SITUATION CONCERNING THE HLW REPOSITORY IN GERMANY

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ABSTRACT

Final disposal of radioactive waste has been defined in Germany as:

- maintenance-free, safe emplacement of radioactive waste, time unlimited and no intention of retrievability.

The responsibility for final disposal lies in the hands of the German Federal Government, which has assigned a federal authority to plan, erect and operate the federal facilities for long-term storage of nuclear waste. The federal authority has in lack of industrial experience contracted my company DBE which is responsible for the engineering, erection and operation of all German nuclear waste repositories.

INTRODUCTION

Presently we operate GORLEBEN as an exploration project, MORSLEBEN, the final disposal for low level waste, which is now under our responsibility after the reunification of Germany, and are within the licensing procedure for the planned KONRAD repository for low level waste. The public hearing for KONRAD will start this year.

The company DBE has 4 owners, presently approx. 540 employees, last year's turnover was about 157 Mio. DM.

WASTE-EMPLACEMENT

The emplacement of radioactive waste in deep geological formations is being regarded as the best solution to isolate hazardous and toxic waste from the biosphere. This can be realized either by the construction of a suitable repository mine or the use and adaption of existing mines in appropriate geological formations.

With regard to the geological formation a lot of long-term studies have been performed. It is the today's experts judgement in Germany that rock salt formations are the suitable solution for the long-term storage of all kinds of nuclear waste.

Salt has essential characteristics and advantages for emplacement of radioactive waste. Worth to be mentioned are the thermal and mechanical properties which allow:

- The excavation of large cavities.
- The evacuation of decay heat.
- And fast closing of all kinds of underground openings.

The mere existence of this kind of formations is a proof of their stability of million of years, with no significant contact to aquifers.

Fortunately Germany has a large number of such rock salt formations.

All mentioned properties and advantages have led to select rock salt as host rock for final disposal.

In 1977 the GORLEBEN salt dome in northern Germany was selected for preliminary site explorations for a high level radioactive waste repository.

NUCLEAR WASTE AT THE BACK-END OF THE FUEL CYCLE

Operating light water reactors are utilizing uranium oxide, or as already demonstrated in Germany mixed uranium/plutonium oxide, the so-called MOX-elements.

According to the Atomic Energy Act, spent fuel elements have to be recycled. However a lot of fuel elements, as fuel elements with high burn-up or MOX-elements are not worth to be reprocessed with today's techniques available. The amount of spent fuel from light water reactors over the next two decades is shown in the first slide.

The diagram shows a forecast of spent fuel with approximately 550 t spent fuel per year, an increase to 600 t in the year of 2000 and 700 to 800 t till the end of the first decade of the next century. However the present trend to higher burn-up may lead to different figures in the future.

Since Germany has stepped out of the reprocessing business, spent fuel will be reprocessed in France (COGEMA) and Great Britain (BNFL).

The high level waste, resulting from reprocessing and non-reprocessed fuel are the main waste stream to be considered for a repository design.

FINAL DISPOSAL CONCEPTS

The major and essential criteria to be considered in a repository design are:

- decay heat, due to high level waste or spent fuel, and radiation exposure during operational and post operational phases to the operating personnel and to the environment are basic criteria to be considered for disposal concepts and designs.

Planning Fundamentals

Final disposal of heat-generating waste in a host rock formation leads to instationary temperature fields. The underground facility design has to take into account these continuously changing thermo and thermo-mechanical solicitation of the host rock.

A repository in a salt dome takes advantage of the special properties of rock salt for the safe confinement of the waste and hence the long-term isolation of radionuclides from the biosphere.

The multibarrier concept takes into account technical and natural barriers. These are the waste matrix, the fuel matrix, the waste containers, the backfilling material, sealings and dam constructions on one side and the host rock and its overlaying strata. All mentioned barriers are not effective at the same time.

For safety and radiation protection reasons waste will be disposed off at the very far end of the repository moving continuously towards the shaft. Once filled the emplacement field will be abandoned, all cavities filled and all drifts sealed.

Emplacement Techniques

The very first considerations with regard to emplacement techniques looked at two different types of containers for final disposal. Containers with lost shielding and suitable for all kinds of transport with relatively easy handling and no additional shielding. Size and weight of these containers however allow disposal only in drifts.

Unshielded canisters and drums will be disposed of in boreholes.

These kinds of containers, only suitable for final disposal, require shipping casks for transportation and shielded transfer casks for facility internal handling.

For the overall design of a high level waste repository both types of containers are being considered.

The container with lost shielding in the well-known Pollux-Container.

Drift Disposal

The POLLUX-container, which allows only drift disposal, is a transport and repository container and fulfills the IAEO (Type B (U)) requirements.

After an entrance control at the surface, the container, placed on a transport vehicle, will be lowered through the shaft to the emplacement level. By an electric driven locomotive the container will be transported to the emplacement area. A remotely controlled lifting device sets the container into its final position, remaining cavities being subsequently backfilled by crushed salt.

Borehole Disposal

As already mentioned canisters and drums are shipped in reusable casks. The handling requires a reloading into transfer casks within the surface facilities.

A special designed emplacement machine lowers the canisters and drums into the borehole on top of each other. A borehole hatch and lid system in the transfer casks are the important features to minimize radiation exposure of the operating personnel.

THE REPOSITORY-DESIGN

The date available today do not allow an exact forecast of the fuel which will be reprocessed and directly disposed of. Therefore assumptions were made which led to a so-called "DUAL-PURPOSE-REPOSITORY"-design. A reference concept is being outlined with the following criteria:

- 500 t heavy metal reprocessed fuel per year, and
- 200 t heavy metal of fuel for direct disposal.

Surface and Underground Facilities

The surface facilities are basically the transfer hall, the shaft hall, social laboratory, and technical service buildings.

The transportation to the repository will be done either by truck or railroad. The reloading from the shipping casks to the transfer cask will be carried out in a hot cell.

Of much more interest are the underground facilities. Since the decay heat, generated by the high level waste or spent fuel, is the decisive element for the design of a disposal field, near field thermal calculations have to be performed.

The results of the mentioned thermal calculations provide basic criteria for the spacing of containers in disposal drifts and the spacing of boreholes and emplacement drifts.

A maximum permissible temperature of 200°C at the interface between containers and rock salt has been selected and agreed upon by the experts in Germany.

It has been recognized at an early stage that an ideal underground facility configuration requires large homogeneous disposal areas. Since this cannot be accomplished in every geological formation, an adaption to specific geology has to be made.

The temperature fields are calculated with LINSOUR, a DBE-own proprietary special computer code.

This code allows detailed temperature field calculations, modelling every single heat source separately. Specific data as local position, decay heat, and interim storage times can be considered. Compared with simplified calculations in the past, excellent improvement has been obtained in accuracy of temperature field predictions with the LINSOUR-code.

The important and significant result is:

- all considered repository layouts being analyzed with different arrangements as drift disposal exclusively or with a mix of drift and borehole disposal comply with the 200°C temperature criteria.

The Gorleben Model

Preliminary planning activities were based on site-independent data. The next step took into account site-specific data of the Gorleben salt dome.

Data from Gorleben explorations and comparisons with other salt domes were the basis for a new site specific model.

The site independent planning is currently being adapted to this geological model.

The present status of our planning activities clearly shows that the site independent analysis is applicable to the specific Gorleben modelling.

DEMONSTRATION OF NEW ADVANCED TECHNIQUES

The licensing authorities have clearly pointed out that the feasibility of spent fuel disposal has to be demonstrated prior to granting a license for a high level waste repository.

Due to this requirement DBE has started a program for demonstrating the feasibility of all equipment and processes which are not state of the art.

Full scale demonstration tests are either planned or presently being performed in the following areas:

1. Shaft transport with loading and unloading of inactive casks; they have been simulated in a test series this year.
2. Handling equipment for underground transportation of casks will be tested in 1993.
3. Remotely operated equipment for final drift disposal of casks, will be tested in 1993.
4. Thermal and thermo-mechanical tests on a 1:1 scale are being performed in a salt mine (ASSE). Six electrically heated cask mock-ups are already disposed and backfilled; the demonstration runs since 1990.
5. Dam-constructions, for long-term sealing of drifts, currently being constructed.

Let me explain a couple of details of the demonstration tests.

Shaft Transport

Shaft hoistings with payloads of 85 t - 65 t weight of the POLLUX-cask and 20 t of the railroad car - have not yet been built world wide.

A review of heavy hoisting systems world-wide was performed in order to find out which components are not state of the art.

The conclusion of the study was, that essential components of the hoisting systems can be easily adapted for our specific application. However, some components have to be specially designed and tested. These components are shown in the next slide.

- The hoistings
- The diagonal arrangements of guide rails
- The cage bottom support
- The passive cage retardation-system
- The loading and unloading unit

After performing 2000 loading and unloading cycles the overall system performance has been very satisfactory. The reliability of the main components has proven to be excellent. The results obtained until present have proven the feasibility of the heavy weight shaft transport and provide important data for the future licensing procedure.

Handling Equipment Test for Drift Emplacement

The underground equipment for handling of heavy POLLUX-casks in areas of limited space will be demonstrated starting this year.

Major attention is given to the remotely controlled lifting or emplacement device for the POLLUX-cask to minimize the cross sections of drifts. Furthermore attention is paid to optimize weight and size of the transport vehicle in order to reduce the payload of the shaft hoisting system.

Thermal Simulation of Drift Emplacement

In September 1990 six POLLUX-cask mock-ups were emplaced in a salt mine in two drifts in at 800 m level (ASSE), the drifts backfilled with crushed salt. Each of the casks is electrically heated with 6,5 KW.

Different types of measurement devices were installed to record the following data:

- temperatures at selected points on the casks' surface, in the backfill- material and in the surrounding rock salt.
- consolidation, porosity and permeability of the backfill-material.
- stresses and strains in the rock salt and convergency rates of the emplacement drifts.

The major purpose of this test is the verification and validation of our computer codes for thermal and thermo-mechanical calculations. The codes verified by the tests will be the basis for future licensing procedures.

Results obtained until present fit well with the temperature field predictions.

Active Handling Test

Another important task which will be separately performed in the near future is a so-called 'Active Handling-Test'. With a neutron source the effect of neutron backscattering in a rock salt will be measured under realistic underground conditions. These results will provide more confidence in all aspects of spent fuel handling.

TODAY'S STATUS OF GORLEBEN

In 1983 a detailed exploration program over an area of 300 km^2 was started. Deep boreholes and 380 drillings provided an almost complete survey of the existing salt formation. All data and information about the geological and hydrological situation have confirmed the suitability of the Gorleben salt dome for a high level waste repository.

Presently two shafts are being sunk through groundwater horizons and the caprock formation utilizing the well-known freezing shaft sinking technique.

Around the shaft at a diameter of 18 m approx. 50 cooling tubes down to 270 m depth have built a stable frost body.

The depth of the two shafts is presently at 265 m and 312 m.

Minor cracks caused by contraction due to freezing are presently properly sealed. A foundation in the shafts at approx. 345 m will bear the load of the combined steel and concrete liners, which will seal the shaft from the top to the foundation. Then the two shafts will be sunk to 940 and 840 m. Afterwards an area of about 18 km^2 will be explored with 50 km drifts and 200 km of drilling.

The present plan, if not jeopardized by political obstruction, is to finish these works by end of the 90's. With a final statement to the suitability of the salt dome, the licensing procedure and erection of the repository can be started, so that the first operation and emplacement of high level waste will be possible in 2008.

FINAL REMARKS

I tried to present to you technical facts and future aspects with regard to the high level waste situation in Germany.

We, the technicians, are proud of the progress being made technically in this field.

I will not however suppress my view of the overall political situation in Germany. All, unfortunately all political parties and the industry, here the utilities, have not come to an acceptable agreement today with regard to further operation of nuclear energy.

Our projects for low and high level waste disposal are all located in a State reigned by a coalition of Socialists and Greens.

Their political public statement is

- no progress with the planned repositories for nuclear waste until all nuclear reactors have been shut down.

This position, I would like to stress this, is illegal and violates federal laws, especially the German Nuclear Law.

It is irresponsible to require the shut down of nuclear reactors, knowing that this will not be possible in the near future due to the energy demands world wide and prevent any progress with the realization of safe nuclear waste disposal.

The latest news we all heard lately from Russia and their way of handling nuclear waste should be a clear warning to all of us.

The additional impact today caused by conventional toxic waste will be a huge challenge for all countries in the future. It has finally been recognized that the same concern and attention has to be devoted to the final disposal of toxic conventional waste.