THE LOW DISPOSAL OF RADIOACTIVE WASTES IN SALT FORMATIONS OF THE FEDERAL REPUBLIC OF GERMANY

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INTRODUCTION

In the peaceful use of nuclear energy, radioactive wastes of all categories occur which have to be safely disposed. Taking into consideration the safety as well as the economic aspect of the various possibilities for final disposal, the one dealing with salt formations of the deep geological sub-surface is to be considered the safest. This applies in particular to the countries of Western Europe with their very dense population and rainy climate.

The reasons are:

-The salt formations of Zechstein evolved approximately 220 million years ago due to sea dessication, upfolded about 100 million years ago into salt domes in the North German area, and have hardly changed their structure since that time.

-Salt formations in the form of diapires, of which there are more than 200 in Northern Germany, generally guarantee a safe hydrological sealing, so that possibly liberated activation products cannot reach the biocycle.

-Northern Europe is a zone which is largely free from earthquakes.

- Large disposal rooms of more than 10 000 m^3 capacity, which can remain accessible for a long period of time without requiring additional suppert, may be constructed under financially justifiable conditions.

- The relatively good thermal conductivity of rock salt is of particular significance in the final disposal of high-level heat generating wastes.

Taking all these facts into consideration, the Government of the Federal Republic of Germany purchased the abandoned Asse Salt Mine, which is situated approximately 20 km to the south east of Brunswick in the State of Lower Saxony, and transferred the right of its utilization to the Gesellschaft für Strahlen- und Umweltforschung (GSF), whose only partner is the Government of the Fed. Rep. of Germany, in order to test and go ahead with the disposal of radioactive wastes of all categories within the frame of extensive research and technical developmental programs.

One of the main issues is the development of suitable and safe disposal technologies. The Asse Mine is therefore a pilot repository. The experiences gained here are important and essential for the planning and construction of the large final repository in the frame of the nuclear recycling and disposal plant in a North German salt dome.

As the site for this recycling and disposal plant, the cabinet of Northern Saxony proposed the salt dome Gorleben in the Lüchow Dannenberg area near the river Elbe. Due to seismic investigations, the size of the salt dome, namely 38 - 42 km^2, as well as the thickness of overburden strata of approximately 300 m, is known. In comparison to Gorleben, the Asse salt dome with a size of about 4,2 km^2 is relatively small.

The detailed geological structure of the Gorleben salt dome, however, is almost completely unknown since exploratory drillings were just started in Jan. 1980. To determine its suitability, an extensive geohydrological investigation is required in order to obtain an idea as exact as possible on the inner structure of the salt dome, as well as on the constitution of the water carrying overburden strata (in particular in the boundary area Salinar/deeper overburden strata layers). The most important questions in this case are those on the structure of the caprock, the thickness of the rock salt layers, which are to be considered solely suitable for the disposal, as well as the questions on the existence, position and thickness of the potash seams, in particular of the Carnallite (such seams are not

suitable for disposal).

Taking the size of the salt dome at Gorleben into consideration, it may be fairly definitely assumed that it will be able to fulfill the goals set for it.

ASSE PILOT REPOSITORY AND PLANNING OF GORLEBEN DISPOSAL-PLANT

1. Geological and Mine Situation

The Asse is a range of hills approximately 8 km long which is situated in the northern foreland of the Harz mountains. It was formed by an asymmetrical anticline of the Triassic age. Below a sedimentary mantle of Buntsandstein and Muschelkalk several hundred meters thick, lies the anticline proper which is formed by strata of the German Zechstein series of the Permian age.

Salt Mine Asse II was initially concerned with the mining of Carnallite. And then after 1923 only with the exploitation of rock salt While the potash rooms were backfilled, about 100 mine rooms in the older and younger halite, in the range of 15 levels between 490 and 800 depth, were created by rock salt exploitation. All of these mine rooms represent a volume capacity of approximately 3,5 mill. m^3.

Each room is 60 m long, 40 m wide and 15 m high and therefore has a volume of 36 000 m^3.

It should be mentioned here that in 1906 already, the potash mine Asse I (situated 1,4 km to the west) was flooded as a result of inexpert drilling of the water carrying overburden strata of the mine.

Shaft Asse III, situated about 3 km to the east, also filled with water from above gradually after being abandoned in 1923. The safety pillars between Asse I and Asse II on the one hand and the neighboring Asse III on the other hand are so thick, that a flooding of Asse II from this side may be excluded in all probability, according to a statem made by nationally and internationally recognized experts.

Taking these circumstances into consideration as well as the facts that

- the Asse salt dome is relatively small
- the constructional form of the mine was conceived for the purpose of salt exploitation
- Carnallite was exploited and pierced (i.e. tunnels were mined)

it may be definitely said that Asse Mine II can only be and is a national pilot repository.

2. Experiences gained so far

Parallel to extensive restorations below and above surface, more than 10 000 m³ low level wastes were tentatively disposed of from April 1967 to March 1974 in four disposal rooms on the 750-m-level.

The solidified wastes have to be supplied in 200 l drums. Liquid wastes, as for example evaporated concentrates and precipitation sludges have to be fixed in concrete or bitumen.

The three disposal techniques tested during this period

- vertical stapling of the drums in rows of four with corresponding pathways for control purposes;
- horizontal stapling of the drums in six to eight tiers on top of each other with fork trucks;
- and finally horizontal stapling of the drums in up to thirteen tiers by means of a special transport vehicle with a telescopic arm and swivelling canister grab system.

These techniques had proved themselves but could not be considered optimal as regarded the length of time they required, nor with respect to the radiation protection on the operating personnel.

Since 1974, therefore, disposal of the drums has been carried out successfully according to a new method. In this method the rooms were not filled by stapling from top to bottom, but rather from above to below by dropping the drums from a scoop shovel over a salt ramp, so that the drums are covered by loose salt at short intervals.

This "salting-in" of the wastes drums offers the following advantages:

- the drums are no longer dealt with separately, which leads to a higher capacity and decreases the radiation strain of the personnel;

- the disposal drums are covered by protective salt within a short period of time;

- the space utilization is considerably improved on and this also permits for the optimal use of the higher rooms on the upper levels;

- furthermore, regarding the long-term safety aspect, this method represents a considerable advantage. In the event of an inrush of water (MCA), the large amount of loose salt present is quickly dissolved, and thus a removal of salt from the vertical and horizontal pillars of the mine as well as an attack on the disposed radioactive wastes as a result of fast saturation of brine would be rendered considerably more difficult.

Up to the end of 1976 a total of approximately 73000 containers of low-level wastes were disposed of in the Asse. During more than four years of "long-term-disposal" a lot of experience was gained, so that it became appropriate to work over the acceptance conditions used up to now.

With the January 1976 extension of operational permission, the worked over "Conditions for the disposal of low-level radioactive wastes in the salt mine Asse (Position: December 1975)" became valid.

With a view to the rational and at the same time with respect to the radiation protection of the operating personnel, and the long duration security for final deposit, the advantageous method of "salting-in" of the waste barrels was, with respect to the

regulations regarding the waste product and the drum-cover-lock, intensified.

The radiation strain on the Asse Personnel was kept far below the permissable dose rate for professionally exposed personnel, due to further development of the disposal technique, and in spite of the rapidly growing waste amounts and simultaneously rising active contents per container. Today it lies on an average only a little above the dosimeter detection border of 40 mrem per month.

With the take-up of operation of the reprocessing plant in Karlsruhe (WAK), an increasing scope of low-level waste arose, which lead to such high dose capacities at the drum surface that these drums had to be inserted into concrete jackets. Since 1973 such so-called "lost concrete shields" are disposed of with inserted containers.

In spite of the difficult handling these concrete containers proved to be advantageous with respect to the radiation exposure of the disposal personnel.

Concentrates fixed into concrete or bitumen, contaminated and/or activated metal parts (from burned fuel-elements) and other solid radioactive wastes reach activities up to 100 Ci and more per 200-l-drum, but they develop no significant heat. In order to handle such waste drums an additional shielding is necessary; such as disposal in accessible disposal rooms, as in the case of low-level waste with lower activity and dose rate.

Therefore, a special method for the disposal of this waste was developed:

- The drums are transported under ground in shielding containers; according to the necessary shielding in each particular case, two different types of single containers, or, as it may be, a collecting container for seven drums, are processed. Due to the fact that the collecting container weighs up to 35 t, the drums are reloaded into single shielding containers for the transportation under ground.

- At the pit-bottom of the 490-m-level, an unloading and charging crane lifts the shielded containers from the hoisting cage and puts them onto a special transport vehicle. This conveys the single sheilded container to the charging room. Within this room the

container is taken off the vehicle by using a 10-t-crane, and deposited onto the radiation-protection-slide of the transport boring hole. After the opening of the radiation-protection slide of the bore hole, as well as the shielding container, the lowering of the 200-l-waste drum is effected by means of a 1-t-crane. It is taken out of the shielding container and lowered down through the boring hole into the underlying hermetically closed disposal room.

The heavy shielding containers during manipulation and the 6 m thick salt-float, as well as the all around mighty walls of the disposal rooms, supply such sufficient radiation protection that the radiation strain of the disposal personnel remained below the dosimeter proof zone of 40 mrem/month.

The disposal of such wastes took place from September 1972 until March 1977. During this trial phase approximately 1300 drums were disposed of. Although the disposal permission was not extended, the up to now collected experience is quite sufficient with respect to the already carried out first post-independent planning for a final disposal mine.

3. Foreseeable Further Development

The disposal of low-level wastes took place until the disposal license expired at the end of 1978 in long-time-operation. Resulting from this, there is no hindrance for the planning and erection of a great mine in a "virginal" salt dome for the disposal of large volumes of all categories of low-level wastes from the planned reprocessing plant "Gorleben" on the basis of the tested disposal technologies in the pilot-plant Asse.

For optium achievement of disposal processing for low-level wastes, further development work is necessary. When this work can be effected is dependent upon the licensing situation.

Due to the plitical curcumstances existing in the Federal Republic of Germany after the "Hannover Hearing" in Spring 1979, the situation is as follows:

- Disposal licenses for radioactive wastes are only issued in accordance with the Atomic Law (Atomgesetz) -§ 9b, plan verifiation - procedure (Planungsfestellungsverfahren). Duration approximately 5 years;

- Construction of a big reprocessing plant in a so-called "Integrated Nuclear Fuel Cycle Center" cannot be done; at least not in the foreseeable future.
- Construction licenses for some smaller reprocessing plants in different States of the Federal Republic, possible after 1985.

Research Cavern

It seems to be a good idea that, with a view to larger amounts of low-level waste in the future final disposal center, new methods be developed, which, with the highest measure of security, will make a great breakthrough possible. Therefore it is planned, that as of 1980, the cavern-technique will first be tested in an inactive phase and then later in an active phase.

In the pilot-plant Asse, a trial-cavern of approximately 10 000 m^3 in about 1000 m depth was produced in mining form. It will be fed through a special, newly made shaft from the surface. The drums will be unloaded from the shielding transport container at the shaft via a shielding cell, and after this transported into the cavern without a protection shield (jacket).

In case this new disposal system proves to be fully satisfactory, the experience gained in the pilot-plant Asse could be employed at the end of the eighties for the planning and construction of a great cavern-plant in the scope of the disposal of radioactive waste center which is to be built.

Two to three caverns of at least 1000 000 m^3 are to be leached (dissolved), as is already being done for the interim storage of mineral oil in the coast vicinity. The setting up of these great caverns in rock-salt has today become routine work.

Because of the great need for water for leaching on the one hand, as well as secure drainage of the salt brine on the other hand, only appropriately large salt domes in the vicinity of big rivers or the coast are suitable for situating such caverns.

The liquid, low-level radioactive waste, which arises in the reprocessing plant, could be mixed with cement forming a thin-liquid pulp, and then pumped into the cavern via a pipe-line. Once in the cavern, the cement binds the pulp to a solid block. As a result, the old mountain rock is nearly recovered.

4. For the safety of a salt mine

When considering the total safety of final disposal in salt rock, one first considers the security of the mine itself and its possibilities for danger. Such danger could arise in the form of earth-quakes, an accident on the basis of rock-mechanical disburbances, or in case of water inbrake.

4.1 Earthquakes

Earthquakes are closely connected with geological tectonic movements. They mainly originate from the breaking zones of the earth rind. The geological underground of the Asse Anticline is very stable. It consists of stratum of the geological ancient earth, which were rigidly bound and consolidated by means of mountain formations. The tectonic culmination of the Asse structure took place at about 110 millions of years ago.

During the younger geological formation, the Quarternary, the duration of which, approximately 600 000 years, is quite well known, no major earthquake took place in the North German district,or in the area of the Asse, as well as the salt dome - Gorleben.

From the geological structure of these salt domes, surrounding and underground, it can be assumed with an almost certain probability that for a period of some hundred thousands of years an earthquake is not to be expected, which could perhaps endanger a final disposing.

4.2 Disturbance based on rock mechanical reasons

A disturbance due to rock mechanical reasons could then arise, such as a case where a barrier pillar no longer withstands the rock pressure. This would result in a partial or entire breakdown of mining rooms, or, in an extreme case, of the whole mine. In salt mining,a disturbance for rock mechanical reasons could possibly be followed up by hydrological endangering of the mining rooms through water-inflow out of strata layers containing water, and this, in turn, could lead to a flooding of the whole mine.

The salt mine Asse mainly consists of adjoining and one-above-the-other arranged mining rooms in younger Halite (No. 3). Between these rooms pillars run in horizontal and vertical directions. Solidity deformation behavior and supportability of these carrying elements in a great sense determines the standing safety of the mine on a whole.

In a large-scale rock mechanical investigation program, this standing safety is determined and constantly controlled. For this, laboratory as well as in-situ-examinations are carried through.

Tectonic movements always occur in a mine, even if only in small absolute amounts. Therefore, measuring spots were installed in all of the interesting spots of the salt mine Asse, from which, on the basis of differentiated measuring procedures, the tectonic movements arising there can be registered.

Considering the up-to-date results of the mining mechanical laboratory examinations, the measurements taken regarding the supervision of the mine, the age and condition of the mining rooms, the expert evidence available about the Asse Salt Mine, the evaluation of experience gained from other potash and rock salt tectonic movements and the available literature, and the probability of a disturbance case arising in the whole mining rooms of the Asse can be judged as follows:

1. Immediate danger to the whole mine from a rock mechanical disturbance does not exist.

2. In this century a total of nine disturbances took place in the German salt mines (including the German Democratic Republic after 1949). Fundamentally connected herewith were cases of popping rock and roof collapses with the exploitation of potash salt within or near the effected fields of catastrophy. However, in the salt mine Asse II all exploitation has rested since 1964; with respect to potash salt, since 1923. A disturbance due to popping rock is not to be expected.

3. The breaking of a normal pillar can, with the highest probability, be looked upon as impossible.

4. The long-term compression of individual mining rooms by all-sided convergence cannot be avoided entirely. This process does not lead to a hydrological danger because of its local boundaries and the resulting breakless deformation of the salt rock. The collapse of a greater underground Department, i.e. more above and adjoining mining rooms, is to a high degree not probable. As the shafts Asse II and IV do not show any water or brine inflow and possess a very secure steel concrete connecting lining, no water-inbreak will occur. This is almost certain.

4.3 "Gorleben"

The salt dome Gorleben is still "virginal". Should geoscientific explorations show that it is suitable for the setting-up of a commercial final repository, then, in an early planning phase, all necessary security factors such as thickness of the safety pillars to the overburden, the flanks of the salt dome within the to-be-constructed mining rooms, and the possibly existing Carnallite layer, could be constructed so regidly that the flooding of such a plant, even in the long run, can be regarded as imporbale as in the case of the pilot-plant Asse. (Fig. 14)

The conception and keeping of a necessary safety plan possess greater possibilities because of the size of the salt dome.

Because of an order given by the future mine owner of the prospective final repository, the Physikalisch-Technische Bundesanstalt in Braunschweig (PTB), a technical planning-syndicate worked out a far-reaching technical planning study for the final disposal

plant, independent of its location, during the years 1977 - 79. After completion of the hydrogeological exploration of the salt dome Gorleben to determine suitability, this existing technical data will be the basis for precise planning. These hydrogeological explorations will probably be completed in 1982.

5. Summary

One can be assured that at the time of the erection of the final repository for the disposal of high-level radioactive waste, dependable and acceptable solutions will be available. As in all young technologies - such as the nuclear technique, and particularly at the last link of the nuclear fuel cycle - the development is pressed forward with emphasis, in order to improve the solutions and in order to optimize, especially with a view to safety.

LITERATURE

Albrecht, E.: Disposal of radioactive wastes by storage in a salt mine in the Federal Republic of Germany. IAEA/NEA-Symposium on "Management of low- and intermediate-level radioactive wastes"; Aix-en-Provence 1970 - IAEA-STI Pub. 264, p. 753

Krause, H., Randl, R.: Treatment and final disposal of radioactive wastes from fuel reprocessing in the Federal Republic of Germany - a survey on policy and R&D work. IAEA/NEA-Symposium on "Management of radioactive wastes from fuel reprocessing"; Paris 1972 - NEA 1973, p. 199

Kühn, K.: Asse salt mine, Federal Republic of Germany - operation facility for underground disposal of radioactive wastes. 2nd International Symposium on "Underground waste management and artificial recharge"; New Orleans 1973 - reprint Vol. 2, p. 741

Breest, H.Ch.: Radiological safety aspects of nuclear waste management. IAEA-regional seminar on "Radiological safety aspects of nuclear industry", Rome 1975 - to be published by IAEA

Hamstra, J.: Radiotoxic harzard measure for baried solid radioactive waste. Nuclear safety, 16 (1975), S. 180-189

Albrecht, E.: Erfahrungen und Probleme beim Abteufen eines Bohrschachtes auf die Salzlagerstätte der Schachtanlage Asse. Kali und Steinsalz, Heft 1/76, Verlag Glückauf, Essen

Kühn, K. Hamstra, J.: Geologic Isolation of Radioactive Wastes in the Federal Republic of Germany and the Respective Program of the Netherlands, Management of Wastes from the LWR Fuel Cycle - Denver, Colorado - July 1976

Kühn, K.: Zur Endlagerung radioaktiver Abfälle. Stand, Ziele und Alternativen, Atomwirtschaft, Jahrgang XXI, Nr. 7, 1976

Albrecht, E., Breest, H.Ch.: The Development of Radioactive Wastes, Disposal-Techniques and the Radiation-Exposure of the Personnel at Asse Pilot Plant. Waste Management 1976 - Tucson, Arizona 1976

Albrecht, E., Perzl, F.: The Research and Development Program on Waste Disposal in the Federal Republic of Germany. Waste Management Fuel Cycles 1978 - Tucson, Arizona 1978, Seite 239 - 250.

Röthemeyer, H.: Site Investigations and Conceptual Design for the Mined Repository in the German Nuclear "Entsorgungs-Zentrum". Helsinki, July 1979.