Present Status of the Closure Plan for Radioactive Waste National Repository from Baita, Bihor, Romania – 14023

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ABSTRACT

The main objective of the National Policy for radioactive waste management resulted from nuclear activities is to assure a practical, reasonable minimum impact of the waste management activities on population and environment according to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management ratified earlier by Romania. The National Repository for Low and Intermediate Level Radioactive Waste (DNDR) was arranged in a former uranium mine, in the central-western part of the Bihor Mountains in Transylvania, Romania. The disposal started in 1985 and the current estimation is that disposal activities will continue until 2040. The repository accepts low and some intermediate-level radioactive wastes from "non-fuel cycle" industry, medical establishment and research activities. Waste drums are horizontally stacked in disposal galleries and, since 1996, the gaps between the drums have been filled with bentonite powder contained by wooden shuttering. This paper will present the status of works and envisaged strategy for elaboration of Closure Plan according to Romanian and international requirements at top level.

INTRODUCTION

The Main Objective of Romania's National Policy for Radioactive Waste Management is the improvement of all activities for impact reduction on population and environment to IAEA and UE acceptance levels. All existing and future waste management facilities are the main subject of the continuous improvements of technologies and long-term safety. The existing DNDR at Baita, Bihor is designed only for the disposal of institutional waste, respectively waste from non fuel cycle activities. Further a recent safety analysis performed in the frame of a PHARE (Poland and Hungary: Assistance for Restructuring their Economics) project indicated that the safety of this repository will be improved according to the Preliminary Safety Analysis Report (PSAR) Recommendations. This activity is under development in the frame of a nationally funded project related to disposal galleries filling improvement and repository closure according to best practices.

One of the objectives of DNDR's rehabilitation is the necessity to have the available disposal capacity of radioactive waste generated by decommissioning of the Nuclear Research Reactor Water Cooled and Moderated (VVR-S), which is a light water cooled, moderated and reflected, heterogeneous, thermal reactor sited on Platform of IFIN-HH.

The VVR-S reactor is the first major nuclear facility in Romania which will be decommissioned. The radioactive waste streams will be safely managed taken into account the existing provision for improvement of Radioactive Waste Treatment Plant (STDR), situated in the immediate vicinity of the VVR-S reactor.

Also, an important objective of radioactive waste management is population and environmental impact reduction, starting with the initial planning process.

ACTIVITIES TO IMPROVE STDR AND DNDR

The non fuel cycle wastes, known as institutional wastes, consist of wastes generated by industry, medicine and research and these wastes are managed by the existing STDR from IFIN-HH.

The existing STDR sited near VVR-S Research Reactor was designed for the following capacities:

- Liquid wastes (3300 m^3/year);
- Solid wastes – Combustible: 10 m^3/year;
- Compactable waste: 50 m^3/year;
- Non-combustible – non-compactable: 10 m^3/year;
- Shreddable waste: 10 m^3/year;
- Intermediate radioactive waste with concrete shielding: max. 150 drums/year.

In order to improve the site, the following technical solutions are selected at feasibility phase [1]:

- Build a new liquid treatment plant;
- Refurbish the solid treatment plant, improving compaction, incineration and cementation lines, and decontamination and cutting systems;
- Build a new interim storage facility or remediate the existing capacity.

The radwastes management plan associated with the VVR-S nuclear reactor decommissioning plan starts from the prerequisite that the STDR is in operation and available to treat the radioactive solid wastes generated by VVR-S reactor decommissioning using the following facilities [2]:

- Concrete preparation station for max. 800 packages/year;
- Incinerator for about 2000 kg/year textiles, paper, wood, organic materials;
- Thermal forming press for 3000 kg/year plastic materials;
- Plastic material cutting machine with maximum 200 kg/day;
- Ultra-compactor for metallic components and materials;
- Mobile station for radwaste liquids, with flow rate of about 20 - 30 liters/minute;
- Shielded transport devices for the transport of 30 - 120 packages/month.
- Equipment for metallic aluminum melting, eventually mobile installation.

All the above equipment and installations are assumed to exist on the date of Phase 1 start-up in this radwaste management plan.

It is also considered that DNDR has the necessary license for final disposal of conditioned radwaste resulting from VVR-S reactor decommissioning.

The DNDR is emplaced in a former uranium mine in the central-western part of the Bihor Mountains in Transylvania. Two galleries at a depth of 840 m were selected as shown in Fig. 1.

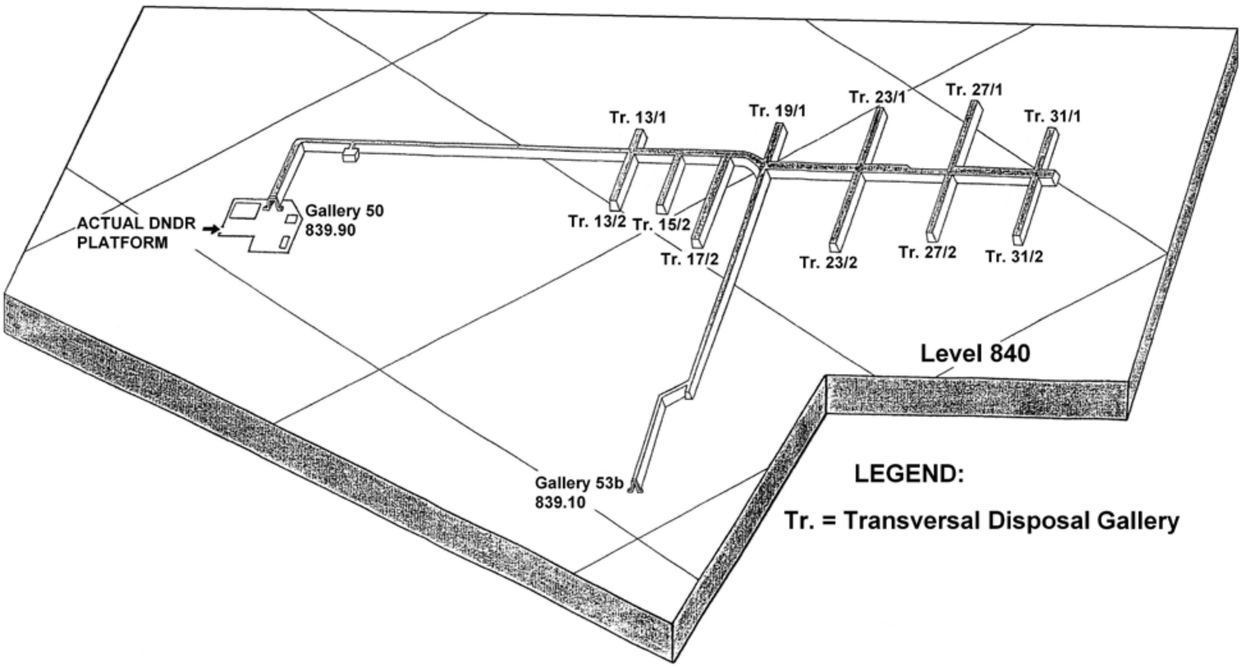

Fig. 1. The Illustrative Representation of the DNDR with Transversal Disposal Galleries.

The wastes include sludge, evaporates and ashes, solid wastes (including shredded plastics and small components), activated materials, ion-exchange resins, spent sealed sources and components from decommissioning of research reactors. Wastes are generally conditioned using an Ordinary Portland Cement based grout and, disposed in standard containers (mostly 220 liters carbon steel drums, although some 320 liters and 420 liters drums are also present). Waste drums are horizontally stacked in disposal galleries and, since 1996 the gaps between the drums have been filled with bentonite powder contained by wooden shuttering.

The life cycle of this disposal facility involves the following stages:

- Disposal room preparation;
- Operational period;
- Rooms closing;
- Disposal facility closure;
- Institutional surveillance.

In order to improve overall activity, a first step was proposed to achieve the following objectives [3]:

- The construction of an administrative building;
- Reconstruction of drainage channels in galleries;
- The attainment of a physical protection system;
- Waterproofing of 200 m of main access gallery and supplementary works to disposal rooms;
- Reconstruct the power supply;
- Reconstruct the ventilation system;
- Utilities supply for technological building;

- The collection of the water from decontamination;
- Purchase the necessary equipment (equipment for dosimetry, auxiliary equipment, concrete mixer, etc.).

This first step of the improvements was performed in the frame of international project: “Modernization of Baita, Bihor, National Repository for Radioactive Waste (DNDR)” [4] funded by IFIN-HH.

Next step of improvements will be performed in the frame of National Project: "The Strategy Development for Closing the National Radioactive Waste Repository Baita, Bihor, Based on the Optimization of Engineering Barriers" [5]. The main objectives of this project are the following:

- Assessing the technology for filling the gaps between packages, in final repositories for low and intermediate active waste, applied in similar facilities, and selecting an appropriate filling technology, to implement at the Baita, Bihor, disposal facility;
- Development of the closure plan at DNDR Baita, Bihor, for nuclear safety;
- Proposal of a safety closure system at DNDR Baita, Bihor;
- Closing System performance assessment, proposed at DNDR Baita, Bihor.

The first phase of this project will finalize the following objectives:

- Analysis of the filling technologies used in the disposal rooms of LLW and ILW, in the case of other disposal facilities similarly to DNDR and selecting the filling technology applicable to DNDR Baita, Bihor;
- Laboratory Experiments on the behavior of filling materials;
- Proposals for filling material alternatives of gaps between disposal containers;
- Analysis of the reaction in time of the disposal system of packages with radioactive waste, in terms of changing the technology for filling gaps and other isolation solutions.

The degree of isolation of the waste repository for the environment depends on the waste-storage system performance as a whole, taking into account the waste package, engineering works in the deposit and the geology of the site. These components of the system must be selected or designed using a systems approach to ensure the isolation required by the radiological safety of the population and the environment, now and in the future, at a predetermined level [6].

All these components have a specific role, depending on the method of storage, and represent a unique system able to meet the main objective of radiological safety, which is to prevent, delay and limit the release of radio-nuclides from the waste in the environment, at a level at which any adverse effects would remain acceptable. In addition, the institutional control and passive markers must be implemented, at the component level (natural and engineering), to facilitate, at least for a while, the protection against human intrusion.

At the same time, an important goal of the project is shaping the release of radionuclides in the disposal galleries. A robust assessment on implementation of engineering barriers can include information from past practices in similar deposits (in geological formations), experiments conducted for the analysis of their effectiveness, and the proposed in-situ and laboratory experiments including the assessment of changes over time.

In this stage, two different modeling concepts were evaluated for the source-term. The first concept is based on computer analytical approaches developed previously by the research team.

These approximations have a high degree of conservatism and represent the upper limit for the release of the radio-nuclides in the disposal galleries. These approximations are based on the mixed cells cascade concept incorporating fundamental hypotheses widely used for this case. The second concept developed for the evaluation of the source term is represented by a numerical solution of the radionuclide transport equation. The release from the waste form includes three mechanisms: surface rinsing, diffusion and leakage (uniform release). These release mechanisms, can be optionally represented, either analytic or numeric. For this work, numerical modeling of the release mechanisms was preferred. Simulations based on the transport equation ion solute were performed with DUST-MS (Disposal Unit Source Term – Multiple Species) computer code for one-dimensional simulation of the disposal gallery.

Modeling results for the radio-nuclides generated by research reactor decommissioning indicated the need to make some supplementary improvements [6]. In order to improve the insulation of radiological waste and radiological safety, it is proposed to lay - out the first 3 rows of packages, fill the gaps between them, and then place the next two lines, following the filling of remaining drums gaps and finally the closure of the gallery. Metal casings, will be made in two phases, respectively, for the first three rows and then for the last two rows. Introduction of this methodology facilitates the innovative technique to fill gaps. The following improvements to disposal galleries will also be studied [5]:

Option I: Modification Of Gaps Filling Technique

I.1 Fill with wet materials:
- I.1.1 Bentonite mud paste (bentonite, clay, water and cement);
- I.1.2 Bentonite concrete paste (bentonite, water, cement, sand);
- I.1.3 Alkaline concrete paste (bentonite, water, cement, limestone).

I.2 Fill with dry materials:
- I.2.1 Powder bentonite;
- I.2.2 Powder bentonite, sand – in proportion of 50%, each;
- I.2.3 Powder bentonite 30%, clay 20% and sand 50%.

In these sub-options, it is necessary to use mobile equipment for the transfer of wet materials and a pneumatic transport system for dry material, through flexible hoses/pipes.

Option II: Increase of Isolation Degree

The use of modern isolation materials, such as geo-membranes and geo-composites to increase the degree of isolation of waste packages will be assessed. Two insulation options have been identified, namely:

II.1 The fitting of a multilayer system, on the walls and the vault of each storage gallery, to isolate the radioactive waste packages;

II.2 The covering of drums layers, with a multilayered system, consisting of a bentonite geo-composite.

The disposal chamber will be waterproofed with a synthetic diaphragm, geo-membrane type as shown in Fig. 2. This alternative may be used in a disposal gallery dedicated to some intermediate radwastes generated by VVR-S research reactor decommissioning.

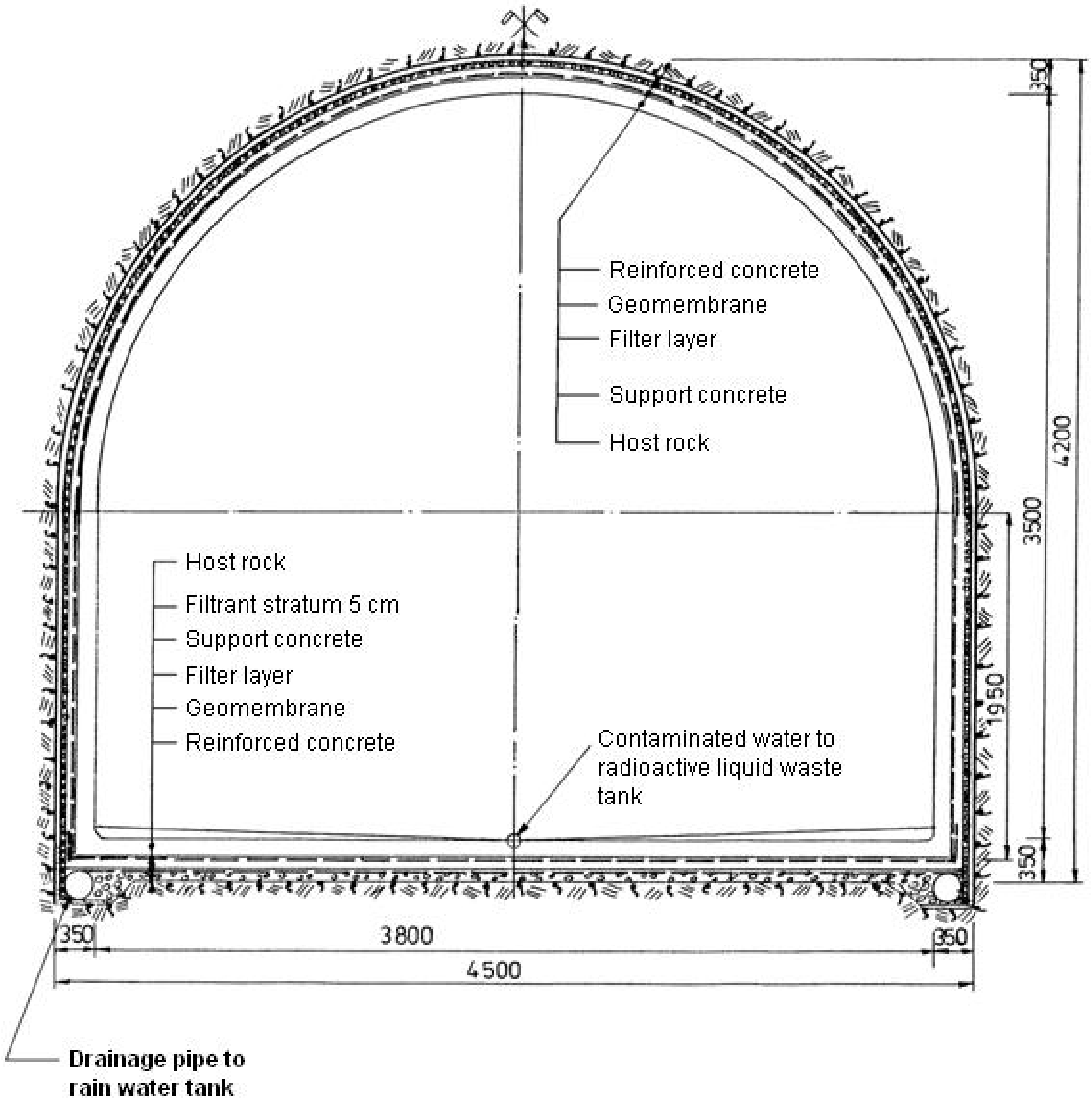

Fig. 2.Sealing Alternative of Disposal Galleries.

The infiltrating water outside the diaphragm will be directed to the potentially radioactive liquid waste tanks, located on the exterior platform and the infiltrating waste inside the diaphragm will be directed to radioactive waste tanks sited also on the platform. This improvement will reduce unfortunately the repository's capacity by ~15%. The research activities for this alternative will be evaluated during the running phase and will be assessed in overall contexts of safety and cost-benefit.

After the demonstration of the optimum technical solution for gaps filling, the Closure Plan of the DNDR Baita, Bihor, will be developed based on best international practices.

This activity will be performed in the phase II of the “The Strategy Development for Closing The National Radioactive Waste Repository Baita, Bihor, Based on the Optimization of Engineering Barriers SARAWAD-BB” Project dedicated to the development of DNDR Closure Plan.

PRELIMINARY CONCEPT OF DNDR CLOSURE PLAN

At the end of the DNDR operation period, it is presupposed, according to the present concept of operation, that a part of access gallery will be used for drum disposal. The result is that about 243 m of the dry part of gallery will be filled with disposal drums; whereas, the last 240 m would be used as an access gallery.

A preliminary analysis showed that a suitable filling material for the galleries is the host rock previously excavated, processed by crushing, in order to be brought to the dimensions of the aggregates used for forming layers used on roads.

The following galleries are to be sealed at the close of DNDR:
- Access gallery, on a length of approx. 240 m;
- Air gallery, on a length of about. 340 m.

Details of the closure will be completed later, after performing safety analysis, obtaining approval from the authorization bodies, and consulting with the actors involved in developing the plan for closing DNDR.

The Main Materials Used and Their Justification

According to the preliminary analysis conducted under this project, the filling of natural excavated host rock presents the best properties of chemical compatibility with the walls of the galleries. Also the mechanical resistance of this material, in the long run, is superior to cement materials. Accordingly, it is proposed to fill the galleries mentioned above with aggregates resulting from crushing the previously excavated rock, which will become the main material that will be used when closing DNDR [7].

Under this preliminary concept, it is proposed to fill the access and venting galleries by transoms, of about 50 m, according to the outline shown in Fig. 3. Four of these transoms will be used to fill the access gallery of about 240 m and six transoms for the venting gallery of about 340 m.

The sandwich type closing technology was proposed, in which layers of crushed rock are interrupted by waterproofing layers and sealed in bentonite, bentonitic mud and reinforced concrete membrane. One type section is formed of the following layers:

1. The previously excavated rock layer, processed by crushing, in order to be brought to the size of ballast for roads.

2. The sealant layer of approx. 3 m, consisting of a mixture of 30% swelling bentonite, 20% non-swelling clay, and 50% sand preventing the formation of preferential channels, preventing migration of radionuclides but without affecting other materials by excessive swelling.

3. Bentonite mud filling between layer 2 and sealing membrane 4 is designed to ensure the diffusion of potential radionuclides escaping through the other layers.

4. The sealing membrane with a thickness of 1 m, made of bentonite concrete, acting as retention of potential radionuclides escaping after penetrating the other barriers.

5. Bentonite concrete sealing membrane with a thickness of 3 m, which delimits the storage area of the gallery.

6. Shotcrete sealing made of 10 cm Xypex concrete, applied on all the surfaces of the gallery, except for the floor.

7. The bottom plate of the porous bentonite concrete floor, 10 cm thick, for drainage through controlled diffusion and retention of potential radionuclides.

In Fig. 3 the closing components for an access gallery transom section are presented.

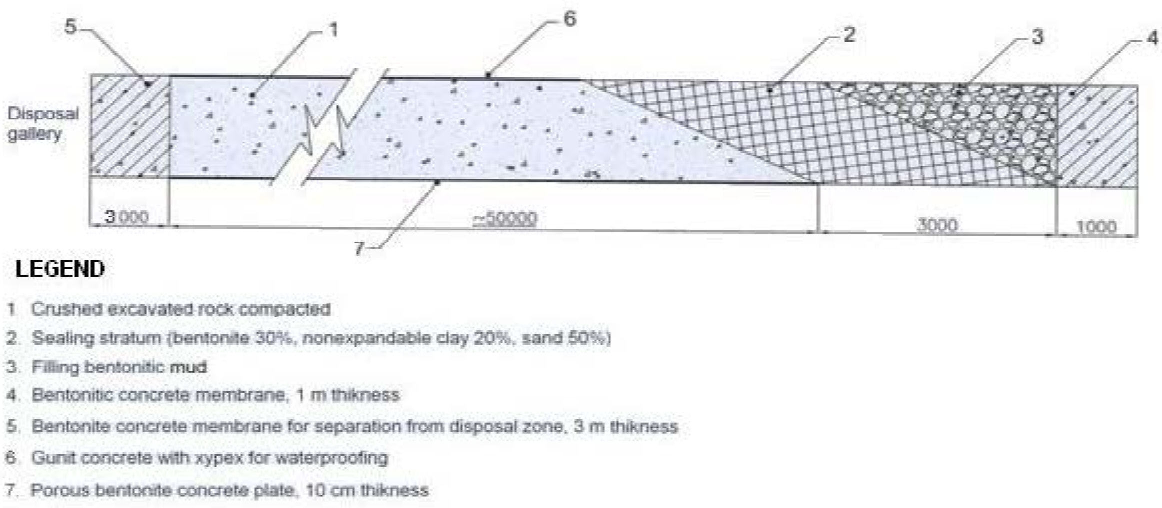

Fig. 3. The Closing Components for an Access Gallery Transom Section.

Sealing and Anti-intrusion Protection

Sealing plugs and anti-intrusion protection shall be provided, set in the feasibility stage of the DNDR project.

Hydro-technical concrete plugs, waterproof, 15 m thick, will be used at the outer ends of the access and ventillation galleries, as well as a plug of the same material, 10 m thick, at the intersection of the ventilation gallery with the access gallery.

DEVELOPMENT OF THE DNDR CLOSURE PLAN

Closing a repository includes those operations required to transform the facility into a final form, even if all active operations, apart from monitoring and inspecting activities and plant intrusion controls, have ceased.

Engineered barriers will be placed in a manner that will ensure the integrity of the repository, undertake hydrological isolation and moderation of radionuclides, minimize required maintenance while also protecting from human intrusion, contributing to proper performance of the entire insulating system. In this context, the elimination of human intrusion is an important factor for all nuclear installations.

For nuclear facilities located in rocky cavities, similar to DNDR, Baita - Bihor case, the closure process includes sealing all the engineering access routes, for example, sealing columns, shafts or other openings that connect the repository to the surface.

Closing the facility will be performed in accordance with an approved closure plan, which will include updating the security assessment and description of planned controls for the post-closure monitoring and surveillance program and record keeping system.

The decision to implement a very accurate Closure Plan will be based on the synthesis and analysis of all relevant information and will be approved by Regulatory Body.

For the development of the Closure Plan, the following factors shall be considered:

- Regulatory requirements;
- Quality assurance;
- Inventory and characteristics of waste;
- Characteristics of the land;
- Design;
- Operational experience;
- Public requirements;
- Availability of materials;
- Experience in closing other storage facilities.

The preliminary concept of Closure Plan periods is presented in Fig. 4.

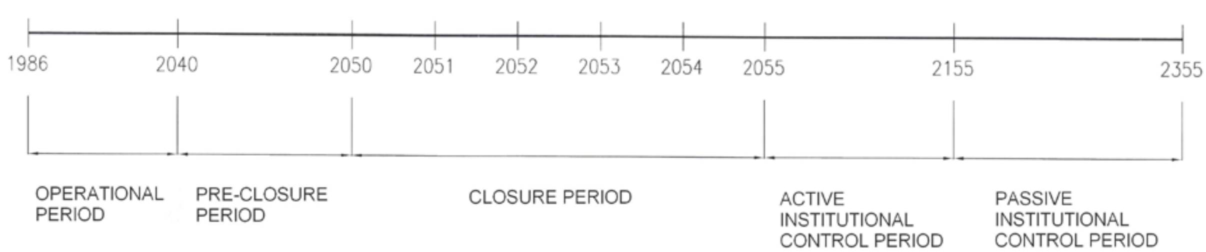

Fig. 4.The Preliminary Concept of Closure Plan Periods.

The advantages to the Safety Case of these improvements (i.e., new buffer material and closing the access gallery by special transoms) were demonstrated in this new analysis including the reduction of radioactive impact on the biosphere.

PRESENT STATUS OF THE CLOSURE PLAN FOR DNDR

In order to establish the optimum buffer material, a Testing Program was initiated with the purpose to demonstrate the performance of materials in contact with disposal drums. Five testing programs were started.

Preliminary Corrosion Effect Determination of Solid Buffer Material on Disposal Drum

The receipts of solid buffer materials (bentonite mud, bentonite concrete and alkaline concrete) were presented above.

In order to determine the corrosion effect,3 samples were prepared for every solid receipt and a supplementary sample with current receipt of mortar cement used for drum filling. The representative sample consists of a miniature drum at scale 1:10 filled with current mortar cement introduced in a testing cube filled with one of the proposed buffer materials: bentonite slurry paste, bentonite concrete paste, alkaline concrete paste and mortar cement.

One sample of every receipt was inserted in a climatic chamber at the temperature of 14^0 C and humidity of 98% for 7 days. The last two samples from every buffer material were transported to DNDR repository and disposed in the gallery reserved for testing. These samples will be tested for 6 months and 12 months.

All these samples will be put to visual examination in order to determine the corrosion effect of different buffer materials.

Compression Test of Solid Buffer Materials

Six samples of every receipt, with the shape of a cube with 20 mm sides, will be tested in the following conditions:

- a pair of every receipt will be put to the compression test 28 days after pouring;
- a pair of every receipt placed in the climatic chamber (temperature 14^0C and 98% humidity) will be put to the compression test 3 days after pouring;
- another pair of every receipt placed in the climatic chamber will be subjected to the compression test 7 days after pouring.

Permeability Test of Solid Buffer Materials

One sample of every receipt obtained by pouring in a shape of a cube with 100 mm sides will be tested by subjection to the water pressure permeability test.

Leaching Test of Solid Buffer Materials

A leaching test was performed in order to establish the behavior of the solid buffer material in the presence of infiltrating water. The following tests will be performed:

- a pair of every receipt will be immersed in the simulated water similar to DNDR's water composition;
- 3 concrete forms of current mortar cement used for disposal containing Cs-137 markers will be poured in the miniature testing drums and, after 28 days of hardening, will be extracted and placed in matrices of slurry bentonite, concrete bentonite and concrete alkaline. After 7 days the samples will be immersed in the simulated water representing DNDR's water composition.

The conductivity and the pH will be measured with authorized procedures.

Leaching Tests on Powder Buffer Materials

The powder buffer materials were defined as above:
- bentonite powder;
- bentonite 50% and sand 50%;
- bentonite 30%, clay 20% and sand 50%.

Tests will be performed by flowing a simulated water representing that in situ at DNDR Baita, Bihor, into columns filled with the above powder materials. pH, conductivity and presence of marker will be measured.

Additional tests will be performed using the water with Cs-137 from the spent fuel cooling basin. The content of Cs-137 will be spectrometric measured before and after the flowing through testing columns.

On the basis of these results, the Testing Program will be finalized including selecting the optimum alternative for buffer materials that will be demonstrated based on the Closure Plan for DNDR Baita, Bihor.

It was envisaged that by improving buffer material the workers doses will be reduced and applying the closing systems proposed, the impact of DNDR on biosphere will be also, reduced.

CONCLUSIONS

After the Fukushima NPP disaster, it appears prudent to verify all radioactive waste management activities.

This paper presents the main characteristics of radioactive waste management systems of the non fuel cycle radioactive waste from Romania, one country with the highest carefulness on responsible and ethic concept for the safety radioactive waste isolation at the top level internationally recommended. All existing and future Waste Management Facilities are the main subject of the continuous improvements of technologies and long-term safety.

One of the main issues is to reduce the human and environmental impact by improvement of some important aspects of radioactive waste management strategy.

In this domain, the concern on radioactive waste management is focused on existing STDR and DNDR, in order to improve the long-term isolation of radioactive waste generated, taking into account decommissioning wastes that will be generated in future years. STDR is under modernization including new equipment, with highest performance and consequently with new technologies being put in place. Also, DNDR will be continuously improved by introducing new modern technologies, and on this basis the Closure Plan will be developed.

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