DECOMISSIONING OF THE RADON TYPE RADIOACTIVE WASTE STORAGE FACILITY IN LITHUANIA

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Abstract

Maišiagala Radioactive Waste Storage Facility (MRWSF) in Lithuania is a Radon type disposal facility that had been in operation from 1963 till 1988 and was closed in 1989. It consists of a subsurface concrete vault with an overall volume of about 200 m^3. The vault was filled to about 60 % with legacy radioactive waste (RW, ~114 m^3) generated at industrial, medical, military, and scientific research institutions. The RW was concrete grouted layer by layer inside the vault cells. Since 2002, it has been supervised by the SE Radioactive Waste Management Agency (RWMA), which was established in 2001 to deal with RW disposal. In 2019, after reorganization by merging RWMA to SE Ignalina NPP, the supervision of MRWSF was transferred to SE Ignalina NPP which is also is charge of MRWSF decommissioning. In 2016, the decision was taken to retrieve the RW from MRWSF and transport it to Ignalina NPP for further management. The site of MRWSF needs to be remediated and released for unrestricted use. In the paper, a detailed description of MRWSF and the waste loaded in the vault is provided. The selection of the decommissioning strategy based on the MCDA analysis is described. The auxiliary systems designed in the Demolition Project for the retrieval and transport of RW to Ignalina NPP are analyzed. Main safety issues analyzed in the Safety analysis report are highlighted.

1. INTRODUCTION

Maišiagala Radioactive Waste Storage Facility (MRWSF) is a Radon type disposal facility that had been in operation from 1963 till 1988 and was closed in 1989. MRWSF is located in Bartkuškis forest of Žalioji forestry, Širvintos district, at the distance of 9 km from Maišiagala to the northeast, and 40 km from Vilnius. The area of MRWSF territory is 2.7 ha. In this territory there are following facilities erected: an administrative building, a garage, a former decontamination building, a liquid radioactive waste tank and the vault for solid waste. There is also so called „area B" that is an area of several square meters contaminated with Ra-226 salts.

The storage facility consists of the rectangular monolith concrete vault with internal dimensions 5 x 15 x 3 m (W × L × D). The overall volume is about 200 m^3. The vault is of typical design TP-4891 of repository for special type waste.

The vault is divided into six sections by wooden walls. The RW was concrete grouted layer by layer inside the vault sections. The concrete absorbs and weakens ionizing radiation emitted by the radionuclides contained in the radioactive waste and prevents them from being washed out with water and spreading farther.

Waste loaded to MRWSF is radioactive waste generated in industry, military, medicine and scientific research institutions. The waste was transported to the MRSF not only from Lithuania, but also from Kaliningrad region (Russian Federation), Grodno region (Republic of Belarus) and a small amount of RW from Leningrad (Russian Federation). The waste had been transported to MRWSF until 1989 when the vault was 60 percent filled. The remaining space was filled by sand, and covered by concrete, bitumen, asphalt, and a thick layer of soil.

A liquid radioactive waste tank (200 m^3) is cylindrical shape and is situated 30 meters northeast from the vault. The diameter of the tank is about 9 m and the depth is ~ 3 m. The concrete walls and bottom of the tank are covered with stainless steel plates. This tank was never allowed to be used as intended because its tightness had not been tested. However, due to irresponsible behavior of workers, the inside of the tank was contaminated.

Throughout the long life of MRWSF, its operators have changed. Since its construction in 1963 until 1 March 1967 it had been operated by Bath and laundry trust of Vilnius city. And since 1 March 1967 until 1 August 1973 by the Cemetery maintenance office of Vilnius city. The repository was transferred to the Institute of Physics 1 August 1973. On 1 February 2001, the SE Radioactive Waste Management Agency (RWMA) was established by the Lithuanian Government resolution No. 1487. One of the RWMA responsibilities was supervision of the MRWSF. When the MRWSF was taken over, it was in poor condition, not meeting the standards of the time (see Fig. 1). In 2019, after reorganization by merging RWMA to SE Ignalina NPP the supervision of MRWSF was transferred to Ignalina NPP which is also is charge of MRWSF decommissioning.

FIG. 1. MRWSF in 2002.

2. INVENTORY AND SAFETY UPGRADING

The filling of the vault started from the first section (see Fig. 2). During the filling of the third section, the wooden partitions collapsed, and the stacked waste fell from the third section to the fourth and fifth sections.

Clothes, used filters, paper, plastic waste were placed in plastic bags and thrown down through the openings above the section. Disused sealed radioactive sources (DSRS) with shielding were also thrown down into the vault from the vehicle through the top opening by simply removing one of the floor slabs. DSRS without shielding were lowered into stainless steel containers of 10 liter and 15 liter capacity through stainless steel pipes.

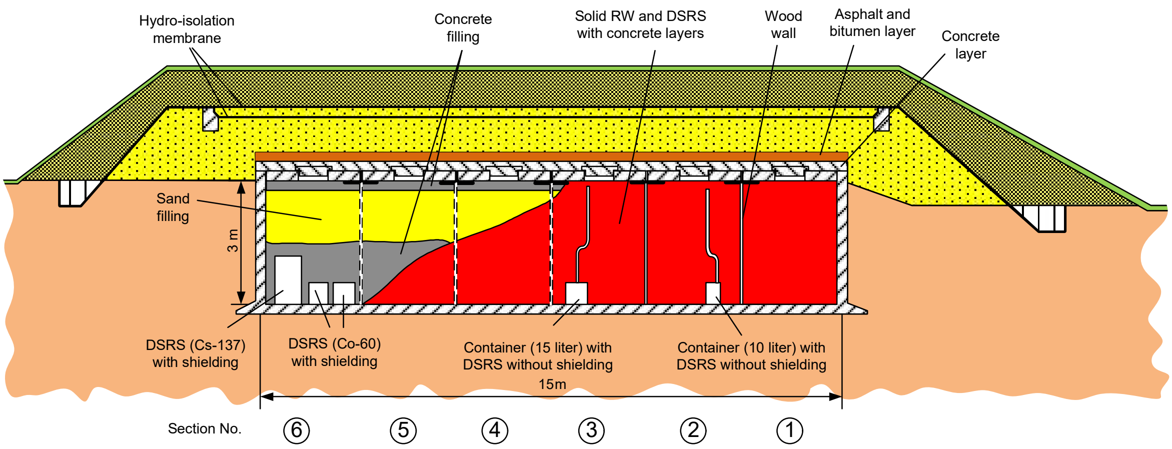

FIG. 2. MRWSF with upgraded protective engineering barriers in 2006.

Liquid radioactive waste was mostly cemented. However, records have been found of the arrival and disposal of liquid radioactive waste in the first vault section. In most cases it is self-luminous liquid spirit solution of Ra-226.

During the operation of the storage facility, once or twice a year, the waste in the storage facility was covered with a layer of concrete.

High activity DSRS (two Co-60 gamma therapy sources and one Cs-137 irradiation source used in research) were placed separately in the sixth vault section keeping them separated from the other waste.

The radionuclide composition and activities of the solid RW (without DSRS) in the vault of the MRWSF are summarized in Table 1. The complete list of radionuclides includes 83 radionuclides. As Table 1 shows, the short-lived H-3 is the most active radionuclide.

TABLE 1. ACTIVITY OF RADIOACTIVE WASTE (EXCEPT DSRS) AT MRWSF IN 2020

Type	Radionuclide	$T_{1/2}$, y	Activity, Bq	Activity, %
Long lived	C-14	5.73 E+03	1.7 E+11	0.34
	Ra-226	1.60 E+03	1.0 E+11	0.21
	Ni-63	96.0	3.3 E+10	0.07
	Cl-36	3.01 E+05	1.2 E+09	0.002
	Pu-239	2.41 E+04	3.0 E+08	0.001
	Others		4.1 E+07	< 0.0001
Short lived	H-3	12.3	4.8 E+13	99.4
	Cs-137	30.0	1.2 E+09	0.003
	Sr-90	29.1	8.7 E+08	0.002
	Others		4.1 E+07	< 0.0001
Total:			4.8 E+13	100

Radionuclide activity in the DSRS is shown in Table 2. Short-lived Cs-137 predominates in terms of radionuclide activity. Its total activity is about 95 percent of the activity of the DSRS in storage. Other significant radionuclides are short-lived Sr-90, Co-60, and long-lived Pu-239, which are dominant in respect of the accumulated activity and the existing DSRS units. Cs-137 and Co-60 are various DSRSs used in industry or research, i.e., mainly BGI-A (Russian: БГИ-А) and EM (Russian: ЭМ) type sources with their biological protection. DSRS with Pu-239 are mainly AIP-N (Russian: АИП-Н) type neutralizer plates and sources used in AIP-RID (Russian: АИП-РИД) type smoke detectors. DSRS with Sr-90 are RIO (Russian: РИО) type sources used as icing sensors in aviation.

TABLE 2. ACTIVITY OF DSRS AT MRWSF IN 2020

Type	Radionuclide	T1/2, y	Activity, Bq	Activity, %	Number of DSRS
Long lived	Pu-239/Be	2.41 E+04	6.0 E+11	2.1	8
	Pu-239	2.41 E+04	3.2 E+11	1.1	2324
	Others		6.5 E+08	< 0.002	40
Short lived	Cs-137	30.0	2.7 E+13	95.2	366
	Sr-90	29.1	3.0 E+11	1.1	1449
	Co-60	5.27	1.2 E+11	0.4	2167
	Others		1.1 E+10	< 0.04	351
Total:			2.8 E+13	100	9872

Comparatively small amounts of radioactive waste are accumulated at MRWSF, but there are different types of waste: short-lived very low level waste, short lived low level and intermediate level waste, and long lived waste.

During groundwater monitoring, increased tritium (H-3) leakage was determined. The preliminary long term safety assessment of MRWSF showed that after the degradation of concrete barriers, the concentrations of H-3 and Cl-36 in groundwater can exceed acceptable values [1, 2]. The modeling of radionuclide migration [3] showed that MRWSF is not safe enough to prevent its surroundings from contamination with radionuclides in the future. H-3, Cl-36, and Pu-239 concentration in the groundwater can be significantly higher than acceptable limits and can cause doses above 1 mSv/y. As demonstrated in [4], the most important processes forming radionuclide (especially H-3) distribution in the unsaturated zone and groundwater of the MRWSF are the following: advection in unsaturated and saturated zones, infiltration recharge, capillary elevation and evaporation. The highest activity concentration of H-3 (29 800 ± 1500) Bq/l was measured in a sample taken in December 2005.

In 2005, the technical state of the MRWSF was assessed under the EU PHARE project [5]: its safety evaluated, safety improvement solutions were proposed and the database of RW inventory in the vault of the MRWSF was developed. The database was developed based on the remained RW acceptance and accounting records (passports, bills of lading) and the expert evaluation of these records [6]. According to the database, more than 30 000 items are stored in the vault.

To prevent an increase in the precipitation infiltration, a vault capping system was proposed and implemented (see Fig. 3 and Fig. 4). The system of protective engineering barriers is comprised of two layers of very low permeability high-density polyethylene (HDPE) membranes with the warranty of durability not shorter than 30 years.

FIG. 3. Installation of new protection barriers at the facility in 2006.

FIG. 4. Installation of HDPE at the facility in 2006.

The entire territory of the MRWSF was fenced with a double fence. Video cameras were installed to perform continuous monitoring of the territory of the MRWSF. As a result, the physical security of the MRWSF was improved (see Fig. 5).

FIG. 5. MRWSF territory after upgrading in 2006.

Based on the results of the safety assessment [5] of the MRWSF, it was concluded that the engineering barriers placed on the ground surface cannot provide long term protection against the spread of radionuclides (do not meet long term safety requirements), and therefore, the MRWSF cannot be licensed as a repository. Thus, in 2006 the regulator licensed the MRWSF as a storage facility.

The H-3 activity concentration in the underground water monitoring wells started to decrease thus proving the effectiveness of the new barriers installed during the facility upgrading.

However, analysis of the collected data concerning groundwater showed [7] that the radionuclide Pb-210 is yet being released into local environment at sufficiently short distances from the vault.

3. PREPARATION FOR DECOMMISSIONING

In RWM Strategy adopted by the Government in 2008, it was decided to retrieve RW from the MRWSF and transport it to the Ignalina NPP for further processing. From that time preparation for decommissioning of the MRWSF launched. In 2011 the Preliminary Decommissioning Plan of the MRWSF [8] was prepared by RWMA and approved by the regulator.

During the project implementation, in 2017–2018, the Environmental Impact Assessment Report [9] was prepared and agreed with the regulatory institutions. Public hearings were organized at the municipality of Širvintai district in October 2017. On 5 June 2018 the responsible institution, the Environmental Protection Agency, made the decision on the admissibility of the planned economic activity.

In 2017–2018, the Final Decommissioning Plan of the MRWSF [10] was prepared and, after coordination with regulatory institutions, approved on 5 October 2018 by the Order No. 1-272 of the Minister of Energy of the Republic of Lithuania. This plan outlines how the process of MRWSF decommissioning will be implemented.

In 2020–2021, the Description of Decommissioning Project [11], the Safety Analysis Report [12], the Discharge into the Environment Plan, the Radiation Protection Programme, the Demolition Project and other documents required to obtain the decommissioning license and necessary construction permits were prepared, reviewed and approved by regulatory institutions. On 13 May 2021, SE Ignalina NPP received a license to decommission the MRWSF.

As foreseen in the Radioactive Waste Management Development Program approved by the Government of Lithuania in 2015, by 2023 the RW will be removed from the MRWSF and transported to Ignalina NPP, afterwards the site will be remediated and released for unrestricted use.

4. DECOMMISSIONING PERIOD

4.1. Decommissioning strategy and its alternative

The Final Decommissioning Plan of the MRWSF [10] includes analyses of and reasoning for alternatives of MRWSF decommissioning strategy implementation. To select the preferable decommissioning alternative, MCDA method – AHP (Analytic Hierarchy Process) was applied. The analyzed alternatives were assessed based on the following criteria: waste routes, economics, duration, safety, technology, and environment. Three alternatives were analyzed and the below described alternative was selected:

- RW is removed from the vault and treated separately from potentially contaminated materials of engineered barriers and structures and soil.
- Radiological characterization of the vault soil cover and surrounding soil is performed on site and compliance with the clearance level is determined.
- Partial decontamination of the vault walls and bottom is carried out on site to allow safe further dismantling and excavation works.
- RW from the vault is pre-sorted on site (visually separated DSRS and RW with DSRS) and placed in containers according to their location in the vault, i. e. not mixing RW from different sections, and transported to Ignalina NPP for their final sorting and storage and final disposal.
- RW is retrieved from the vault using remote control equipment as much as possible.
- Decommissioning waste is transported from MRWSF to Ignalina NPP by road.

The concept of radioactive waste removal from the MRWSF vault was presented in the Final Decommissioning Plan [10]. This concept was further developed in the Decommissioning Project Description [11]. The essence of the concept is that the system used consists of two confinements:

- Primary Confinement means a cover made of light structures and covering the whole vault area to protect outside areas from radioactive contamination.
- Secondary Confinement means a construction made of light structures to protect the environment from radioactive contamination. Simplified layout of radioactive waste retrieval presented in Fig. 6.

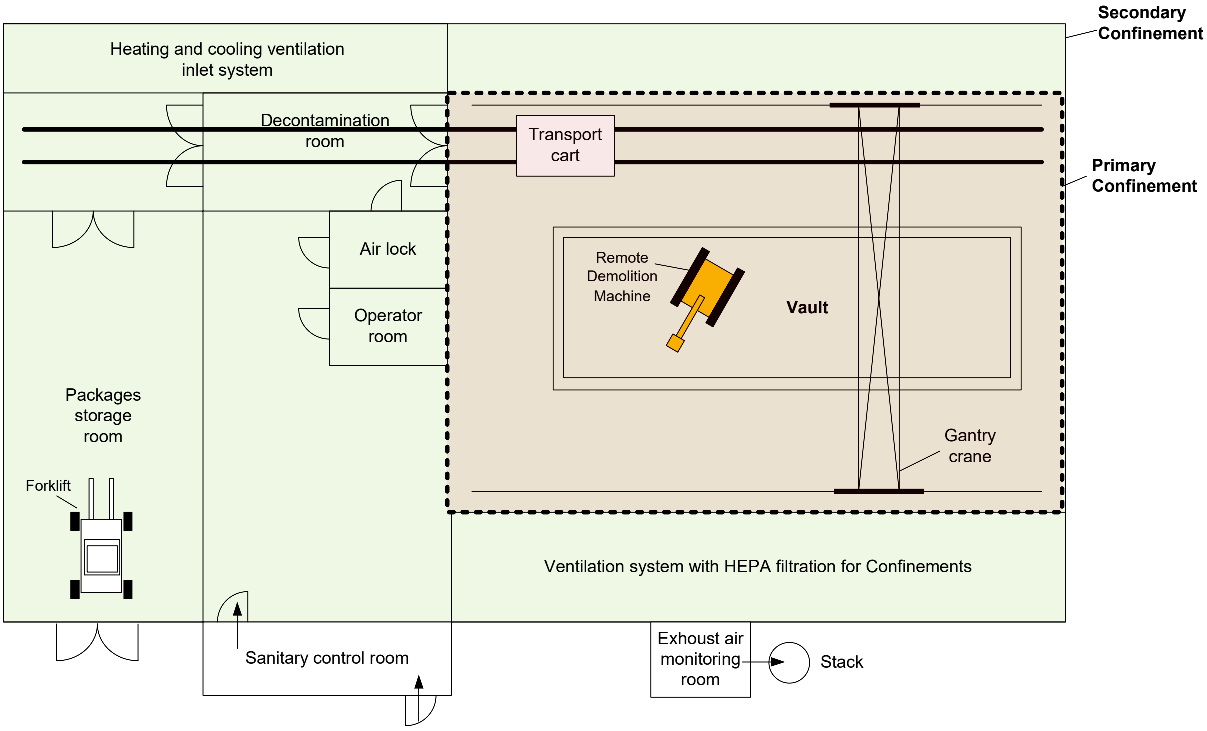

FIG. 6. Simplified layout of radioactive waste retrieval facility at MRWSF.

The following technological systems need to be installed in order to successfully retrieve the RW from the vault:

- Radiation monitoring (control) system;
- Radioactive waste retrieval and transportation system with main components:
  - Remote Demolition Machine for retrieval of waste;
  - Gantry crane of capacity of 5 t for removal of large size items, 200 l drums, RW packages, remote demolition machine for RW retrieval from the vault;
- Ventilation system;
  - Ventilation system with HEPA filtration for Primary Confinement
  - Ventilation system with HEPA filtration for Secondary Confinement
  - Mobile filtration unit (MFU) inside Primary Confinement
  - Heating and cooling ventilation inlet system
- Packaging:
  - FIBC for soil/crashed concrete waste;
  - 200 l drums for mixed radioactive waste;
  - 200 l drums IP-2 type for retrieved packages with liquid waste;
  - A type containers for transportation of loaded 200 l drums;
  - A type containers for transportation of the large size items/ and large DSRS;
  - Special steel containers (type K-100/K-150/K-190) for 10 litter, 15 litter containers with DSRS and neutron sources;
  - ILW-LLS container as overpack for special steel containers;
- Video monitoring system inside Primary Confinement;
- Fire safety system;
- Lighting, including emergency lighting;
- Power supply system;
- Compressed air system for personnel to breathe when hazmat suits are used.
- H_2/CH_4 (hydrogen/methane) detection system.

4.2. Main safety issues

In order to evaluate the safety related issues, Safety Analysis Report [12] was prepared. The safety analysis was performed for normal decommissioning conditions and for design and non-design basis accidents both during the RW retrieval and transport from the site to Ignalina NPP. An impact assessment was carried out for workers and residents. A fire hazard analysis was also performed.

The modeling of direct gamma radiation dose rates was performed using the VISIPLAN 3D ALARA Planning Tool. Since neutron sources are also located in the vault of the MRWSF, the modeling of neutron dose rates was performed using the MCNP5 code. The program MicroSkyshine 2 was used to estimate the skyshine effects.

From a safety point of view, the most dangerous sources during the retrieval of the radioactive waste are the 10 liter and 15 liter containers filled with DSRS without shielding. The modeled surface dose rate is about 240–270 mSv/h.

The assessment of worker exposure showed that the maximum annual dose is for the radiation protection specialist; however, it does not exceed 5 mSv/y, which is 4 times lower than the dose limit of 20 mSv/y. Therefore, the MRWSF decommissioning can be carried out by ensuring that occupational exposure does not exceed the limit values.

5. SUMMARY

After a long period of the MRWSF operation (1963–1989), preparation for decommissioning was started in 2008. In 2011–2021 decommissioning documents were prepared. In 2021, SE Ignalina NPP received a license to decommission the MRWSF and construction permits to erect the necessary infrastructure for decommissioning.

It is planned that by 2023 the RW will be retrieved from the facility and the site will be remediated and released for unrestricted use.

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