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Draft Safety Analysis Report for the Vrbina Krško LILW Repository

Section 13 Radiation protection for workers

DOCUMENT HISTORY

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1	May 2017	amendment of document following review	
2	January 2018	amendment of document following review by certified nuclear and radiation safety expert	
3	November 2018	amendment following review by SNSA	
4	February 2019	amendment following review by SNSA	
5	March 2019	supplementing of application	

CONTENTS

13 RADIATION PROTECTION FOR WORKERS

13.1 Introduction

Radiation protection at the LILW repository is addressed by the radiation protection study for the compiling of the design documentation for the LILW repository at the Vrbina site. [1] Additional analysis and estimates of exposure during normal operation and during the postulated operational occurrences and accidents is provided in the safety analysis and waste acceptance criteria document [2] and in Section 7 of this draft safety analysis report.

A summary of the safety analysis, which includes exposure during operational occurrences and accidents, is given in Section 7 of this draft safety analysis report.

According to the ZVISJV, [3] radiation protection is also addressed separately and additionally by the radiation protection assessment enclosed in the application for authorisation to pursue radiation practices. The radiation protection assessment will also be reviewed by a certified radiation protection expert. The assessment will be drawn up in accordance with the Rules on the conditions and methodology for assessing doses in the ionising radiation protection of workers and the public (SV5) [4] and will take account of all the key characteristics of the LILW repository. The radiation protection assessment will be drawn up in the next phase of preparation of the documents for the safety report for the LILW repository.

Radiation protection at the LILW repository at the Vrbina site is the responsibility of the ARAO’s radiation protection service (the SVS). The SVS operates in line with Slovenian legislation, EU law, and international recommendations, and works to minimise the exposure of workers and members of the public to ionising radiation, and to minimise the facility’s environmental impact.

Construction measures and administrative measures are envisaged for preventing and reducing the radiological consequences of any accidents in all phases of the facility’s lifecycle. A description of the measures follows in Sections 13.2 and 13.3 of this document.

Workers will be exposed to ionising radiation during the operation of the LILW repository at the Vrbina site. Estimates of the doses received by workers are drawn up for various groups of workers performing specific work at the repository. The estimates of received doses are given in Section 7 of this draft safety analysis report. A summary of the doses received by employees is given in Table 7.9, while the estimated doses for members of the public are given in Table 7.10.

13.2 Structural features for radiation protection

The core of the repository consists of the technological facility and the hall above the disposal silo, where the controlled area is designated. The controlled area lies on a flood protection plateau at an elevation of 155.2 m. The technological facility is intended for the temporary storage and remediation of any damaged containers and waste, for basic laboratory research, for the control of technological processes, and for the remaining vital technological and service functions of the repository and functions for ensuring nuclear and radiation safety. The facility is designed from a functional, structural and design standpoint to be able to be constructed in two phases. The technological facility also houses a radiological entry/exit checkpoint for the controlled area, and thus represents the entry and exit point for the access of persons to the repository's controlled area. [7]

There are two points of access to the controlled area, with separate access for personnel and for container deliveries: to the south, on the access road, lies the main entrance for deliveries of containers for disposal, with sliding gates in the perimeter fence, and a pedestrian access via the control point in the technological facility. [7]

The construction of the technological facility is feasible in two phases. The following premises are planned for construction in the first phase:

- control point with accompanying premises,
- storage of secondary RW and measurement room,
- service, energy and technical areas serving the technological facility during Phase 1, and
- common areas and utility rooms.

The construction of the following is planned for the second phase:

- back-up storage capacity with hot workshop and secondary LILW storage area,
- ventilation control room and measurement room for operational requirements during Phase 2.

In the part of the technological facility with the control point there is an area for a measurement room and a temporary storage room for secondary RW, a changing room and area for disposal of personal safety equipment and clothing, a chemical toilet, sink and showers for personal decontamination, an area for storage of personal safety equipment, and an area equipped with apparatus for measuring hand and foot contamination on personnel. Alongside the technological facility there is a sanitary tank for collecting waste water from the controlled area of the technological facility. [1]

The silo is located inside the security fence, and during the period in which it is being filled it will be covered by the hall, which will protect against the weather conditions. The disposal of containers of radioactive waste in the silo will be undertaken with a gantry crane, which in the parking position will not encroach over the disposal silo.

Below the silo itself is a collection tank where seep water and groundwater will collect. Access to the collection tank is via a vertical access shaft. The water collected in the collection tank below the silo will be regularly controlled and analysed. When the parameter limits are exceeded, the water is pumped to the control tank alongside the hall above the silo, where the contaminated water will be processed. When the limits are not exceeded, the water is pumped either into the public sewage system, or exceptionally into the control tank alongside the hall above the silo (see also Section 6 of this draft safety analysis report). [1]

A control tank is located alongside the hall above the silo, and serves to collect water from the area of the hall above the silo. Exceptionally the control tank may also receive water from the collection tank in the silo or water generated in an emergency event. [8]

At the repository site there is a variety of measurement equipment to ensure monitoring of radiation levels in releases, and radiation levels on site [1] (see Section 13.3).

A more detailed description and definition of the SSCs that reduce exposure in all activities and in all periods of the repository's lifecycle are given in Section 6 of this draft safety analysis report.

13.3 Monitoring of radiation

Monitoring of all important sources of radiation in all activities and states of the repository is conducted at points where leaks of radionuclides or ionising radiation might occur. Monitoring of liquid emissions, gaseous emissions, dose rates and contamination is carried out. [1]

13.3.1 Liquid emissions

A radiation counter will be installed in the silo water that collects in the collection tank below the silo in order to monitor water contamination. The counter will be linked to the control room.

The water from the technological facility (personnel decontamination room) will be collected in the sanitary tank in the first phase of the construction of the technological facility, and in the floor drain sump in the second phase. Potential water contamination in the tanks will be analysed using high-resolution gamma spectrometry. If the water is not contaminated, it will be released into the sewage system. The release will only be made if the measured values are within authorised limits. If the limits are exceeded, the water will be pumped into the sanitary tank alongside the technological facility, and released for further processing as contaminated water. The contaminated water can be used to produce backfill mortar, or it can be further processed on site or at another site with suitable capabilities. [8]

Measuring equipment:

Liquid emissions will be monitored in the collection tank below the silo. The counter will be immersed in the tank, and connected to the control room, where the water contamination readings will be displayed.

Basic features of the system:

Detector:	NaI, dimensions at least 3'' x 2''
Energy range:	gamma radiation, 60 keV (or lower) – 2 MeV (or higher)
Measurement range:	3.7 x 102 Bq/m^3 to 3.7 x 1,012 Bq/m^3
Display:	Readings displayed in command room and at measurement site (alongside counter)
Measurement method:	Detector (probe) immersed in the water being measured
Measurement frequency:	Continual measurements at intervals of several minutes (15 minutes or less)

13.3.2 Gaseous emissions

The probability of atmospheric releases containing radioactive substances during normal operation is low; this might occur only in the case of damaged containers and during work with radioactive waste at the repository. Gaseous emissions from the silo will be monitored at the silo exhaust. The emissions will be monitored using a continuous aerosol sampler. The samples (i.e. filters) will be measured using gamma spectrometry.

There will be similar sampling of aerosols in the exhaust from the technological facility. During the first phase of operation, the exhaust from the decontamination room will be sampled. After the completion of the second phase, when back-up storage capacity has been built in the technological facility, the exhaust from the air conditioning utility room will be sampled.

Because the disposed waste contains Ra-226, and because of radon exhalation from the foundations of the repository, the concentration of Rn-222 will also be monitored in the silo and in the vicinity of the silo. [9]

A detailed description and a programme of measurements, which also contains a description of the measurements to be taken in the event of an accident and during the standby phase, are given in Section 15.2 of this draft safety analysis report. [9]

The ionising radiation monitoring programme is further defined in the radiation protection evaluation. This will be performed later, in collaboration with a certified radiation protection expert. The evaluation will define the alarm levels for individual measuring instruments at the LILW repository site.

Measuring equipment:

Gaseous emissions will be monitored at the silo exhaust and the exhaust from the technological facility. The counter will capture air from the ventilation system. The total activity of alpha, beta and gamma emitters will be determined. It will allow for separate sampling of particulates for analysis using high-resolution gamma spectrometry, which is carried out later in the laboratory. The activity of Sr-90 is determined later in the same sample. A C-14 sampler will also be installed. The level of C-14 will be determined by a radiochemical method in the laboratory.

Basic features of the system:
Type of radiation detected: alpha, beta, gamma

Detector:	double-sided silicon strip detector
Sampling:	isokinetic
Filter type:	millipore
Measurement technique:	capture of air from air duct
Energy range:	alpha radiation: 2 MeV – 10 MeV beta radiation: 80 keV – 2.5 MeV gamma radiation: 80 keV – 2.5 MeV
Measurement range:	alpha radiation: 0.01 Bq/m^3 – 1 MBq/m^3 beta radiation: 1 Bq/m^3 – 1 MBq/m^3
Settable alarm levels:	Option of setting alarm, at least two levels, lights that warn of radiation levels (green/red)
Display:	Readings displayed in command room and at measurement site (alongside counter)
Measurement frequency:	Continual measurements at intervals of several minutes (15 minutes or less)

C-14 monitoring

Flow rate:	50 – 500 ml/min
Flow rate measurement uncertainty:	maximum 5%
Absorber:	NaOH
CO_2 sampling yield:	at least 99%

13.3.3 Dose rates

The SVS regularly monitors the dose rates from external gamma radiation in individual locations in the controlled area and the supervised area. The current state of external gamma radiation is determined through regular checks, and compared with expectations. In the event of any change in the state, the SVS may modify the extent of the controlled area or the supervised area on the basis of measurements.

Measuring equipment:

Dose rates will be monitored in the silo.

Basic features of the system:

Detector:	ionisation chamber; Geiger-Mueller tube or scintillator
Energy range:	40 keV (or lower) – 2 MeV (or higher)
Measurement range:	0.05 µSv/h – 1 mSv/h
Settable alarm levels:	Option of setting alarm in dose rate, at least two levels, system has lights that warn of radiation levels (green/red) and sound alarm
Display:	Readings displayed in command room and at measurement site (alongside counter)
Measurement frequency:	Continual measurements at intervals of several minutes (15 minutes or less)

13.3.4 Area contamination

The SVS regularly monitors area contamination at multiple points in the controlled area and the supervised area. The SVS checks both removable and fixed area contamination. An additional description of the sites and frequency of measurements will be set out in the radiation protection evaluation.

Measuring equipment:

A personal contamination counter (hand and foot contamination monitor) will be installed at the exit to the radiologically controlled area.

Basic features of the system:

Detector:	plastic scintillator
Type of radiation detected:	alpha, beta, gamma
Energy range:	40 keV (or lower) – 2 MeV (or higher)
Detection limit:	40 Bq or less for Cs-137
Settable alarm levels:	option of setting alarm, system has lights that warn of radiation levels (green/red) and sound alarm

13.4 Radiation protection programme

The ARAO's radiation protection service (the SVS), which is an independent unit directly answerable to the director of the ARAO (see Section 3), is responsible for drawing up and implementing the radiation protection programme. The unit consists of the head of the SVS and two other employees, who have passed general training for work at the repository and additional training in the area of radiation protection, as set out by the Rules on the obligations applying to entities conducting radiation practices and holders of ionising radiation sources. [1] The full training programme for SVS employees is set out in a training document. [10] The implementation of the radiation protection programme is based on the radiation protection study for the compiling of the design documentation for the LILW repository at the Vrbina site, [1] and will additionally be addressed by the radiation protection evaluation drawn up during the next document preparation phase.

The basic tasks of the SVS are as follows: [11]

- conducting entry controls on arriving consignments of LILW (containers),
- ensuring radiation protection at the repository site for employees, occasional workers and visitors, and
- conducting surveillance measurements of radiation in the working environment and the natural environment for the needs of the operation of the repository.

<u>Measuring instruments and devices</u>

In order to conduct entry controls on arriving consignments and surveillance measurements, the SVS provides measurement equipment that is regularly maintained and serviced by certified servicers, regularly calibrated and regularly subject to control inspections. [12] The SVS thereby ensures that the quality of the measurements is maintained continuously. The SVS keeps regular records of maintenance, servicing, calibration and control inspections of measuring instruments and devices.

The SVS provides the following to conduct surveillance measurements:

- a portable area contamination monitor,
- a portable external gamma radiation dose rate meter, and
- a portable neutron radiation dose rate meter.

A hand and foot contamination monitor will be installed at the exit to the radiologically controlled area, where every employee who leaves the controlled area will have to undergo checks.

<u>Controlled area and supervised area</u>

Given the expected dose rates, the hall above the silo is classified as a controlled area, while the remainder of the technological facility is a supervised area. The classification into controlled and supervised areas is not static, and can change according to conditions. [1]

During the transportation and acceptance of individual containers, dose rates may also be higher than 60 µSv/h along the entire transport route. In such cases the area around the container is designated a controlled area. [1]

<u>Shielding of sources and premises</u>

The area with elevated radiation will mainly be the hall above the silo, where radioactive waste will be disposed of, and in the vicinity of the container during its acceptance. Personnel will face additional exposure in the technological facility during the construction of its second phase, which is intended for back-up storage capacities with a hot workshop and a secondary LILW storage area. [1] Ensuring that personnel are protected against excessive and unintentional exposure to radiation will be undertaken by restricting and controlling access to the LILW repository site.

The envisaged siting of the facilities, systems and equipment in the LILW repository complex ensures adequate conditions for the safe operation of the repository. Access to the LILW repository site will be restricted and controlled; the repository site is fenced, and is divided into:

- an exterior area with a perimeter fence and physical security controls
- an interior radiologically controlled area with additional fencing

Access will be controlled, and managed by individual area and premises. Access for external contractors will be determined in line with the activities that the external contractors will carry out at the repository. Access for visitors will only be allowed when accompanied by employees or external contractors with the appropriate authorisations. [14], [15]

Personal protective equipment

Workers will wear protective coats and gloves when entering the controlled area. These clothes are designed to prevent personal contamination. Area contamination is not anticipated, and the clothing is designed to be a reminder of the safety culture and the need for different behaviour in areas with elevated levels of ionising radiation. [1]

Additional personal protective equipment is not envisaged for entry to the hall above the silo.

During emergencies in which area contamination occurs, personal protective equipment needs to be worn in the remediation of the event according to the level of contamination, as follows:

- cotton jumpsuit,
- coverall,
- multiple layers of gloves,
- overshoes,
- breathing masks, etc.

Administrative procedures in radiation protection

The preliminary planning for work in the controlled areas was in line with procedures and instructions (see Section 3.3). [14] All planned work in radiologically controlled areas is approved via ARAO procedures by the SVS, which prescribes personal protective equipment and ensures that workers are not unnecessarily exposed to ionising radiation.

List of SVS procedures setting out the specific tasks and responsibilities of SVS employees: [14]

- Radiation protection programme and implementation procedures
- Programme of radioactivity monitoring and implementation procedures, Programme of extraordinary radioactivity monitoring
- Entrance control of LILW (shipments)
- Surveillance measurements of the working environment
- Measuring equipment management
- Instructions for safe work in the radiologically controlled area
- Measures and management in case of contamination
- Decontamination procedures
- Storage of radioactive waste generated in the process of disposal and implementation of clearance

Controls on personal exposure

Employees at the repository facility working in the controlled and supervised areas are classed as workers exposed to ionising radiation. In line with the legislation, [15] workers are included in a personal dosimetry system, and use personal thermoluminescent dosimeters provided by a certified personal dosimetry provider. In addition, before entering the controlled area in the technological facility workers will be provided with an electronic dosimeter to provide additional monitoring of their exposure to external gamma radiation.

Emergencies

In the event of an emergency at the LILW repository site, it is necessary to act in accordance with the procedure set out in the document entitled Measures to be taken in the event of an emergency at the LILW repository (NSRAO2-POR-007-01/02-08-011-003). [16] The document sets out the scope of planning, the response concept and the response organisation. An additional description is provided in Section 14 (Emergency preparedness) of the draft safety analysis report.

13.5 References

[1] Odlagališče NSRAO Vrbina, Krško, Idejna zasnova (*Vrbina LILW repository, conceptual design*), Rev. C. 2016.

[2] Safety analysis and waste acceptance criteria preparation for low and intermediate level waste repository in Slovenia, Phase II and III, Revised Operational Safety Assessment, ARAO, EISFI-TR-(15)-37 Vol. 1, Rev. 1, NSRAO2-PCS-019-01-eng. EISFI consortium (ENCO, INTERA, STUDSVIK, FACILIA, IRGO), 2016.

[3] Ionising Radiation Protection and Nuclear Safety Act (ZVISJV-D). (Official Gazette of the RS, 102/04 [official consolidated version], 70/08 [ZVO-1B], 60/11, 74/15).

[4] Rules on the conditions and methodology for assessing doses in the ionising radiation protection of workers and the public. (Official Gazette of the RS, 115/03).

[5] Decree on dose limits, radioactive contamination and intervention levels (UV2). (Official Gazette of the RS, 49/04).

[6] Obratovalni pogoji in omejitve (*Operating conditions and constraints*), reference document for draft safety analysis report, Revision 1, NSRAO2-POR-027-00 02-08-011-003. IBE, 2016.

[7] Odlagališče NSRAO Vrbina, Krško, Idejna zasnova rev. B, 1 Načrt arhitekture - Tehnični opis, Objekti odlagališča (*Vrbina LILW repository, conceptual design Revision B, 1 Architectural plan - Technical description, repository facilities)*, NRVB ---1A/1001, October 2015. IBE d.d.

[8] Odlagališče NSRAO Vrbina, Krško, Tehnologija odlaganja (*Vrbina LILW repository, disposal technology).* IBE d.d., 2015.

[9] Obratovalni monitoring (*Operational monitoring)*, reference document for draft safety analysis report, Revision 1, NSRAO2-POR-028-00 02-08-011-003. IBE d.d., 2016.

[10] Usposabljanje (*Training*), reference document for draft safety analysis report, NSRAO2-POR-004-01, Revision 1, 02-08-011-003. ARAO, 2016.

[11] IBE, Odlagališče NSRAO Vrbina, Krško, Referenčna dokumentacija – Obratovanje, (*Vrbina LILW repository, Reference documents – Operation*), Revision 1, NSRAO2-POR-020-00 02-08-011-003, NRVB 5x/M23.

[12] Rules on the obligations applying to entities conducting radiation practices and holders of ionising radiation sources (SV8). (Official Gazette of the RS, 13/04).

[13] Odlagališče NSRAO Vrbina, Krško, Investicijski program (*Vrbina LILW repository, Feasibility Study*) Rev. C. IBE d.d., 2013.

[14] ARAO, Formati in seznami postopkov in navodil (*Formats and lists of procedures and instructions*), reference document for draft safety analysis report, NSRAO2-POR-010-00 02-08-011-003, Rev. 1, 2016.

[15] Rules on the obligations applying to entities conducting radiation practices and holders of ionising radiation sources (SV8). (Official Gazette of the RS, 3/17 and 8/17).

[16] Ukrepanje v primeru izrednega dogodka na odlagališču NSRAO (*Measures to be taken in the event of an emergency at the LILW repository*), reference document for draft safety analysis report, Revision 1, NSRAO2-POR-007-00 02-08-011-003. ARAO, Simona Sučić, 2016.