

NEK's LILRW Management and Handover Preparations for 2028–2030

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ABSTRACT

Low and intermediate-level radioactive waste (LILRW) represents an important segment of radioactive material management. It originates from the operation of nuclear power plants and research reactors, as well as from medical, industrial, and research activities. Although its radioactivity is lower than that of high-level radioactive waste, LILRW still requires careful planning for handling, storage, and final disposal to ensure the protection of people and the environment. Key challenges in LILRW management include ensuring the long-term stability of storage and disposal facilities, preventing contamination, and maintaining transparent communication with the public.

The Krško Nuclear Power Plant (NEK), in cooperation with the Slovenian Agency for Radwaste Management (ARAO) and the Croatian Fund for financing the decommissioning of NEK and disposal of NEK radioactive waste and spent nuclear fuel (Fund NEK), has been making great efforts in recent years to enable and implement the handover of LILRW to the final recipients. In accordance with the conclusions of the Coordination Committee and the Interstate Commission, Slovenia and Croatia are carrying out preparations for the LILRW transfer in the following areas:

- a new revision of the study on preparation for the transfer of LILRW to both transferees,
- the second revision of the study of the Possible Division and Takeover of the Operational and Decommissioning RW from Krško NPP,
- procurement of handling and transport equipment, and
- development of handover documentation.

Because the start of the handover process was postponed from 2023/2024 to 2028, NEK was required to provide additional temporary storage capacity for LILRW. Currently, the first four phases of the LILRW handover are planned for the years 2028, 2029, and 2030.

The paper presents the preparation measures NEK has already implemented and evaluates the key challenges (technical, regulatory, and logistical) anticipated during the upcoming handover.

Keywords: *Low- and intermediate-level radioactive waste (LILRW), NEK (NPP Krško), ARAO, Fund NEK, Handover*

1 INTRODUCTION

Effective management of LILRW is a fundamental component of safe and reliable nuclear power plant operation. Since NEK began operating more than four decades ago, all generated LILRW has been stored on site, pending the establishment of a national disposal or long-term storage facility. Although the original design of the Radioactive Waste Storage Building (RWSB) envisioned temporary storage for approximately five years, the absence of an operational disposal solution necessitated a continuous adaptation of NEK's waste management strategy. Over time, storage

occupancy increased to levels requiring immediate action, prompting the implementation of extensive volume-reduction activities and the search for additional interim storage capacities.

Given the shift of the planned national handover of LILRW to public service providers from the originally anticipated 2023–2024 period to the new timeframe of 2028–2030, NEK has had to ensure the safe and efficient handling, conditioning, and storage of waste throughout the extended operating period. This included intensifying campaigns to melt radioactive material, alongside a systematic reorganization of existing facilities to optimize storage capacity. The use of the Decontamination Building (DB), originally intended for equipment decontamination and storage, represents an important strategic measure that enabled improved waste accessibility, additional storage space, and alignment with ALARA principles.

This paper provides a comprehensive overview of NEK’s LILRW management activities leading up to the handover period, including volume-reduction technologies, reorganization of storage facilities, preparation for melting and incineration, and the development of the practical takeover strategy. The objective is to document the key technical, organizational, and regulatory steps taken to ensure that NEK will be fully prepared for the safe, orderly, and efficient transfer of LILRW to national waste management institutions within the newly established timeline.

2 NEK’S LILRW MANAGEMENT AND HANDOVER PREPARATIONS

In more than 40 years of operation, approximately 2500 cubic meters of LILRW have been generated at the NEK. More than twenty years ago, it was clear that a disposal or long-term storage facility would not be available in the foreseeable future. Therefore, even before 2000, NEK began various volume reduction campaigns such as supercompaction, melting, and incineration because the RWSB occupancy was around 90 %. Despite this, the occupancy of the RWSB continued to increase, so NEK had to intensify campaigns to reduce the volume of newly generated waste and older waste suitable for additional processing. In addition, NEK was seeking additional opportunities to increase the capacity of the temporary storage of LILRW and RWSB to ensure sufficient space for LILRW storage and safe operation of the power plant.

2.1 Incineration campaigns

Initially, incineration campaigns with the aim of reducing volume were carried out for newly generated combustible waste. After realizing there was no disposal or long-term storage facility in sight, NEK began incinerating suitable waste at an intensive rate. It is worth emphasizing that the waste intended for volume reduction must meet the waste acceptance criteria (WAC) for incineration. For this purpose, the LILRW preparation process was adapted as much as possible, enabling the sending of as large a proportion of waste as possible for incineration.

In the period from 2021 to 2026, NEK sent 1140 drums of waste for further processing through the incineration process in five campaigns. Four campaigns were performed by a Swedish company (mainly compressible waste), and one campaign (blow down resins) was performed by an American company. Usually, the volume reduction factor is approximately 10 and depends on the type of waste and its preparation. That means NEK’s volume of combustible LILRW was reduced by about 235 to 25 cubic meters by incineration.

2.2 Use of the Decontamination Building

The DB building was primarily built to store old evaporators after their replacement and to carry out the decontamination process of the equipment, which is mainly used during outages. The old steam generator room also stored equipment for work in the Reactor Building (RB) and some equipment and materials left over from past modifications and the implementation of the NEK safety upgrade program (SUP) after Fukushima.

The solution used to increase storage space for LILRW was to store incompressible and non-combustible LILRW, as allowed by the Updated Safety Analysis Report, around the old steam

generators, which is intended for the first phase of LILRW handover. As a result, 616 drums that were produced during the first supercompaction campaign have been transferred from RWSB to DB. All drums were inspected, decontaminated, and relabelled before being moved.

This provided additional space for the newly created LILRW to be generated in RWSB until 2028. At the same time, all drums that are subject to the first phase of the handover of LILRW to the Fund NEK were inspected and prepared. This waste is now easily accessible and allows for easy loading while respecting the ALARA principles.

Equipment stored in the DB that was assessed as no longer needed was decontaminated and radiologically characterized. Most of it was successfully decontaminated, and consequently, a free release procedure was carried out. This process has made the equipment or material become normal waste. The remaining part (65 tonnes), which was not successfully decontaminated or is activated, was sent for further treatment using the melting process described in chapter 2.3.

A small portion of this waste that did not meet the waste acceptance criteria was stored as LILRW in the RWSB.

2.3 Melting campaign

As mentioned in chapter 2.2, due to maintenance, modifications and SUP, there was a large volume of radioactive material in the DB that needed to be characterized. Most of this material was metal. During the process of preparing of the material for the melting campaign, the aforementioned metals were precisely characterized. Based on radiological characterization results, metals were separated into three categories, as mentioned in the last paragraph of Chapter 2.2. All metals that can be processed by the melting process were then additionally prepared in accordance with the waste acceptance criteria (WAS) for melting. It is important to emphasize that some components were large and irregularly shaped, so processing them requires good preparation and is time-consuming. Preparing metals according to melting criteria means more data is required per batch. Below are some of the main ones:

- metal type separation (stainless steel, carbon steel, painted steel, galvanized steel, copper),
- weight data,
- dose rate (contact, 1m distance),
- contamination (alpha, beta/gamma),
- activity, specific activity (Co-60, Cs-137),
- origin of material.

If the material is not properly prepared, the melting facility is not obliged to process it. The aforementioned data is also used to obtain transport permits in accordance with ADR requirements. Once the radioactive waste Holder and the contractor have received all transport permits, the transport of radioactive material can be carried out.






After melting, ingots and secondary LILRW such as dust and ash are produced and returned to the LILRW owner. There is also the possibility that the ingots remain at the contractor's facility for decay-in storage after which the free release of ingots can be performed, and the volume reduction factor is even bigger.

2.4 Procurement of equipment for the implementation of the LILRW handover







To perform smooth handling of LILRW packages in accordance with safety at work standards and ALARA principles NEK and NIS Simpelkamp developed a list of equipment, which is needed for:


- manipulation of all types of LILRW drums, overpacks, and ingots,
- transport of all types of waste in and outside the radiologically controlled area (RCA),
- all other equipment relevant for the storage and preparation of LILRW for takeover.

Table 1: List of equipment for manipulation and takeover

Description	Picture
Gripper 35 kN (for TTC's T2, and SSdrums)	
Gripper 12 kN (for SS drums)	
Gripper 700 kg (for 55 gal drums)	
Pneumatic gripper (for 55 gal drums) 1000 kg	
Pellet gripper 400 kg	

Description	Picture
Mobile shield walls	
Shielded forklift 4,5 t	
Rotating hydraulic clamp for TTC's, 3000 kg	
Rotating hydraulic clamp for 55 gal and SS drums, 1000 kg	

Description	Picture
Forklift 4 t	
Forklift 1,4 t	
Towing tractor	
Trailer 40 t	
Trailer 50 t	
Genkinger, shield trolley (for SS drums)	

Description	Picture
Magnetic gripper – remote control (2000 kg)	
Truck crane (100 t)	
Gripper for TTC T1, 3500 kg	

2.5 Practical takeover strategy

^[2]The practical takeover strategy was developed in accordance with the Implementation Coordination Committee's (ICC) Practical phase concept of the division, packaging and takeover strategy (Coordination committee, Dec 2021) and NEK's practical approach of emptying the storage compartments. Practical takeover strategy of the operational LILW generated until the end of 2023 is divided in following phases:

- Phase 1 - Takeover of 617 D6 waste packages (WPs) by Fund NEK.
- Phase 2 - Takeover of different TTC packages by ARAO to fill up to 200 N2d containers, which is equal to 800 TTC packages. The selected packages have similar characteristics of waste stream and waste form as waste packages taken over by Fund NEK in phase 1. The proposed practical takeover strategy for phase 2 ensures, as much as possible, a minimal number of waste package manipulations.
- Phase 3 – Takeover of remaining LILW packages (Croatian part) by Fund NEK (approx.1000 m3).
- Phase 4 - Takeover of remaining LILW packages (Slovenian part) by ARAO (approx.500 m3).

For each phase, the exact waste packages to be taken over were defined, based on provided input parameters. It should be noted that some of the WPs scheduled for takeover in phases 3 and 4 will

undergo further processing; therefore, the exact number of final waste packages and their characteristics cannot be determined at this stage.

The first campaign of the takeover of LILRW packages, consisting of phases 1 and 2, is foreseen to take place in 2028 and 2029, followed by the second campaign for phases 3 and 4, which is foreseen for the period of 2029-2030^[1].

In addition to the phases provided for in the ICC’s Practical phase concept of the division, a 5th phase was considered, in which all LILW generated from 2023 onwards, i.e until 2043 or until 2063 if NEK will apply for subsequent lifetime extension. For now, the takeover is unified into a single phase, assumed to be carried out together with the decommissioning LILW.

Takeover process will have adequate oversight by Slovenian bodies competent in the areas of radiation and nuclear safety:

- Slovenian Nuclear Safety Administration (SNSA) and
- Slovenian Radiation Protection Administration (SRPA).

Table 2: Takeover periods ^[1]

Phase/Period	Who takes over	What takes over			Processing / conditioning	Share (% of 1/2 LILW)
		Types of waste	RW Packages	SRSF cells / DB		
1 (2028)	Fund	SC	D6 (320l)	I, J, K, L, M and DB	Packaging in RCC or IP2 containers. Transportation to the RWM Centre in the Republic of Croatia.	17%
2 (2028)	ARAO	different	TTC	H, G, F	Packaging in N2d at NEK (approx. 200 N2d). Transportation to Vrbina Repository.	58%
3 (2029-2030)	Fund	different	TTC	A, B, C, D, E, F, G, H, I, J	Packaging in RCC or IP2 at NEK. Transportation to the RWM Centre in the Republic of Croatia.	83%
4(2029-2030)	ARAO	different	TTC	A, B, C, D, E, F, G, H, I, J	Packaging in N2d at NEK site. Transportation to Vrbina Repository.	42%

3 CONCLUSION

The paper demonstrates that NEK has already implemented the key technical and organizational measures necessary to ensure a safe, orderly, and efficient handover of low- and intermediate-level radioactive waste (LILRW) in the 2028–2030 period. The most important findings can be summarized as follows:

- Long-term volume-reduction efforts have proven essential. Incineration, supercompaction, and melting campaigns significantly reduced the occupied volume in the Radioactive Waste Storage Building. These measures ensured continued safe operation and created sufficient buffer capacity until the start of the national takeover.
- Reorganization of facilities increased storage efficiency and readiness. The strategic use of the Decontamination Building enabled the relocation, inspection, and preparation of priority waste

packages. This action simultaneously increased interim storage capacity and improved accessibility for future handling operations.

- Procurement of dedicated handling equipment enhances safety and operational performance. The newly introduced tools and devices will minimize handling complexity, reduce radiation exposure, and support consistent implementation of ALARA principles during the takeover phases.

The phased approach, developed jointly with ARAO, the Fund NEK, and the Implementation Coordination Committee, establishes clear priorities, optimizes logistics, and aligns the handover process with regulatory oversight requirements.

NEK's preparatory actions reduce future operational risks, improve predictability for national waste management institutions, and ensure that the upcoming takeover can begin without unnecessary delays or re-work. The experience gained through these campaigns also strengthens NEK's long-term waste management capability, which will be critical both during continued plant operation and later during decommissioning. Overall, it is confirmed that NEK is well-positioned to meet its obligations within the revised national timeline while maintaining high standards of nuclear and radiological safety.

4 REFERENCES

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