*Nuclear Society of Slovenia*
2nd Regional Meeting: ***Nuclear Energy in Central Europe***
*Portorož, SLOVENIA, 11.-14.September 1995*



# SURFACE-TYPE REPOSITORY FOR LOW AND INTERMEDIATE LEVEL RADIOACTIVE WASTE IN THE REPUBLIC OF CROATIA

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**ABSTRACT**

The low-level and intermediate-level (LL/IL) radioactive waste repository siting and construction project is one of the activities related to establishing the radwaste management system in the Republic of Croatia. The repository project design is one in an array of project activities which also include the site selection procedure and public attitude issues. The prepared design documentation gives technical, safety and financial background relevant for making a final decision on the waste disposal type, and it includes the technological, mechanical, civil and financial documentation on the preliminary/basic design level.
During the last few years, the preliminary design has been prepared and safety assessment conducted for the tunnel-type LL/IL radwaste repository. As the surface-type repository is one of alternatives for final disposal the design documentation for that repository type was prepared during 1994.

## 1. INTRODUCTION

The Republic of Croatia is one of the Krško Nuclear Power Plant co-owners, and has a commitment of active participation in the search for a solution for safe and environmentally suitable final disposal of the LL/IL radwaste produced in the power plant, and the waste expected to be generated during the power plant decommissioning. The decision on which country, Croatia or Slovenia, shall house the radwaste has not been brought yet but both countries are under obligation to run concurrent preparations and actions preceding construction of a LL/IL radwaste repository. The preparatory activities include a series of steps from site selection, repository type proposal, disposal technology, to preparation of repository design documentation. Such documentation shall be a quality technical and investment background once the final decision on the repository site and type is brought.

So far, two options have been considered for permanent disposal of the LL/IL radwaste in the Republic of Croatia, i.e. (a) final disposal in deep geological formations, i.e. in horizontal tunnels and (b) surface disposal in specially built facilities. The Preliminary Design [1] for the tunnel-type repository was generated in 1988, and updated [2] for to the new design parameters during 1992.

Since the design documentation of the same level of completeness was requested for the surface-type repository, the Preliminary Design was developed for this type of repository in the Republic of Croatia, as well. The new solution included process, technical and investment documentation required for comparison of the two types of disposal facilities.

The present paper describes the concept, technical and process philosophy and cost estimate for this type of repository.

## 2. PROJECT INPUT DATA

The design process requests defining the input design parameters, primarily the quantity, type and form of radwaste, and making some assumptions due to a number of unknowns related to this project.

Radwaste disposal - quantities and form

The repository is designed to receive **the total quantity of the LL/IL radwaste generated in the Republic of Croatia and the Republic of Slovenia by the year 2050.** In addition to the LL/IL radwaste generated during the Krško NPP [3] operation and decommissioning, the facility should also receive the LL/IL radwaste from industry, medicine and research institutes [4].

| | |
|---|---|
| **Quantity:** | approx. **18,000 m$^3$** of LL/IL radwaste **from the Krško NPP,** and approx. **500 m$^3$ from other sources** |
| **Form:** | 205 l drums with solid or conditioned waste |
| **Contact dose rate:** | 10% of all drums shall request additional protection during transportation and handling |

Basic design criteria and project constraints

All the requirements, criteria and recommendations of the International Atomic Energy Agency for design and construction of this type of projects [5],[6] were respected in the design, along with the local regulations [7], [8]. The essential request is the principle of maximum public and repository staff safety, the principle of minimum personnel exposure in all the LL/IL radwaste handling procedures, from receipt to final disposal (repository lifetime 300 years), and design flexibility namely application of modular approach.

Since the design was developed for an unknown site, the below assumptions were made:

- the site was selected respecting all the site suitability criteria set for the repository of this type, from physical and chemical, to hydrological and geological, including availability of a geological formation sufficiently large to receive the integrated LL/IL radwaste disposal system along with other factors such as population density, natural resources, possible environmental impact,
- access road of category which permits the LL/IL radwaste transportation,
- infrastructure available at the site - water and power supply, sewerage.

# 3. PROJECT OVERVIEW

## 3.1 REPOSITORY PROCESS DESIGN

The LL/IL radwaste final disposal process includes the following process units:

- waste input and receival procedures,
- LL/IL radwaste treatment,
- LL/IL radwaste disposal in concrete containers, container filling and closing,
- final disposal of LL/IL radwaste containers and the disposal unit closing.

The repository is conceived to be a complex process plant for receival, treatment and final disposal of LL/IL radwaste, including all the main and auxiliary systems, facilities and areas providing for safe and independent operation of the repository. Therefore, it is planned that, in addition to the LL/IL radwaste final disposal unit and the so called main building for receival, treatment and intermediate storage, the repository site shall house a number of auxiliary and safety facilities such as the reinforced-concrete (RC) containers fabrication and storage plant, workshops, boiler house and switchgear, infrastructural facilities - roads, water supply, sewerage system, office building, water tank, fire protection building, etc. The auxiliary facilities are separated from the main building in which the LL/IL radwaste is handled, and the final disposal units are separated from other facilities. The repository layout is shown in Fig. 1.

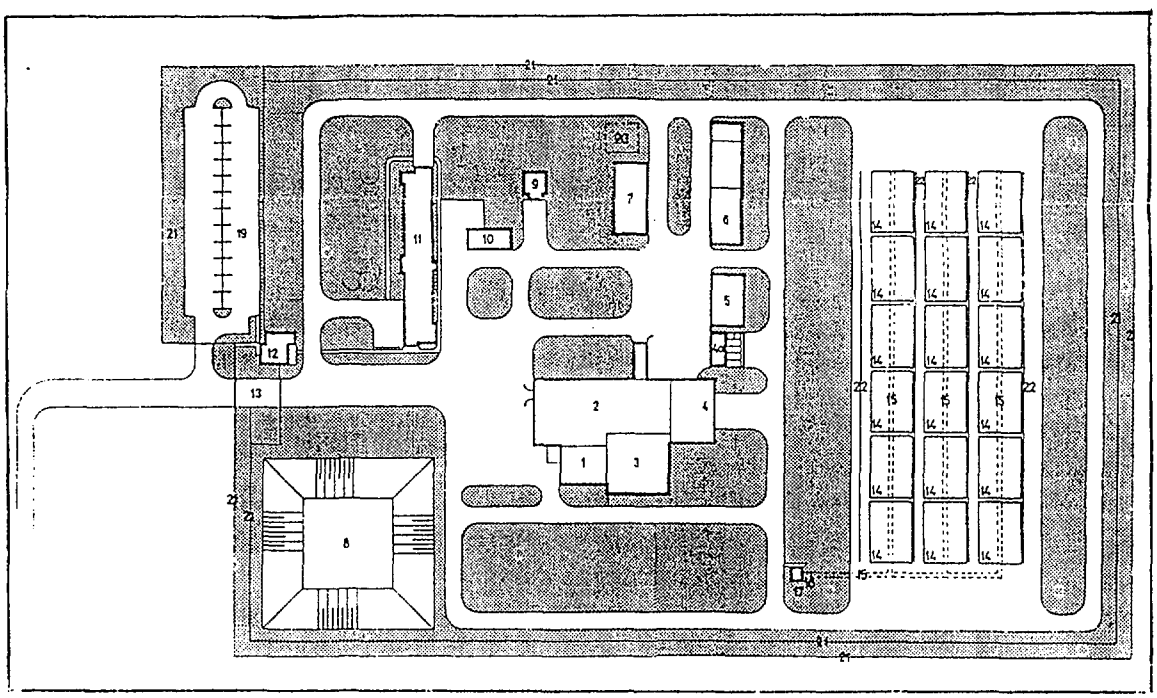

**Fig.1. Repository layout**

| | | | |
|---|---|---|---|
| 1,2 | Main buiding; receival, control, treatment | 7-13 | Infrastructural facilities - roads, sewerage system, office building, boiler house,water tank, etc |
| 3 | Intermediate storage | 14 | Disposal units |
| 4 | Final treatment of RC containers | 15-17 | Special drainage system- galeries and leakage collecting tank |
| 4a,5 | RC containers fabication and storage plant | | |
| 6 | Workshops | | |

The main building accommodates all the waste-related activities, from receival and unloading, to preparation of the concrete containers for transportation to the final disposal units. These activities include receival, unloading, record taking, radiological and radiochemical control of waste, LL/IL radwaste treatment, intermediate storage, disposal of drums in containers, filling up and closing of containers. Additionally, the main building is planned to include the Main Process Control Room, and a number of necessary auxiliary premises – entrance, toilet facilities, locker rooms, fork lift area, hot workshop, laboratory, laundry for contaminated protective clothing, radiological protection room.

**Environmental protection – radiological control, contamination control, long-term monitoring**

Although the designed project prevents any release of radioactive substances into the environment from the repository site, special attention is paid to the repository monitoring and its possible environmental impact, along with the long-term monitoring after the repository is closed down.

The radiation level within and outside the repository fence shall be permanently monitored using the radiological protection and control of personnel and radiological control of the area.

The radiological monitoring of the facility premises and the surrounding area shall be realized using the integrated radiation and contamination monitoring and measurement system. The system consists of the radiation and contamination continuous monitoring screens and procedures for sampling and sample analysis in the radiochemical laboratory. The system alarms the operators in case of increased or excessive radiation dose.

A mobile radiological and weather station is set up on the repository site for acquiring the best possible input data.

Systematic supervision during the repository operation stage shall provide for the data necessary for a decision on the final repository close down. When the repository is closed down, the supervision shall be continued for a certain period of time, in compliance with the regulatory stipulations.

## 3.2 SURFACE-TYPE REPOSITORY AS THE FINAL DISPOSAL SYSTEM

### 3.2.1 CONCEPT

The disposal principle consists in setting up the successive barriers, natural and engineered, preventing migration of radionuclides from the LL/IL radwaste into the environment. The LL/IL radwaste isolation degree depends on a disposal system which consists of reinforced concrete (RC) containers for LL/IL radwaste, above-ground units for final disposal of containers, and geology of the surrounding area (Fig. 2).

The disposal units are the above-ground RC structures. When filled with LL/IL radwaste containers, they are closed with RC slab and covered with layers of natural material (gravel, sand, and similar).

The system of successive barriers includes three different cement-based materials used in the LL/IL radwaste preparation for the final disposal, i.e. material for the waste drum sealing and waste immobilization, concrete for filling in the space between the drums and the RC container walls, and concrete for containers.

These three sorts of material with entirely different composition and function constitute, together with the LL/IL radwaste, a technological entity.

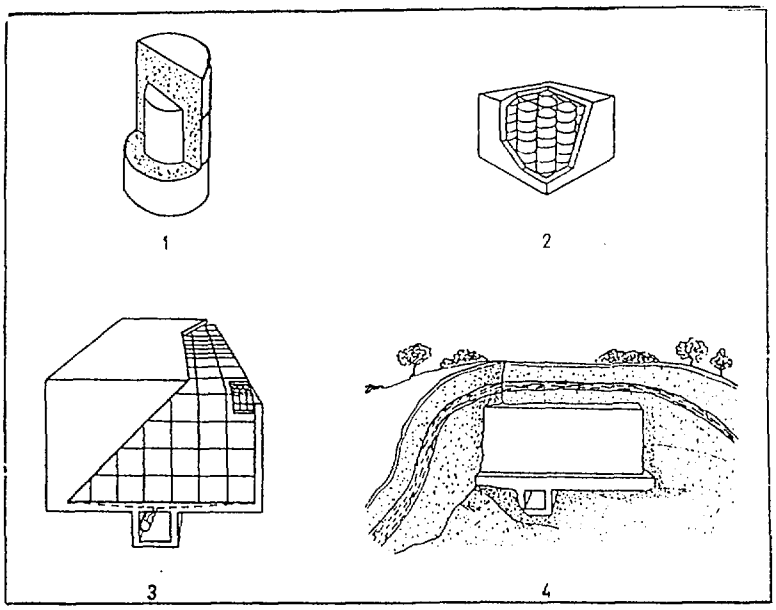


**Fig.2. Successive barriers in the surface-type final disposal system**

### 3.2.2 ELEMENTS OF THE SURFACE-TYPE FINAL LL/IL RADWASTE DISPOSAL REPOSITORY

RC containers for LL/IL radwaste drums

The radwaste is transported to the repository in the form of solid/conditioned waste in 205 l drums. After control and recording, the LL/IL radwaste drums are placed in special RC containers housed within the main building. The container capacity is 18 drums. The space between the drums and the container walls is additionally filled with the concrete of specific mix ratio. In this way the container assumes the form of a compact 2.44 m x 2.44 m x 2.13 m block.

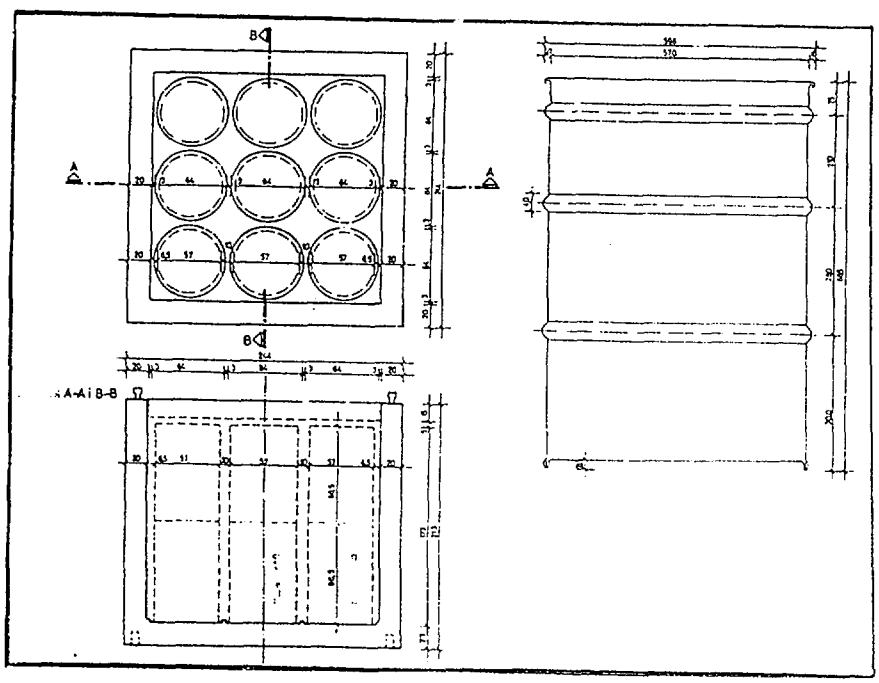

**Fig.3. Reinforced concrete (RC) containers for LL/ILradwaste**

Units for final disposal of RC containers

The units for final disposal of LL/IL radwaste are the above-ground RC 25 m x 18 m x 10 m structures. One unit can receive 280 containers (7x10x4), namely 5,040 drums of LL/IL radwaste.

According to the evaluated LL/IL radwaste quantities 18 such units arranged in three rows are required. The modular concept enables simple increase in capacity, when necessary, with no interruption in the LL/IL radwaste disposal process.

When the unit is filled with the LL/IL radwaste containers, they are covered with the RC slab so that the unit assumes a shape of a large parallelopiped RC block. Prior to final covering with earth, the plastic-based protective coating is applied.

The disposal unit concrete is of the same characteristics as the concrete for containers, i.e. it includes all the necessary additives, mostly those for increase in impermeability.

Disposal of LL/IL radwaste containers into the final disposal units

To prevent ingress of water (rain, snow) during "filling" of the unit with LL/IL radwaste, the units shall have a sliding roof structure on rails protecting the disposal unit while the planned number of containers is being placed (Fig. 3). When the unit is full, the protective roof structure is moved to the next unit.

The LL/IL radwaste container is brought in by a special vehicle and lifted and unloaded on an earlier set area within the unit for final disposal, using the bridge crane which is a part of the protective roof structure.

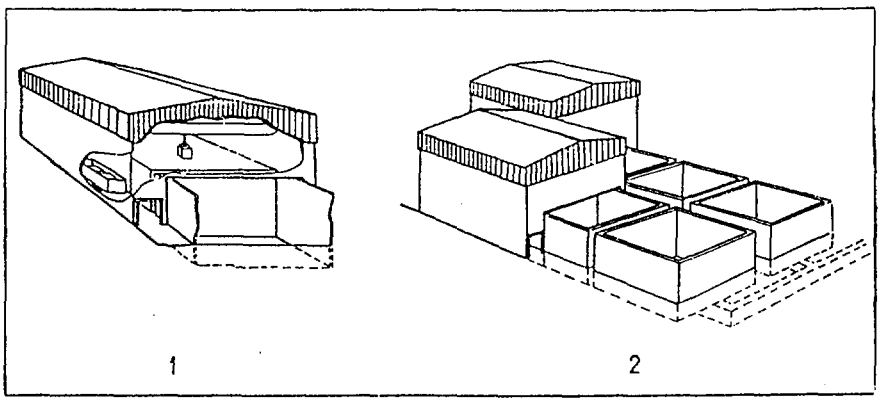


**Fig. 4. Final disposal units with sliding roof structure**

Drainage system

Although the LL/IL radwaste containers and the disposal units are made of special impermeable concrete, drainage system is planned as the additional protective measure. It runs under all final disposal units. The drainage system is planned to collect any leakage under the units prior to and after the final coverage of all the units with additional protective layers.

The drain piping is routed within galleries, under the disposal units, and connected to the 100 $m^3$ leakage collecting tank.

The collected water shall be treated on the repository during its operation. Once the repository is closed down, during the institutional control, any collected leakage shall be tested and, if necessary, treated.

The container disposal unit with its drainage system is the forth level protection.

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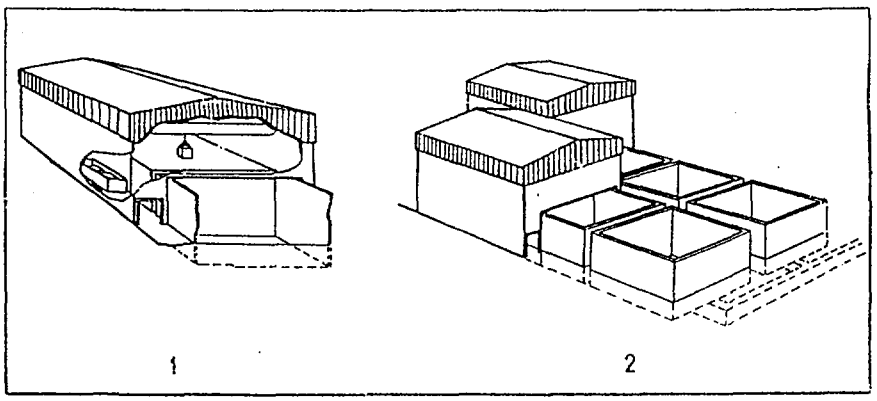


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Unit covering and fitting into the geological environment

The basic characteristic of the surface-type repository is that, once the disposal unit is filled in, it is covered with the natural material, commonly gravel, sand and clay. This forms an additional engineered barrier and enables better adaptation of the repository to the natural environment. The LL/IL radwaste disposal unit cover type shall be decided on with respect to the repository site characteristics.

The site characteristics affect the increase or deceleration of the migration of any released radionuclides, and protection of the repository against the external impacts. Therefore, the siting procedure has to evaluate an array of geological characteristics including lithostratigraphy, hydrogeology, geochemistry, and seismotectonic conditions.

The geological environment, along with the LL/IL radwaste disposal unit cover material, are the fifth level protection.

## 4. SURFACE-TYPE REPOSITORY CONSTRUCTION COST

The repository construction cost is evaluated on the basis of estimated costs of civil works and equipment. The civil works quantity estimate includes all the stages of project realization, from excavation and backfilling, to concrete and masonry works, and glazing and finishing works. The unit prices are determined on the basis of different documentation, primarily on the data from the Bulletin on Standard Calculation of Building Construction Works.

The equipment costs are estimated on the basis of data obtained from the equipment suppliers and designer information.

Since the repository site is unknown, **the land acquisition costs are not taken into account.** The civil costs are broken down per facilities, and equipment costs per systems. The basic cost breakdown is given in Table 1.

Table 1. **COST ESTIMATE, DEM**

| | | |
|---|---|---|
| 1. | Civil costs estimate | 25,750,000 |
| 2. | Main systems equipment cost estimate | 6,720,000 |
| 3. | Auxiliary systems equipment cost estimate | 12,670,000 |
| **TOTAL** | | **45,140,000** |

With respect to the waste quantity, the price is approx. 2,500 DEM/$m^3$ of disposed LL/IL radwaste, not including the land acquisition costs.

## 5. CONCLUSION

The presented design includes a possible comprehensive solution for final LL/IL radwaste disposal. Similar facilities have been in operations in countries with extensive nuclear energy programs for several decades, which proves they are confirmed and reliable solution for the final LL/IL radwaste disposal.

The basic characteristics of the surface-type LL/IL radwaste repository are:

- simple disposal procedure,
- flexibility regarding the possible change in LL/IL radwaste quantity,
- comparatively low investment costs (compared to the tunnel-type repository) and subsequent operation costs.

**The described technical and technological solution respected all the requirements, criteria and recommendations of the International Atomic Energy Agency and documentation and information obtained from the countries with rich experience in radwaste management, and it meets all the global criteria and standards.**

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