CLOSURE OF A CHAMBER IN THE RICHARD UNDERGROUND REPOSITORY

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ABSTRACT

Underground disposal of low and intermediate level radioactive waste from nuclear research, medicine and industrial applications has been carried out at the Richard Underground Repository near Litoměřice, in the Czech Republic since the mid nineteen-sixties. Currently, some 25,000 waste packages, mostly 200-liter drums, are disposed of at Richard. In January 2000, the Radioactive Waste Repository Authority of the Czech Republic (RAWRA), established by the Atomic Act in 1997, took over into its possession the repository, and is now responsible for site operation. The atomic act requires preparing a general plan for repository closure including a safety assessment demonstrating the long-term safety of the disposal system. In compliance with this requirement, RAWRA has developed a preliminary plan for the Richard repository closure, based on existing data and on general information on backfilling materials, as well as a Safety Assessment of the proposed disposal system. Additionally, RAWRA has undertaken a series of preparatory activities, leading to closure of several disposal chambers, particularly those with "historical waste". In 2003 RAWRA launched an international call for tenders for the development of the repository closure concept and for the detailed design of the closure of a chamber in the Richard Repository. This project, financed by the European Union, will set up the basis for the realization of the closure of a selected disposal chamber at Richard to be carried out in the next few years. The prototype chamber closure will provide a basis to demonstrate the closure technology and will render a chamber properly instrumented in which the adequate functioning of the waste isolation system can be monitored for a longer period of time, in preparation of the site's final closure

INTRODUCTION

In May 2004 Europe witnessed with the accession of ten Central and Eastern European countries to the European Union a major historical milestone. In the decade before their accession those ten countries have undergone a deep transformation process that involved almost every aspect of daily life, and have undertaken substantial efforts to adapt their legal systems and institutions to standards compatible with the legal framework of the European Union. The European Commission and institutions of the previous EU members as well, intensively supported such efforts by a variety of means, including the EU Phare program to provide assistance to accession countries in specific fields. One important Phare project for the Czech Republic was the assistance given to the Czech Ministry of Energy and Industry by CASSIOPEE, a grouping of waste management agencies of six major EU countries.

As a result of this project the Radioactive Waste Repository Authority (RAWRA), was founded on June 01, 1997 and entrusted with a range of responsibilities in waste management and disposal, including operation of existing and planning of future final repositories. On January 1st, 2000 RAWRA took over on behalf of the Czech Government the operation of the three existing repositories for radioactive waste: the Dukovany repository, in which operational LILW from the Dukovany nuclear power plant is disposed of; the Bratrství – Jáchymov repository, in which naturally occurring radionuclides are dispose of since 1974; and the Richard repository for radioactive waste from institutional waste producers. A map showing the location of these repositories is included in Figure 1.

Fig. 1. Location of the three repositories operated by RAWRA

The Richard Repository for Institutional Radioactive Waste

The Richard repository for radioactive waste from institutional waste producers is located in the outskirts of Litoměřice, a historical small town on the shores of the river Labe, in Northern Bohemia, some 100 km Northeast of Prague. Richard is a former limestone mine in which during WW2 an underground facility for military production was installed. To this aim a series of caverns were excavated, which at later times remained unused. With the start of nuclear research and isotopes use in medicine and industry in Czechoslovakia in the nineteen fifties the need for a facility to dispose of resulting waste arose, eventually leading in the mid of sixties to the installation of a repository in some chambers of the central section of the former Richard mine.

The Richard mine consists of three distinct areas, denominated Richard I, Richard II and Richard III. The areas were originally separate facilities, later interconnected by tunnels. Only the Richard II mine is used as a repository. While Richard III is abandoned and no longer accessible, the former Richard I mine is open to restricted access. A layout of the mine is shown in Figure 2. The chambers currently in use for waste disposal are colored pink.

In the Richard repository low-level waste from nuclear and other research involving radioactive materials, from hospitals, and from radioisotope use in the industries is disposed off in adapted chambers of the former mine. The waste is mostly packed in standard 200-liter drums, which comply with radiation protection criteria for contact-handled waste. Currently, the by far most widely used waste container is such a 200-liter drum containing a 100-liter drum cemented into it, so that a radiation shielding of about 5 cm of concrete is included in every standard waste package.

An impression of the state of the repository in its interior is given with Figure 3, with shows a disposal chamber in the area of the repository most distant from the entrance. In the foreground the main mine ventilator can be seen, which via a ventilation stack with about 0.5 m diameter and 70 m length discharges mine air into the environment. In the background one of the disposal chambers can be recognized that has already been filled with 200-liter drums containing LLW.

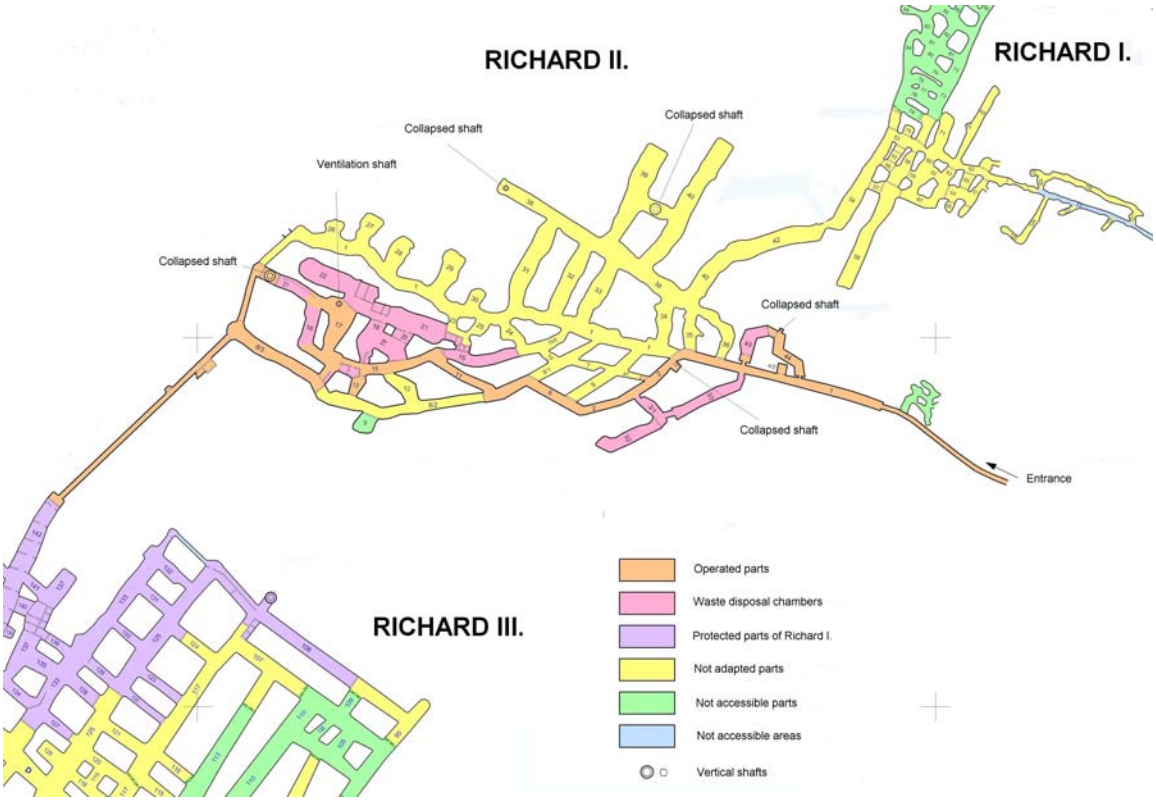

Fig. 2. Layout of the Richard mine, with the repository in Richard II

The Closure Concept

In discharging its statutory duties RAWRA prepared a preliminary site closure concept, which is part of the repository license documentation. The concept anticipates the closure of the chambers with walls separating them from the rest of the repository mine, the backfilling of the chambers with low-permeability, high quality concrete, and later the closure of the access tunnels. Furthermore, the ventilation shaft is to be backfilled with low-permeability material, as well as several existing, not sufficiently plugged former ventilation shafts remediated to become high quality seals. This closure concept, as well as a comprehensive site documentation, which was completed by RAWRA to include a sufficiently accurate description of the geological and hydrogeological situation of the site and its surroundings, of the waste inventory, the area seismicity and meteorology, etc., was used to establish a safety case for the likely repository evolution after closure.

The safety analysis rendered in general very satisfactory results but to one specific scenario. In the case of the so-called geosphere bypass scenario it is assumed that water percolating into backfilled chambers becomes contaminated with radionuclides, is swiftly discharged out of the repository isolation system without any dilution, and becomes the sole source of drinking water for members of the critical group. Such an extreme worst-case scenario would result in radiation exposures well above acceptable values. This is not the least due to the fact that a significant part of the activity inventory of about 1015 Bq is made up of long-lived radionuclides, mainly 241Am, 239Pu, and 238Pu. Notwithstanding the radiological risk associated with such a scenario was considered in principle rather limited due to the fact that the probability of occurrence was judged very low.

Fig. 3. Richard repository disposal chamber and main mine ventilator.

At a later time the rationale for this judgment was considered to offer too much room for uncertainty and hence criticism. Therefore, instead of concentrating in a better analysis of the probability of occurrence of such a scenario, work in the mentioned detailed design of the closure concept focused on developing an enhanced closure concept alternative that would eliminate or reduce the radiological consequences of the bypass scenario, should this ever occur. By these means an effective reduction of the radiological risk of future generations is achieved, irrespectively of the probability of occurrence. Furthermore, an enhanced closure concept would also help reducing the probability of occurrence of the bypass scenario, thus effectively optimizing protection against future radiological risks in the sense of ALARA. A further paper presented to this conference focus on the details of the safety assessment and its results, pointing out the impressive advantages of the proposed enhanced concept [1].

The proposed optimized closure concept for waste disposal chambers consists in implementing a "hydraulic cage" around each waste disposal chamber, to exclude the build-up of a pressure gradient across the disposal chamber which would be the driving force for radionuclide mobilization by advective transport out of the chamber. This hydraulic cage is realized by building a high permeable layer around the chamber as preferential pathway for possibly present groundwater. A sketch outlining the hydraulic cage realization for the Richard repository is shown in Figure 4. With this, the former radionuclide isolation system of the repository, which was based only on the principle of reduced groundwater flow through the waste body by enclosing the waste with low-permeability barriers, would be complemented by a redundant barrier based on an alternative, totally different working principle: avoiding water flow through the waste by eliminating the flow driving force.

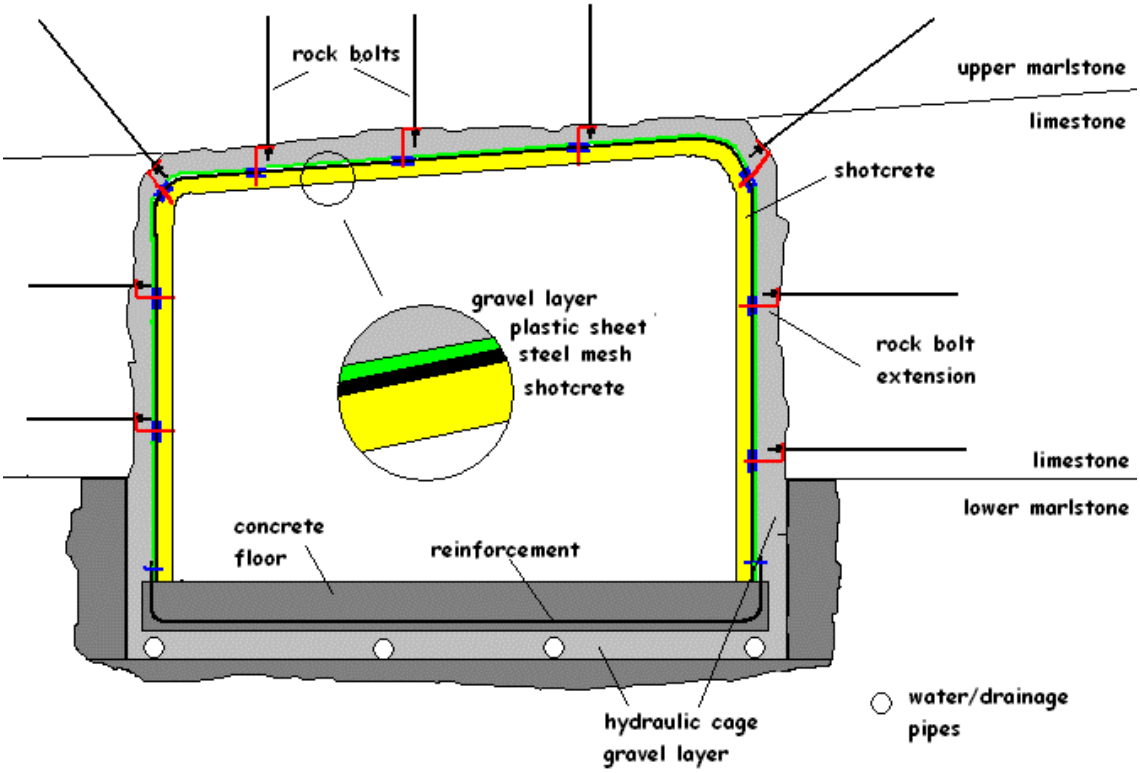

Fig. 4. Concept outline for the hydraulic cage realization

After reviewing the different technical implementation alternatives, a rather simple to apply and robust solution for the construction of the hydraulic cage, analogous to techniques used in tunnel building was developed. In principle the stacked waste is backfilled with low-permeable concrete as foreseen in the preliminary closure plan. In addition, a layer of pure concrete, which again is enclosed in a gravel layer with high hydraulic conductivity, surrounds the waste/concrete body. A drainage and monitoring system allows monitoring the performance of the hydraulic cage before repository closure, thus allowing verifying the proper functioning for a period of up to several decades.

The enhanced closure concept will be realized for a single, selected chamber in the course of 2005/2006. The planned work include the preparation of a chamber system subdivided for technical reasons into several segments, the transfer of waste from its present position into the prepared chambers, the isolation of the chamber segment by means of a concrete wall, and the backfilling of the disposal chamber with pumped concrete. During the backfilling process the concrete temperature will be monitored at a number of positions in the chamber to verify that during the concrete solidification temperature limits potentially leading to cracking are not exceeded. The backfilling process will be also monitored and quality controlled by means of TV cameras and by sampling and testing the backfilling concrete after solidification.

CONCLUSIONS AND OUTLOOK

A novel, enhanced concept has been proposed and will be realized in the near future for the isolation and closure of single chambers in the underground repository Richard for LILW from institutional producers. The safety analysis carried out for the enhanced concept leads to exposure values in the case of the most unfavorable scenario some three orders of magnitude below exposure estimations with the preliminary, former closure concept. With this, the goal of reducing the radiological consequences of the most problematic scenario has been achieved. Together with the increased insight on the performance of the repository system as a whole, it appears that this scenario can be now considered as having low relevance.

The tendering procedure for realization of the chamber closure is about to start, the work is due to commence in the course of 2005. With this, Richard in the Czech Republic will be after Morsleben in Germany the second underground repository in the European Union in which final closure work is being carried out as a routine operation.

REFERENCES

1. Haverkamp, Biurrun, Kučerka. Update of the Safety Assessment of the Underground Richard Repository, Litoměřice. WM'05 Conference, February 27 – March 3, 2005, Tucson, AZ.