement of nuclear submarine and ATOs;
- remediation of contaminated facilities and areas belonging to the enterprise;
- disposition of nuclear submarine and ATO reactor compartments;
- assembling nuclear submarine reactor compartment units and ATO packaged units;
- operation of buildings, facilities and equipment during spent nuclear fuel and radioactive waste management;
- construction of necessary facilities on sites where radiation hazardous operations on the disposition

of nuclear submarine and ATO reactor units takes place;
- maintenance of infrastructure facilities with necessary power, transport, communication resources being supplied;
- security and physical protection of nuclear materials and radioactive waste.

FEC DalRAO being a subsidiary of FSUE RosRAO consists of two departments:
- Vilyuchinsk branch of the Far Eastern Center for Radioactive Waste Management;
- Fokino branch of the Far Eastern Center for Radioactive Waste Management.

SNF management

In 2014, FEC DalRAO completed its efforts on the spent nuclear fuel (SNF) accumulated as a result of naval operations including necessary preparatory activities, unloading from the storage facility and hand over to FSUE PA Mayak for reprocessing. During its entire lifetime, the enterprise handed over some 23,808 irradiated fuel assemblies (SFAs) packaged into 3,636 canisters (43 echelons). At present time, FEC DalRAO possesses nuclear materials held at two emergency nuclear submarines.

At the stage of SNF hand over from the Naval fleet (Ministry of Defense of the Russian Federation) to FSUE Mayak PA, shielded transportation containers with SFAs are temporarily placed on a purpose designated storage site for container accumulation.

Liquid Radioactive Waste Management

In 2001, 3,188.0 m^3 of liquid radioactive waste (LRW) of complex physicochemical composition (salt content from 1 to 22 g/l, pH = 6.5—9) with a total activity of 1.67E+12 Bq was held in temporary storage tanks.

Operations on the management of SNF, radioactive substances (RS) and radioactive waste (RW), remediation of contaminated sites, operation and maintenance of radiation hazardous facilities resulted in 9,450 m^3 of LRW emplaced into storage tanks with some 619.0 m^3 of LRW handed over by the Russian navy (Ministry of Defense of the Russian Federation) having a total activity of 5.62E+11 Bq.

Since the beginning of its production operation, FEC DalRAO have treated some 13,703.0 m3 of LRW of various physicochemical composition to remove strontium-90 and cesium-137 using a pilot production facility “Barrier”.

Since 2015, LRW treatment complex developed by JSC ATOMPROEKT and JSC VNIPIpromtekhnologii has been in operation (Figure 1, 2) [2]. Its design capacity amounts to up to 600 m^3/year (up to 0.2 m^3/h). Solutions are treated to remove contaminants using sorption filters. Replacement and unloading of spent filters is automized.

If non-compliance of treated water parameters with the established discharge standards is revealed, the water is returned to the cycle and the process is repeated from the very beginning. Protection against tank overfilling is provided. The treatment process is controlled automatically from a centralized control panel (Figure 3).

Figure 1. LRW treatment complex

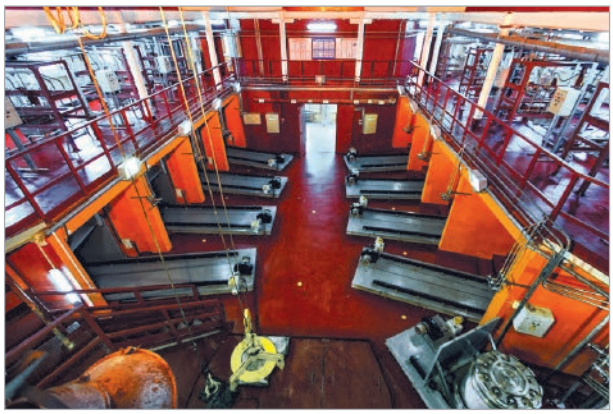

Figure 2. Equipment of the LRW treatment complex

Figure 3. Control panel of the LRW treatment complex

Solid radioactive waste (SRW) resulting from LRW treatment complex operation (disposable filter containers, spent sorbent cartridges) is placed into certified containers and transferred to SRW storage facilities.

All the equipment, including reusable filters can be decontaminated if necessary.

In 2017—2018, to upgrade LRW treatment process, SRM-N sorbent was developed by FEC DalRAO based on already applied SRM sorbent and tested in the pilot production installation Barrier. The newly developed sorbent was designed to remove strontium-90 radionuclides from treated LRW with high salinity [3].

The tests showed that:

1. The efficiency of sorbent SRM-N is higher if compared to SRM when applied to treat solutions with a high content of hardness salts (magnesium and calcium ions) resulting in 1.5–2 fold increase in the treatment capacity of the complex.

2. Due to availability of sodium sulfate, the rate of barium leaching from SRM-N sorbent is much lower as compared to SRM sorbent enabling a 10-fold reduction in the frequency of pipelines washing with chemicals.

Specifications for the modified sorbent were developed jointly with the Institute of Chemistry of FEB RAS and registered with the Federal State Institution "State Regional Center for Standardization, Metrology and Testing in the Primorskiy Territory".

In June 2018, an application was filed with the Federal Service for Intellectual Property by FEC DalRAO requesting a patent for the novel Method of Producing Strontium Sorbent for Hardness Salt Containing Solutions.

Management of solid radioactive waste

The scope of FEC DalRAO activities on SRW management involves collection of waste, including those generated from the decontamination of facilities and territories, its transportation, packaging and temporary storage.

Activities performed in this area during the entire lifetime of FEC DalRAO can be quantitively described as follows:

- 11,223.0 m^3 of solid radioactive waste (SRW) was collected, sorted, packaged and placed into temporary storage facilities;
- 1,656.8 m^3 of SRW was handed over for temporary storage by organizations engaged in nuclear submarine dismantlement;
- 157 radioisotope thermoelectric generators (RTGs) were handed over for disposal;
- 7,321.7 m^2 of contaminaed lands was remediated.

Currently, 20 storage facilities belonging to the Fokino branch hold some 24,871.0 m^3 of low-, intermediate- and high-level SRW (Figures 4, 5). Besides that, 1,050.8 m^3 of SRW are stored in reactor compartment units of dismantled submarines and ATO packaged units.

In the Vilyuchinsk branch, work is underway on SRW retrieval from storage facilities, its packaging and certification enabling its subsequent shipment to the Fokino branch for long-term storage.

Upon completing these efforts, the storage facilities and the adjacent territory will be remediated. To enable comprehensive solution of SRW management challenges, construction of a Regional Center for the Radioactive Waste Conditioning and Long-Term Storage was started at the Fokino site in 2016.

The Center is designed as an industrial complex enabling processing and conditioning of radioactive waste resulting from the operations on the disposition of nuclear submarines, surface ships with nuclear power units, nuclear maintenance ships, remediation of nuclear sites, as well as disposition of nuclear weapons and military equipment.

The Center will enable waste processing and conditioning to ensure the safety of the RW both accumulated in storage facilities and being

Figure 4. Temporary storage facility for conditioned RW

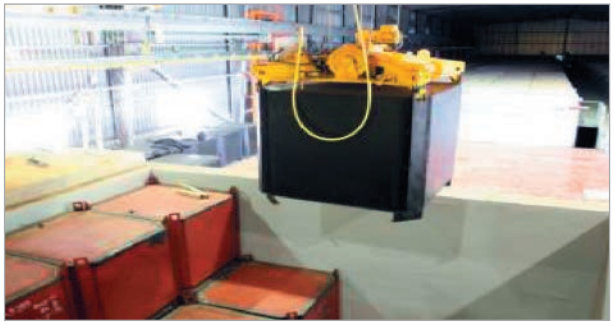

Figure 5. Emplacement of conditioned RW into a storage compartment

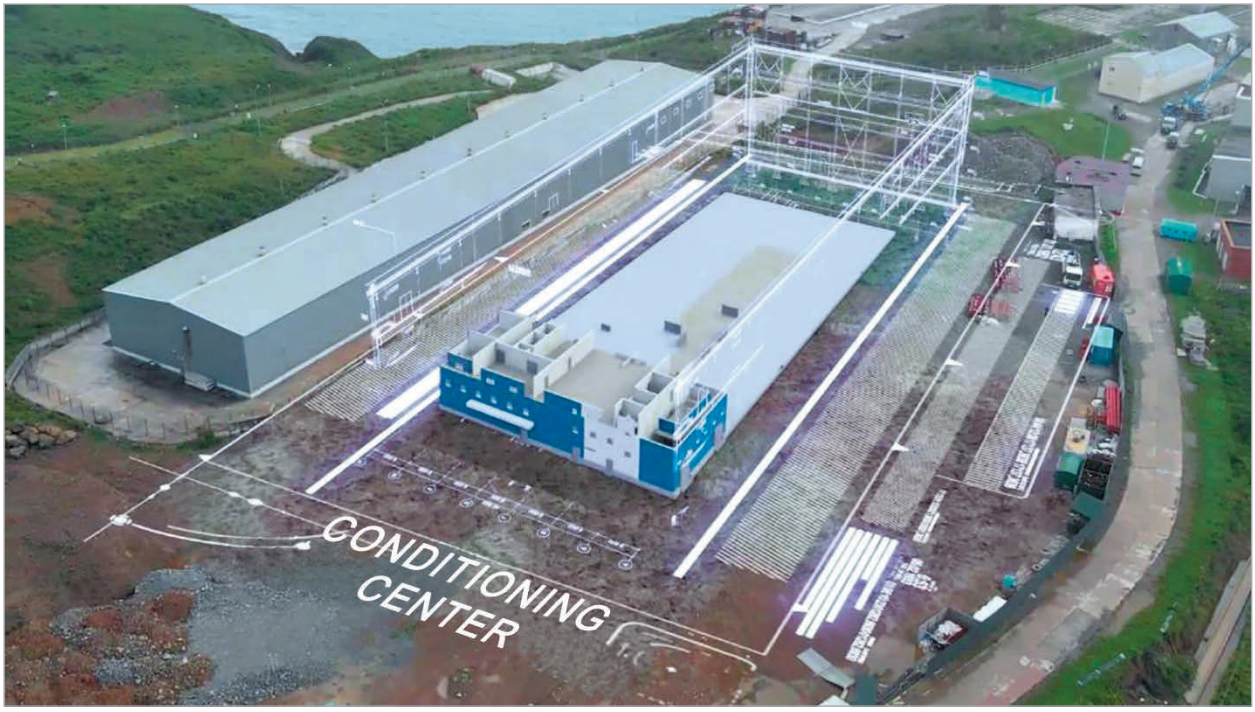

Figure 6. General view of the Regional center for conditioning and long-term storage of radioactive waste

generated during operation and decommissioning of radiation hazardous facilities. Conditioned radioactive waste will be handed over to FSUE NO RAO for disposal. The complex has a design capacity of 1,500 m^3 of RW delivered to the site per year (Figure 6).

Developed designs provide for the following units and installations to enable RW processing and conditioning at the site:

- container receiving and segregation unit for low-level waste;
- dry decontamination unit for low-level metal waste;
- drying unit for incinerated and compacted low-level waste;
- fragmentation unit for low-level metal waste;
- segregation unit for intermediate-level waste;
- dry decontamination unit for intermediate-level metal waste;
- fragmentation unit for intermediate-level metal waste;
- drying unit for incinerated and compacted intermediate-level waste,
- liquid decontamination unit;
- radioactive waste compaction unit;
- solid radioactive waste incinerator;
- RW cementing unit;
- unit for radioactively contaminated soil separation.

In 2021, pre-commissioning operations are planned to be completed and the RW processing and conditioning complex to be put it into commercial operation.

Formation and storage of dismantled nuclear submarine reactor compartment units, ATO packaged units and insulating containers with nuclear power units

Formation and controlled storage of dismantled nuclear submarine reactor compartment units, ATO packaged units and insulating containers with nuclear power units is seen as a main task of FEC DalRAO. This type of waste is stored both afloat and at the site of long-term storage facility (Figure 7).

Over the entire operation time of the enterprise:

- a total of 67 floating dismantled nuclear submarine units (64 three-compartment, 2 four-compartment, 1 nine-compartment) were accepted for storage;

Figure 7. Emplacement of single-compartment reactor units into long-term storage facility

- 50 single-compartment units of dismantled nuclear submarines and 5 ATO vessel packaged unit (TNT-50, TNT-16, TNT-4) were produced and transferred for the long-term storage;

Under state contracts, 12 single-compartment units being subsequently subject to long-term storage are produced annually.

Radiation and environmental safety

All operations involving radioactive materials and radioactive waste are arranged for and performed by FEC DalRAO DC in keeping with relevant requirements of environmental legislation, sanitary norms and rules, as well as federal norms and rules in the field of atomic energy use.

NRS service carry out production radiation control operations, as well as radiation monitoring of environmental objects both within the production zone of facilities and in the sanitary protection zones around production facilities, as well as along the routes intended for RW transportation.

Long-term observations show that the controlled parameters do not exceed the established standards demonstrating the environmental safety of the enterprise.

References

1. Rasporyazhenie Pravitel'stva Rossijskoj Federacii ot 09.02.2000 № 220-r "O sozdanii gosudarstvennyh unitarnyh predpriyatij "Severnoe federal'noe predpriyatie po obrashcheniyu s radioaktivnymi othodami" i "Dal'nevostochnoe federal'noe predpriyatie po obrashcheniyu s radioaktivnymi othodami" [Resolution of the Government of the Russian Federation of 09.02.2000 No. 220-r "On establishment of state unitary enterprises "Northern Federal Facility for Radioactive Waste Management" and "Far-Eastern Federal Facility for Radioactive Waste Management"].

2. Unikal'nye tekhnologii ochistki ZHRO ispol'zuyutsya na predpriyatii RosRAO v Primor'e [Unique technologies for LRW treatment are used at RosRAO facility in Primorye]. URL: https://primamedia.ru/news/479616/.

3. Avramenko V. A., Zheleznov V. V., Papynov E. K., Barannikova A. O., Sokolnitskaya T. A. Sovremennye tekhnologii v praktike obrashcheniya s «problemnymi» ZHRO v Dal'nevostochnom regione kak perspektiva dlya «Fukusima-1» [The modern technologies in the practice for the treatment of "problem" of LRW in the Far East as a prospect for "Fukusima-1"]. *Sovremennye naukoemkie tekhnologii — Modern high technologies,* 2016, no. 10, pp. 9—18.

Information about the authors

Sidenko Konstantin Semenovich, PhD in Engineering, director of FEC «DalRAO» — subsidiary of FSUE «RosRAO» (39 A, Flotskaya str., Vladivostok, Primorsky Krai, 690013, Russia), e-mail: KSSidenko@rosrao.ru.

Ponomarenko Igor Nikolayevitch, deputy director of FEC «DalRAO» — subsidiary of FSUE «RosRAO» (39 A, Flotskaya str., Vladivostok, Primorsky Krai, 690013, Russia), e-mail: INPonomarenko@rosatom.ru.

Trofimov Viktor Vitalyevitch, head of service of FEC «DalRAO» — subsidiary of FSUE «RosRAO» (39 A, Flotskaya str., Vladivostok, Primorsky Krai, 690013, Russia), e-mail: ViVTrofimov@rosrao.ru.

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