Document:	NSRAO2-POR-030	Procurer: **REPUBLIC OF SLOVENIA** **Gregorčičeva ulica 20** **1000 Ljubljana** By authorisation of: **ARAO, Ljubljana** **Celovška cesta 182, 1000 Ljubljana**
ARAO identification code:	02-08-011-004	
Date:	March 2019	
Revision:	5	
Number of copies:		
Facility:	LILW repository Vrbina, Krško	
Contractor:	ARAO, Ljubljana	
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Document title:

Draft Safety Analysis Report for the Vrbina Krško LILW repository

Chapter 11 Operational limits and conditions

DOCUMENT HISTORY

Revision:	Date of (previous) revision:	Brief description of changes relative to the previous version:	Notes:
1	May 2017	amendment of the document following review	
2	January 2018	amendment of the document following review by an approved 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

ABBREVIATIONS AND TERMS

OLC – Operational limits and conditions

osnVP – Draft Safety Analysis Report

NRC – Nuclear Regulatory Commission, independent US agency

RW – Radioactive waste

LILW – Low and intermediate level waste

LLW – Low level waste

ILW – Intermediate level waste

WAC – Waste acceptance criteria

WAC – Waste acceptance criteria

SA – Safety analysis

WPS – Waste Package Specifications

WPDS – Waste Package Data Sheet

ZVISJV – Ionising Radiation Protection and Nuclear Safety Act

Operational limits and conditions (OLC) are a group of rules that form part of the safety analysis report, and that determine the parameter limit values, capacity, the operation of equipment and the measures to be taken by personnel to ensure that a radiation or nuclear installation operates safely [1].

Safety margins are differences between the authorised limit values and safety limits [1].

Safety limits are parameter values laid down by operational limits and conditions (OLC) [1].

Authorised dose limits are expressed as authorised dose limit values of any radiation quantity laid down by the competent regulatory authority for a specific radiation source or for a specific practice involving radiation sources. As a rule, authorised dose limits are lower than the primary, secondary or derived dose limits [1]. Dose limits quoted in OLC are authorised dose limits [2].

Operational dose limits are expressed as operational dose limit values of any radiation quantity laid down by an approved radiation protection expert for a specific practice involving radiation or a specific source of radiation. Operational dose limits can be equal to or lower than authorised dose limits. Operational dose limits are specified in the written procedures of the repository and are lower than the authorised dose limits laid down in OLC [2].

Radioactive substance is any substance that contains one or more radionuclides the activity or concentration of which cannot be disregarded as far as radiation protection is concerned.

Radioactive waste management means all organisational and physical activities conducted for the retention, relocation, processing, storage or disposal of radioactive waste or spent fuel.

Acceptance criteria for acceptance of waste in storage or disposal are requirements expressed in quantitative or qualitative terms, concerning radioactive waste that radioactive waste must meet to ensure safe storage or disposal.

Package is the packaging, including its interior partitions or absorption materials, and radioactive waste. Package may also mean unpacked bulk radioactive waste.

Final package (KPE) is a final package conditioned for disposal.

Packaging means products designed for containing or keeping together radioactive waste or spent fuel for the purposes of retention or protection, handling, delivery or relocation on their route from the place of origin to processing, during storage or during disposal. Radioactive waste may be inserted into packaging immediately or prepacked.

RW characterisation means determination of radioactive waste's physical, chemical and radiological properties for the purpose of adapting the waste for further handling, storage or disposal.

11 OPERATIONAL LIMITS AND CONDITIONS

11.1 General

In terms of content, the Operational Limits and Conditions chapter is divided logically into two sections. The first section presents and describes operational limits and conditions for safe operation and definitions of operational limits and conditions applicability, measures in cases of non-compliance with operational limits and conditions and surveillance over parameters that regulate operational limits and conditions. These are summarised from the reference document Obratovalni pogoji in omejitve [3].

The second section presents acceptance criteria for waste disposal, summarised from the reference document Merila sprejemljivosti [4].

11.2 OPERATIONAL LIMITS AND CONDITIONS FOR SAFE OPERATION

The bases for descriptions relating to the repository operation and associated operational limits and conditions are provided in the document Idejna zasnova, Rev. C, za projekt Odlagališče NSRAO Vrbina, Krško [5].

11.2.1 REPOSITORY OPERATIONAL STATES

11.2.1.1 General

The repository operational states, which comprise normal operational occurrences, abnormal operation (anticipated operational occurrences) and design basis emergencies and accidents, are as follows:

- Operational state 1 – Acceptance and disposal of LILW:
- Operational state 2 – Readiness for acceptance and disposal of LILW:
- Operational state 3 – Non-disposal related work in the area of the silo; and
- Operational state 4 – Standby phase (cessation of operations).

Another special repository operational state or mode of operation, as regards compliance with the operational limits and conditions laid down in the WAC, is the repository in the period of long-term monitoring. This state is described in a special reference document Načrt dolgoročnega nadzora [6].

The description of repository operational states is provided below.

11.2.1.2 Operational state 1 – Acceptance and disposal of LILW

The repository operates on a regular basis and accepts disposal containers in accordance with the disposal programme. All containers accepted will be disposed of promptly. A vehicle with an incoming shipment is present at the repository on a weekly basis. Devices and systems required for acceptance and keeping records of containers and their disposal are ready for operation. All the work posts are filled.

11.2.1.3 Operational state 2 – Readiness for acceptance and disposal of LILW

The repository is in a state of readiness for acceptance and disposal of LILW. Devices and systems required for acceptance and keeping records of containers and their disposal are ready for operation. Work posts are filled partially.

11.2.1.4 Operational state 3 – Non-disposal related work in the area of the silo

In the area of the silo (which includes the silo itself and the platform in the hall above the silo), a drainage system will be installed along the silo wall, the gaps between the containers will be filled and levelling layers will be laid over the layers of disposed containers. Outside construction contractors are involved in the works. The number of transports of non-radioactive materials is increased.

11.2.1.5 Operational state 4 – Standby phase (cessation of operations)

The repository has ceased its operation for a prolonged time period. The volume of activities at the repository is significantly reduced. Only a few work posts are filled. The description of the repository standby phase is given in the report Obdobje mirovanja [7] and in chapter 9.13 of the Draft Safety Analysis Report.

11.2.2 REQUIREMENTS REGARDING OPERATIONAL LIMITS AND CONDITIONS

The LILW repository safety analysis report must include, inter alia, operational limits and conditions for safe operation and technical princples explaining the expert basis for each operational limit or condition [1]. Hence, the draft safety analysis report contains proposals for operational limits and conditions to be elaborated in detail in the safety analysis report.

11.2.2.1 Dose at the perimeter

OLC: The annual effective dose at the perimeter of the repository due to direct irradiation, liquid discharges and emissions into the air, and also clearance of secondary radioactive waste substances, may not exceed 200 µSv a year.[1] For this purpose, the dose of the most loaded member of the public must be considered, including workers in the Vipap waste treatment plant (in the case of discharges of liquids into the sewerage system leading to the VIPAP waste treatment plant).

Reason for implementation: The OLC proposal is tabled based on the guideline (see explanation below). The guideline is in line with good international practice.

Applicability: In all operational states.

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[1] In its directives (Sklep o smernicah za načrtovanje predvidene prostorske ureditve – Državni prostorski načrt za odlagališče nizko in srednje radioaktivnih odpadkov, No. 350-05-12/2014(o500), the municipality of Krško. on 9 Feb. 2006, made a request No. 2.1 according to which the minimum practical equivalent radiation dose at the repository perimeter is to be ensured, i.e. the equivalent dose at the Krško NPP perimeter and at the repository perimeter may not exceed 0.2 mSv a year. This dose is already laid down as the limit value for the Krško NPP area, which is governed by the Ordinance on the Krško NPP zoning plan, Official Gazette of the SRS 48/87.

Measures: a) In the case of exceeding OLC, report within 30 days in accordance with section 11.2.7 and announcement of implementation of corrective measures.

b) In the case of exceeding OLC, immediate undertaking of activities to reduce the radiation loads.

Surveillance: a) The cumulative effective dose is determined at least every three months. It covers both direct irradiation and atmospheric and liquid discharges. The dose calculation is performed in accordance with written procedures. The dose coefficients given in Decree UV2 [8] are taken into account in the calculation.

b) The cumulative dose from liquid and gaseous discharges is determined, in accordance with the provisions of this document, at least every three months.

c) The cumulative dose from irradiation is determined on the basis of monitoring data every three months. The value from the point with the highest measured cumulative value is taken into account.

11.2.2.2 Dose from liquid discharges

OLC: a) The annual effective dose from liquid discharges at the repository perimeter may not exceed 5 µSv. For this purpose, the dose of the most loaded member of the public must be considered, including workers in the Vipap waste treatment plant.

b) The concentration of emitter activities in liquid discharges may not exceed the regulatory concentrations for clearance, which will be calculated and evaluated in accordance with articles 14 and 18 of Decree UV2 [8]. The method of calculation and evaluation are to be approved in the scope of approval of the draft safety analysis report.

c) Measurement instruments and sampling points for the purpose of liquid discharge monitoring must be operable, by measurement points and sampling points, at least in numbers listed in the reference document Obratovalni monitoring [9] and summarized in chapter 15 of this draft safety analysis report.

Reason for implementation:

The annual effective dose from liquid discharges at the perimeter or in the surroundings of Krško NPP is less than 0.43 µSv (SNSA annual report 2013, table 24). The authorised annual effective dose limit at a distance of 500 m from the Krško NPP reactor is less than 50 µSv (Krško NPP TS, 3.11.4.2); Decision URSVS 525-01/89-5,34 CSRAO: discharges in accordance with ND-RZ-01 amount to 0.5 µSv (CSRAO safety analysis report, Rev. 0 July 2003).

In accordance with Decree UV2 articles 14 and 18. Taking into account the authorised limit value (template TS Krško NPP 3.11.4.1). Alternative: determination of limit concentrations in accordance with Decree UV2, taking into account the prescribed conversion factors and authorised dose limit (5 µSv/year) and taking into account the percentage of the authorised limit value (template TS Krško NPP 3.11.4.1).

Applicability: In all operational states.

Measures: a) Immediate undertaking of activities to reduce the radiation loads in the case of exceeded OLC.

b) Operability of an inoperable measurement instrument or sampling point listed in the reference document Obratovalni monitoring [9] (presented in chapter 15 of this draft safety analysis report) must be restored within two days in cases of operational states No. 1 and 3, within seven days in the case of operational state No. 2, and within 30 days in the case of operational state No. 4.

c) If operability of an inoperable measurement instrument or sampling point listed in the reference document Obratovalni monitoring [9] (presented in chapter 15 of this draft safety analysis report) is not restored within the prescribed time period, monitoring of liquid discharges must be ensured by means of auxiliary measuring instruments, and, in the case of operational state No. 1, shipment of LILW to the repository suspended. Non-compliance with OLC must be reported within 30 days.

Surveillance: a) Measurements, surveillance of measuring devices and sampling points, sampling and analyses of discharges are carried out in accordance with the reference document Obratovalni monitoring [9] (presented in chapter 15 of this draft safety analysis report).

b) The dose calculation is performed in accordance with written procedures. The dose coefficients given in Decree UV2 [8] are taken into account in the calculation.

11.2.2.3 Dose from discharges into the air

OLC: a) The annual effective dose from discharges into the air at the repository perimeter may not exceed 5 µSv.

b) Measurement instruments and sampling points for the purpose of monitoring of discharges into the air must be operable, by individual measurement point, at least in the numbers listed in the reference document Obratovalni monitoring [9] (presented in chapter 15 of this draft safety analysis report).

Reason for implementation:

The annual effective dose from discharges into the air, including deposits, at the perimeter or in the environment of Krško NPP is less than 0.05 µSv (SNSA annual report 2013, table 24). The authorised annual effective dose limit for noble gases at a distance of 500 m from the Krško NPP reactor is less than 50 µSv (Krško NPP TS, 3.11.5.2); CSRAO: maximum dose from radon inhalation is 0.05 µSv/year (CSRAO Safety Analysis Report, Rev. 0 July 2003, section 7.2.2).

Applicability: In all operational states.

Measures: a) Immediate undertaking of activities to reduce the radiation loads in the case of exceeded OLC.

b) Operability of an inoperable measurement instrument listed in the reference document Obratovalni monitoring (presented in chapter 15 of this draft safety analysis report) must be restored within two days in cases of operational states No. 1 and 3, within seven days in the case of operational state No. 2, and within 30 days in the case of operational state No. 4.

c) If operability of an inoperable measurement instrument listed in the reference document Obratovalni monitoring (presented in chapter 15 of this draft safety analysis report) is not restored within the prescribed time period, monitoring of discharges must be ensured by means of mobile measuring instruments, and (in the case of operational state No. 1), shipment of LILW to the repository suspended. Non-compliance with OLC must be reported within 30 days.

d) Should activity be detected in airborne discharges from the technological facility's ventilation system and the silo sump, the ventilation system is isolated and shut down. The status of the isolation and shutdown is shown in the control and monitoring system.

Surveillance: a) Measurements, surveillance of the condition of measuring equipment, sampling and analyses of discharges are carried out in accordance with the reference document Obratovalni monitoring (presented in chapter 15 of this draft safety analysis report).

b) The dose calculation is performed in accordance with written procedures. The dose coefficients given in Decree UV2 [8] are taken into account in the calculation.

11.2.2.4 Acceptability of LILW for disposal

OLC: a) It is only permitted to dispose of LILW inserted into uniform disposal containers which meet the WAC for disposal defined in the document Merila sprejemljivosti RAO za odlagališče NSRAO [4]. Verification of compliance with WAC is carried out at Krško NPP.

b) At the repository site, it is only permitted to accept, for the purpose of disposal, LILW disposal containers delivered in accordance with the LILW delivery programme and fulfilling conditions agreed in advance and verified at the time of reception inspection.

c) At the repository site, it is only permitted to accept, for the purpose of disposal, LILW disposal containers which comply with all the OLCs.

Reason for implementation:

The LILW repository may not receive for disposal any waste that does not meet the acceptance criteria and is not covered by a safety analysis to demonstrate the safety of its disposal.

Applicability: In operational state No. 1. Accepting LILW at the repository in any other operational state is not permitted.

Measures: a) In the case of arrival of a non-compliant container, such container is returned to the consignor.

b) In the case of arrival of a non-compliant container, causes of non-compliance are examined and corrective measures determined immediately.

c) In the case of arrival of a non-compliant container, reporting within 30 days in accordance with section 11.2.7 and announcement of implementation of corrective measures.

Surveillance: a) Transport of LILW to the repository is carried out in accordance with the programme of LILW acceptance at the repository and announcement of each individual shipment in advance.

b) The repository operator supervises the conditioning of LILW for disposal and compliance of disposal packages with WAC at the point of conditioning for disposal.

c) At the time of entry to the repository, the LILW shipments are subject to reception inspection in accordance with the requirements of the LILW acceptance programme, WAC and ADR requirements and repository physical security requirements.

c) Verification of compliance with the acceptance criteria will take place at the point of conditioning waste for disposal. This verification will be carried out by the entity conditioning the waste for disposal, under the supervision of ARAO in accordance with the reference document Merila sprejemljivosti.

11.2.2.5 Operability of lifting devices

OLC: a) The load carrying capacity of the crane and of lifting devices used for placing containers in the silo is 40 t. The suspended load hangs on two separate rope systems with separate drives and two brakes on each drive system.

b) The gripper used for placing containers in the silo is fitted with a device to sense gripper engaged state, to prevent lifting/lowering of the load if the gripper is not engaged. The same device senses gripper open state to prevent lifting the gripper up and away from the newly placed container if the gripper is not open.

c) When not in operation, the crane is fixed earthquake-proof to the base in its four corner points so as to keep the entire load bearing structure of the crane outside the vertical projection of the silo.

Reason for implementation:

OLC is defined in accordance with the design characteristics of lifting devices and envisaged waste to be placed, and in accordance with the Rules on general measures and standards for protection at work with lifting equipment (cranes), Official Gazette of the SFRY 30/69.

Applicability: OLC.a and OLC.b in operational states No. 1, 2 and 3. OLC.c in operational states No. 2 and 4 and 3, if the crane is not needed for handling materials for more than 8 hours.

Measures: a) In the event of inoperability (fault) of the crane OLC.a or gripper OLC.b, the crane may not be operated. Containers with LILW are not delivered.

b) Earthquake-proof fixing of the crane is established within 1 hour of the end of its use if it is envisaged that the crane will not be operated for more than 8 hours.

Surveillance: a) Crane operability is checked periodically in accordance with the crane master log [10] (and the instructions for crane-lift operation and maintenance to be drawn up in the next project phases).

b) After any crane idle period longer than 7 days, the crane and gripper operability is checked by means of test lifting of a container weighing at least 20 tons.[2] During its test lifting, the container remains outside the silo vertical projection at all times.

11.2.2.6 Operability of the pump station in the silo

OLC: a) Two pumps with a capacity of 5 L/s each must be operable at the pumping station on the silo collection tank.

b) Switching on/off of the pumps is actuated by level switches, which respond to the level of water in the tank. At the point of automatic switching on, the water quantity may not exceed 80% of the collection tank capacity.[3]

c) The current water level in the tank is measured by a level transducer. Water level display is provided in the control and monitoring system.

Reason for implementation:

OLC is defined in accordance with the estimated quantity of water that may accumulate in the drainage system.

Applicability: In all operational states.

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[2] Purpose: testing the operability of the gripper and of the crane control systems. The average container mass is 27 t.

The lifting equipment is described in more detail in the technology design document NRVB---5T/02, with the mounting of the testing container shown in drawing NRVB---5T3010 [5] and described in chapter 6 of this draft safety analysis report.

[3] Only water on which an analysis has been conducted will be pumped into the sewage system, or water for which it will be possible to ensure through long-term monitoring of the radiological status and periodic sampling that the contamination limit values are not exceed. In the event of automatic switching on of the pumps, untested water will be discharged into the control pool.

Measures: a) Operability of an inoperable pump must be restored within two days in cases of operational states No. 1 and 3, within seven days in the case of operational state No. 2, and within 30 days in the case of operational state No. 4.

b) Operability of an inoperable level transducer must be restored within two days in cases of operational states No. 1 and 3, within seven days in the case of operational state No. 2, and within 30 days in the case of operational state No. 4.

c) If operability of the pump (measure a) or level transducer (measure b) is not restored by the prescribed deadline, adequate capacity must be ensured by means of mobile or special equipment to pump water from the silo and verification of the current water level in the silo must be ensured. In the case of operational state No. 1, shipment of LILW to the repository is suspended. Non-compliance with OLC must be reported within 30 days.

Surveillance: a) Water level in the tank is displayed in the management and control system continuously in all operational states.

b) Testing of the pumps and apparatuses for manual pump activation and pump activation by water level in the tank in all operational states every three months.[4]

11.2.2.7 Continuity of power supply

OLC: a) Two independent power sources must be provided: connection to the public distribution network (off-site power supply) and connection to the emergency power supply with a diesel generator.

b) The emergency power supply diesel generator must have guaranteed stocks of fuel to enable 24-hour operation at full power.

Reason for implementation:

OLC is defined in order to secure power supply in the event of off-site power supply failure, in particular during the phase of placing waste in the silo by means of lifting equipment.

Applicability: In all operational states.

Measures: a) In the event of a failure in off-site supply, the acceptance and disposal of LILW will cease with immediate effect, and activities in the non-disposal part in the area of the silo will cease as soon as possible and no later than eight hours after failure.

b) Off-site power supply and emergency power supply must be established within 24 hours in operational states No. 1 and 3, and within 72 hours in operational states 2 and 4.

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4 Template TS Krško NPP, 3.1.2.4;

c) If the off-site power supply or emergency power supply fails to be established by the specified deadline, mobile means must be used to provide adequate backup supply of power. In the case of operational state No. 1, shipment of LILW to the repository is suspended. Non-compliance with OLC must be reported within 30 days.

Surveillance: a) Amount of fuel in the diesel generator tank is checked on a monthly basis.

b) Every three months, manual testing startup of the diesel generator and switching of power supply to the emergency source are carried out. If any problem was noticed during the latest two startups, the testing startup is carried out once a month.[5] Automatic testing startup triggered by loss of off-site power is carried out every 18 months.

11.2.2.8 Continuity of fire alarms

OLC: All fire annunciators installed in accordance with the project design files and based on the fire safety study must be operable.[6]

Reason for implementation:

Based on good practice.

Applicability: In all operational states.

Measures: a) Operability of inoperable fire annunciators must be restored within one week in cases of operational states No. 1, 2 and 3, and within one month in the case of operational state No. 4.

b) In the case operational states No. 1 and 3, in any fire compartments with inoperable fire annunciators, activities must be suspended or control over fire safety ensured with special means (e.g. fire watch).

Surveillance: a) Inspection of operability of the fire annunciator system is carried out continuously in all the operational states, through the fire central control.

b) Operability of the fire annunciator system is tested every six months in cases of operational states No. 1, 2 and 3, and at least once a year in the case of operational state No. 4.[7]

11.2.2.9 Operability of the fire protection systems

OLC: a) In the fire water tank pumping station, a hydrophore station with two pumps, each with a total capacity of 15 L/s, must be operable.

b) Sufficient volume of water in the fire water tank (108 m^3) is supplied from the water distribution network, via an automatic floater valve.

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5 Template TS Krško NPP, 3.8.1.1; Design of Emergency Power systems for Nuclear Power Plants, Safety guide No. NS-G-1.8, IAEA, 2004: testing DG once a month;
6 Template for OLC: TS Krško NPP, 3.3.3.8;
7 Template TS Krško NPP, 3.3.3.8.1;

Reason for implementation:

OLC is implemented based on project conditions.

Applicability: In all operational states.

Measures: a) Operability of an inoperable hydrophore station must be restored within two days in cases of operational states No. 1 and 3, within seven days in the case of operational state No. 2, and within one month in the case of operational state No. 4.

b) Operability of the floater valve must be restored within two days in cases of operational states No. 1 and 3, within seven days in the case of operational state No. 2, and within 30 days in the case of operational state No. 4.

c) If the operability of the hydrophore station or floater valve is not restored in the case of operational state No. 1 or 3, activities must be suspended or mobile or special means must be used to check and ensure an adequate supply of fire water.

Surveillance: a) Inspection of the condition of the hydrophore station, by means of its monitoring system, and the volume of water in the fire water tank, by means of the tank level transducer, is carried out continuously in all operational states, through fire central control.

b) Operability of the hydrophore station and the floater valve is tested once a month in cases of operational states No. 1, 2 and 3, and once every six months in the case of operational state No. 4.[8]

11.2.3 REQUIREMENTS FOR PERSONNEL INVOLVED IN THE WORKS AT THE REPOSITORY

11.2.3.1 General requirements

1. All the employees and outside contractors have completed general training for the purpose of work at the repository, comprising in particular familiarisation with the LILW repository operations, the basics of radiological protection, occupational health and safety requirements, fire protection and first aid requirements, and security and access control requirements. The requirements for training are laid out in the document Usposabljanje [11].
2. The employees and outside contractors executing nuclear safety related works possess competences and are trained according to a special procedure which is in accordance with the requirements of chapter II of the Rules on providing qualification for workers in radiation and nuclear facilities (Rules JV4) [12]. In the cases of workers in the radiation protection organisational unit, the Rules on the obligations of the person carrying out a radiation practice and person possessing an ionising radiation source SV8 [13] must also be complied with.

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[8] Template TS Krško NPP, 3.1.2.4;

3. The employees and outside contractors executing works within the radiologically controlled area or works directly connected with the LILW containers, are trained for such works, whereby the particular programme of training depends on the type and extent of work, and are cleared as fit for such works in terms of their health state.
4. The repository manager and the repository technical manager hold licences in accordance with section IV.3 of the Rules on the provision of training for workers at radiation and nuclear facilities (JV4) [12].
5. The employees and outside contractors executing works relating to nuclear safety related SSCs, have passed security screening.

11.2.3.2 Requirements concerning the number of persons

The necessary numbers of persons for operations in different operational states are given in the table (Table 11.1). The number of persons is expressed in number of work posts, which may be filled by employees or outside contractors.

Work posts may be filled on a full time or part time employment basis.

The number of persons involved in non-disposal activities in the area of the silo in operational state No. 3 is given as an indicative assessment and is not to be treated a requirement.

Filling of work posts is determined in detail by a written procedure.

11.2.4 TRAINING AND COMPETENCES

Requirements concerning personnel training and other competences are laid out in the last column of the table (Table 11.1).

Meanings of designations:

- SU – general training
- PU – special training (in accordance with JV4 rules)
- RZ – training in the field of radiological protection (different skill levels)
- DOV – licence (in accordance with JV4 rules)

Table 11-1: Filling of work posts and personnel qualifications (summarised from [11])

Work post	Number of persons by operational states				Qualifications Licence
	State 1 Disposal	State 2 Readiness	State 3 Non-disposal activities	State 4 Standby phase	
General part					
Repository manager	1	1	1	1	SU, PU, RZ, DOV
Maintenance/service technician	1	1	1	0	SU, PU, RZ
Security					
Head of security	1	1	1	1	SU, RZ
Security officer/receptionist 1	1	1	1	1	SU, RZ
Security officer/receptionist 2	1	1	1	0	SU, RZ
Radiation protection					
Head of the radiation protection service	1	1	1	1	SU, RZ
Radiologist 1	1	0	1	0	SU, RZ
Radiologist 2	1	0	1	0	SU, RZ
Technology					
Repository technical manager/technologist	1	1	1	1	SU, PU, RZ, DOV
Logistician 1 (acceptance, keeping records)	1	1	1	0	SU, PU, RZ
Operator 1 (system and crane operation)	1	1	1	1	SU, PU, RZ
Operator 2 (system and crane operation)	1	0	1	0	SU, PU, RZ
Non-disposal activities in the area of the silo					
Works and transport contractors	0	0	10	0	SU, PU, RZ
TOTAL	**12**	**9**	**22**	**6**	

11.2.5 CALCULATIONS AND ANALYSES

Calculations and analyses of radiological impacts are performed in accordance with the report Obratovalni monitoring [9] (presented in chapter 15 of this Draft Safety Analysis Report) and in accordance with special written procedures to be developed in the next phases.

Analyses of operational states and operational emergencies are performed in accordance with the operational experience feedback programme [14] and in accordance with special written procedures.

11.2.6 PROCEDURES AND RECORDS

Operational activities are carried out in accordance with written procedures adopted based on orientations of the documents Obratovanje [15] and Obdobje mirovanja [7].

Execution of procedures is recorded.

11.2.7 REPORTING

Reporting is performed in accordance with chapter III of the JV 9 Rules [16] and in accordance with the provisions of the programme document Spremljanje obratovalnih izkušenj [14] and procedures pertaining to this document.

In addition, events reported include exceeded annual effective dose limit (OLC 11.2.2.1), refusal of a container (OLC 11.2.2.4) or missed deadlines to restore operability of devices.

Reporting is performed in accordance with a written procedure, which will be developed in the next phases.

11.3 RADIOACTIVE WASTE ACCEPTANCE CRITERIA

Acceptance criteria, or radioactive waste acceptance criteria for disposal, are a set of qualitative and quantitative requirements and limit values set by the repository operator and by the regulatory body[9] and which define the properties of radioactive waste packages that must be achieved to ensure operational and long-term safety of the repository. These criteria include radioactive waste properties, ranging from radiological and chemical through physical and mechanical to thermal and biological properties. Limit values concern the form of radioactive waste, some concern the packaging containing waste, and the formation of packaging units i.e. radioactive waste packages (metal packaging and waste inserted into it). Likewise, limit values concern the final packages – package for disposal (concrete container with metal packaging containing waste), unit for disposal (silo) in which the disposal packages are placed, and some concern the entire repository.

In the first place, acceptance criteria depend on the design, i.e. on the type and characteristics of the repository to be constructed, and on the properties of the envisaged repository site. In other words, the site properties, the method of disposal and technological solutions for a particular type of repository determine the allowable / acceptable properties of the radioactive waste before disposal. Different acceptance criteria are verified by means of deterministic and/or probabilistic analyses of the repository long-term safety. Therefore, the repository design and analyses of its long-term safety are iterative processes, where individual design and safety parameters (including the radiological properties of the waste) are verified by means of analysis of repository operation and analysis of its long-term safety.

The better the repository site and repository design are identified, the clearer can be the definitions of waste acceptance criteria for disposal and the more criteria can contribute to the optimisation of the costs relating to the overall management of radioactive waste. The predisposal radioactive waste management can be optimally sized only when it meets all the required acceptance criteria (those relating to storage, transport and disposal of[10] radioactive waste).

Acceptance criteria, which represent a set of requirements expressed in qualitative or quantitative terms relating to radioactive waste properties that must be fulfilled by the radioactive waste to ensure safety of its disposal, are summarised from the reference document [4].

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[9] The regulatory body approves acceptance criteria for disposal in its consent to construction, in the approval of trial operation and in the repository operating licence.
[10] operational and long-term repository safety

11.3.1 LEGAL AND OTHER REQUIREMENTS FOR THE DETERMINATION OF ACCEPTANCE CRITERIA FOR DISPOSAL

Article 93 of the Ionising Radiation Protection and Nuclear Safety Act (ZVISJV) [17] lays down the following manner of RW and SF management:

(1) A holder of radioactive waste and spent fuel shall ensure that:

- the radioactive waste and spent fuel are handled in the manner prescribed, and
- the transfer of the burden of disposal of radioactive waste and spent fuel to future generations is avoided as far as possible.

(2) The person responsible for the generation of radioactive waste and spent fuel must ensure that the waste radioactive materials are generated in the smallest possible quantities.

(3) The person responsible for the generation of radioactive waste and spent fuel must forward the radioactive waste and spent fuel for further management to the provider of the service of general economic interest, except radioactive waste for which clearance is foreseen.

(4) Notwithstanding the obligation under the previous paragraph, radioactive waste and spent fuel may be stored and processed, for a definite time period, by the operator of a nuclear facility that generated the waste, if such activity is licensed by the authority competent for nuclear safety.

(5) The costs of radioactive waste and spent fuel management shall be paid by the person responsible for the generation of the radioactive waste or the holder of the waste when he has taken possession of it from the person responsible for the generation of it, or acquired it in any other way.

Furthermore, the Rules on radioactive waste and spent fuel management (JV7) [18] lay down requirements for RW management, and article 19 lays down acceptance criteria in terms of limit values for acceptance in storage or disposal:

(1) The criteria for acceptance of radioactive waste or spent fuel in storage or disposal shall specify the limit values, which are grouped into the following sets, according to the provisions of JV7:

Radiological properties:

- the content of emitters and specific activity;
- surface dose rate and dose rates at reference distances from the package surface;
- specific surface contamination;
- degradation effects of radiation.

Chemical properties:

- leachability;
- free liquid content;
- corrosiveness;
- resistance to corrosion;
- presence of chelating and other complex compounds;
- toxin content;

- gas formation and gas content;
- explosive properties;
- chemical stability.

Mechanical properties:

- structural strength;

Thermal properties:

- flammability;
- combustibility.

Biological properties:

- content of organic substances.

Physical properties:

- permeability and porosity;
- homogeneity;
- density;
- presence of voids.

Marking and packaging:

- method of marking packages;
- types of containers and method of packaging

(2) Bearing in mind the above listed sets, the criteria for acceptance for storage or disposal shall also lay down any other limit values specified in the final safety analysis report for the particular storage facility or repository, while limits concerning certain characteristics listed in the previous paragraph may be exempted from the criteria for acceptance for storage or disposal if so provided in the safety analysis report for the particular storage facility or repository.

(3) The criteria for acceptance for storage or disposal shall be specified for individual packages, for storage or disposal units and for the storage facility or repository as a whole.

(4) The criteria for acceptance for storage or disposal shall be specified by the operator of the storage facility or the repository. The Administration shall approve these criteria in its consent for construction, in the approval of trial operation and in the operating licence for the storage facility or the repository.

The development of acceptance criteria took into account as applicable the requirements of IAEA GSR-5 [19], which address the responsibilities for the management of waste prior to its disposal. We took into account the requirements concerning the acceptance of waste at the repository as laid out in the document IAEA SSR-5 [20] and WENRA Report [21].

11.3.2 BASIS FOR THE DEVELOPMENT OF ACCEPTANCE CRITERIA FOR DISPOSAL

The developed radioactive waste acceptance criteria for disposal in Slovenia, presented in this chapter, are based on the following assumptions:

(1) The procedure of selecting the site for the repository is finished (the site at Vrbina, Krško is selected).

(2) The technical design of the repository is in the phase of drawing up the draft safety analysis report on the basis of conceptual design (IDZ) rev. C [5].

(3) The assessments of the total radioactive inventory envisaged in Slovenia up to 2043 [22] and 2062 [23] have been revised.

(4) An iterative process of analyses of repository long-term safety in parallel with the project evolution is under way.

(5) The process of analytical characterisation of the radioactive waste stored in the Krško NPP storage has been performed. Krško NPP has criteria for the acceptance of radioactive waste in the Krško NPP storage in place.

(6) The process of characterisation in the CSRAO at Brinje has been performed. Appropriate acceptance criteria for acceptance and storage of such waste in the CSRAO have been developed.

In parallel with the repository project evolution, we plan to perform further optimisation of acceptance criteria for disposal in the scope of the project “Safety Analysis (SA) and Waste Acceptance Criteria (WAC) preparation for Low and Intermediate Level Waste repository in Slovenia” [22], [24].

11.3.3 ACCEPTANCE CRITERIA FOR DISPOSAL

This section considers the development of acceptance criteria based on safety analyses [24], [25], [26]. This section brings them together as acceptance criteria for disposal.

11.3.3.1 RADIOLOGICAL PROPERTIES

11.3.3.1.1 the content of emitters and specific activity

The content of radionuclides and their concentration (specific activity – Bq/g) must be known for the package containing radioactive waste, for the disposal package, for the disposal unit (silo) and for the repository as a whole. Parameters that need to be determined in the scope of this acceptance criterion for disposal, i.e. parameters that need to have quantitative limits defined, are as follows:

1. The inventory of critical radionuclides, or radionuclides relevant for long-term safety of the repository, is determined based on the list of nuclides deriving from analyses and assessment of radioactive inventory to enter the future repository [1]. The safety assessment following

closure (nominal scenario) for 10,000 years suggests as the most problematic the following radionuclides (by order of listing): Ag-108m, Ca-41, Ni-59, Nb-94, Cl-36 and I-129 [24]. If a longer period is considered (a hundred thousand years), an important contribution comes from decay products (radionuclides Po-210, Pb-210 and Ra-226) of U-238 present in the repository.

2. The total specific activity of α emitters in a package containing radioactive waste is laid down in Rules JV7 and may not exceed $A_{sp}(\alpha) \leq 4{,}000$ Bq/g.

3. Specific activity of individual α emitters in a package containing radioactive waste – Specific activity of each α emitter from the list of critical radionuclides – must be recorded in the process of characterisation (Bq/g).

4. Average specific activity of α emitters in the disposal package should not exceed $-A_{sp}(\alpha) <$ 400 Bq/g.

5. Average specific activity of α emitters in the disposal unit (silo) and in the repository as a whole must be less than 400 Bq/g.

6. Total activity of β/γ emitters in the package containing radioactive waste will be determined in the subsequent phase of revision of acceptance criteria (WAC, in the phase of obtaining the construction permit).

7. Total activity of individual β/γ emitters in the package containing radioactive waste (as a package, equivalent to a volume of one TTC) will be determined in the subsequent phase of revision of acceptance criteria (WAC, in the phase of obtaining the construction permit).

8. Total activity of β/γ emitters in the disposal unit – the limit values for individual critical β/γ emitters will be determined in the subsequent phase of revision of the acceptance criteria (WAC, in the phase of obtaining the construction permit).

9. Total activity of α and β/γ emitters in the disposal unit (silo), or in the repository, will be determined based on values for individual radionuclides and the total activity (Bq) in the subsequent phase of revision of acceptance criteria (WAC, in the phase of obtaining the construction permit).

11.3.3.1.2 Surface dose rate and dose rates at reference distances from the package surface

The dose rate limit for each final package is:

1. Dose rate at the package surface ≤2 mSv/h;
2. Dose rate at a distance of 2 m from any external surface of the final package ≤0.1 mSv/h.

11.3.3.1.3 Specific surface contamination of the final package

The specific surface contamination of a final package is limited to the following values (any external surface in an extent of 300 cm^2)

1. Specific surface contamination of the final package (all α emitters) ≤0.4 Bq/cm^2;

2. Specific surface contamination of the final package (β/γ emitters) ≤4 Bq/cm^2.

No unbound specific surface contamination of the package may be present in measurable quantities. The values are defined based on Decree UV2 [2] Article 26.

11.3.3.1.4 Degradation effects of radiation

Radioactive waste packages must be stable in terms of radiation. Radiation stability is a function of the form of the radioactive waste and the ionising radiation field to which the form is exposed in the long term. The intensity of ionising radiation depends primarily on the classification and the method of placing radioactive waste packages in disposal packages and in the disposal unit. A calculation has been performed that demonstrated that, for an average package with ion resin, effects of degradation due to radiation do not pose problems. With conservative assumed conditions applied, the calculated absorbed dose is approximately $2.5x10^5$ Gy. An acceptable cumulative absorption dose for packages containing organic materials, is up to 10^6 Gy, while for other types of packages, up to a maximum of 10^7 Gy.

11.3.3.2 CHEMICAL PROPERTIES:

11.3.3.2.1 Leachability

Radioactive waste must be conditioned so as to ensure low leachability of radionuclides and other hazardous ingredients. Parameters that need limitation for this purpose, include LIX (leachability index), diffusion coefficient or rate of leaching, and their limit values will be defined in the next phases.

Furthermore, limit values for different radionuclides will also be determined (in particular for H-3 and Cs-137). Particular attention will also be devoted to hazardous ingredients in the waste. Quantitative limits for these parameters will be verified by means of deterministic and/or probabilistic analyses of the repository long-term safety.

11.3.3.2.2 Free liquid content

Free liquid content in a disposal container is, as a rule, not admissible, while minor volumes of free liquid in the package (<2%) are acceptable, provided that their average value within the repository is kept below 1%.

11.3.3.2.3 Corrosiveness

Corrosiveness, or chemical aggressiveness of the conditioned radioactive waste, must be minimised to the lowest practicable level. In order to achieve this acceptance criterion defined in quantitative terms, the pH value of the waste (or free liquids contained) must be limited. Likewise, the content of corrosive ingredients in a package must be limited (an inventory of corrosive ingredients likely to be present in the package must be compiled). Limit values are as follows:

1. Any forms of waste with pH values of less than 2.5 or more than 12.5 are considered corrosive and are therefore unfit for disposal [27].

2. For cemented waste, pH value may not exceed 11.

3. The content of corrosive substances in a disposal package may not exceed 1% of the total package mass.

11.3.3.2.4 Resistance to corrosion

The concrete disposal container must be designed so as to ensure resistance of the final package for disposal to anticipated corrosion processes for a period of 300 years.

11.3.3.2.5 Presence of chelating and other complex compounds

The content of chelating and other complex compounds in the conditioned waste must be minimised to the lowest practically achievable level.

The presence of chelating and other complex compounds in a radioactive waste package may not exceed 1% of the package total mass.

11.3.3.2.6 Toxin content

The limit values for hazardous substances in the final packages containing radioactive waste will be governed by applicable legislation, which will lay down permissible discharges of different substances into the environment.

11.3.3.2.7 Gas formation and gas content

Concentration of accumulated inflammable and explosive gases and mixtures in the radioactive waste disposal package must remain below the bottom explosion limit level. If necessary, the quantity of gas-generating waste in the container is limited, or appropriate processing of such waste is prescribed to slow down gas generation.

11.3.3.2.8 Explosive properties

Disposal of packages containing explosive substances is forbidden (exclusion criterion).

11.3.3.2.9 Chemical stability

Conditioned radioactive waste must be chemically compatible with the materials of the metal drums, concrete disposal container, backfill materials in the concrete containers and reinforced concrete structure of the silo. This criterion is verified in the case where the limit values applying to the leachability and corrosion resistance criteria are confirmed.

11.3.3.3 MECHANICAL PROPERTIES

11.3.3.3.1 Structural strength

The disposal unit and repository structural strength must be guaranteed for a period of 300 years.

The project design parameters relating to structural strength (structural stability) of the disposal unit (silo) are determined in the scope of the repository technical solutions. A similar statement applies to the disposal package, where parameter limit values relating to compressive and

tensile strength must be defined. These limit values depend on the concrete disposal container design, therefore these limit values must also be defined as the repository design parameters. The defined limit values must be verified by means of deterministic and/or probabilistic analyses of the repository long-term safety.

11.3.3.4 THERMAL PROPERTIES

11.3.3.4.1 Inflammability

Packages containing spontaneously inflammable, highly inflammable or inflammable substances are not acceptable for disposal (exclusion criterion – additional processing and conditioning processes are required).

11.3.3.4.2 Combustibility

The packages containing radioactive waste must be resistant to fire in accordance with the applicable IAEA recommendations relating to safe transport of radioactive waste (SSR-6) [28], [29].

11.3.3.5 BIOLOGICAL PROPERTIES

11.3.3.5.1 Content of organic substances

The content of biological substances in radioactive waste conditioned for disposal must be minimised to the lowest practically achievable level. Based on the inventory of organic substances, an assessment will be made whether the biodegradation potential can be reduced to the practically achievable level by means of additional processing.

11.3.3.6 PHYSICAL PROPERTIES

11.3.3.6.1 Permeability and porosity

The following two formulations are proposed for this acceptance criterion:

1. The permeability of radioactive waste in its conditioned form must be high enough to allow ventilation of gases generated in the package. The average permeability of the final package concrete will be determined in the subsequent phase of revision of acceptance criteria (WAC, in the phase of obtaining the construction permit).

2. The porosity of radioactive waste in its conditioned form must be low enough to minimise release of radionuclides from the repository. The average overall porosity of the final package concrete will be determined in the subsequent phase of revision of acceptance criteria (WAC, in the phase of obtaining the construction permit).

11.3.3.6.2 Homogeneity

The radioactive waste in its conditioned form must be arranged within the metal container in a homogeneous way. The same requirement applies to concrete disposal containers with radioactive waste in bulk.

11.3.3.6.3 Density

The limit for this acceptance criterion is a repository design parameter, which limits the maximum allowable mass of a full disposal container to 40 t [5].

11.3.3.6.4 Presence of voids

The anticipated limit value for the void fraction is 10% [5]. The limit value is to apply both to metal drums containing radioactive waste and to the final packages. The void fraction limit values must be verified by means of deterministic and/or probabilistic analyses of the repository long-term safety.

11.3.3.7 MARKING AND PACKAGING

11.3.3.7.1 Method of marking final packages

Prior to their transport, all the final LILW packages acceptable for the repository must be marked with a register mark, both in numerical and barcode form [5].

The method of marking the radioactive waste disposal packages is laid down in Rules JV7 Article 10:

Each package containing radioactive waste or spent fuel shall be marked with a radioactivity symbol specified in the regulation governing the use of radioactive sources and radiation practices, and with a marking allowing the identification of the package and its contents. The mark shall provide at least the following information:

1. unique identification of the package in both eye-readable and digital form;
2. package weight;
3. radioactive waste category;
4. type of radioactive waste;
5. maximum measured dose rate on the package surface.

The symbol and the mark referred to in paragraph 1 of this article, the durability of which shall be adequate for the expected management methods, shall be affixed at visible locations and clearly legible.

11.3.3.7.2 Types of containers and method of packaging

The conceptual design phase structural design document for the LILW disposal container N2 provides the container functional and structural characteristics and requirements to be met by the container in all the phases of its use, from manufacture to disposal at the repository [5].

Prior to disposal, all waste must be inserted into specified disposal containers. Packages – disposal containers must meet the requirements for package type IP-2 [5].

The requirements are derived from JV7 Article 10:

- conditioned radioactive waste or spent fuel shall be packaged in packages meeting the criteria for acceptance for disposal.

- packaging used for packing radioactive waste shall, individually and together with the loaded radioactive waste, ensure safety for the expected method and for the expected time period of package management

And

JV7 Article 18:

- packaged radioactive waste may only be disposed of in packaging approved for disposal.

The limits applicable to the disposal container (disposal packaging) must also be stated as the repository design parameters. The defined limit values must be verified by means of deterministic and/or probabilistic analyses of the repository long-term safety.

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