

REALIZATION OF THE GERMAN REPOSITORY CONCEPT - CURRENT STATUS AND FUTURE PROSPECTS -

Peter W. Brennecke/Helmut Röthemeyer/Bruno R. Thomauske
Bundesamt für Strahlenschutz (BfS)
Salzgitter, Germany

ABSTRACT

Since the early sixties, the radioactive waste disposal policy in the Federal Republic of Germany has been based on the decision that all types of radioactive waste are to be disposed of in deep geological formations. According to the 1979 German radioactive waste management and disposal concept the Gorleben salt dome is investigated to decide upon its suitability to host a repository for all types of radioactive waste. In addition, the licensing procedure for the Konrad repository project has practically been finished, i.e. a decision could be taken. Since German unification on October 03, 1990, the Morsleben repository has to be considered, too. From January 1994 through September 1998 short-lived low and intermediate level radioactive waste with alpha emitter concentrations up to $4,0 \cdot 10^8 \text{ Bq/m}^3$ was disposed of in this facility.

On September 27, 1998, federal elections took place in Germany. As a result, a coalition of the Social Democrats and the Greens has come into power. Based on the coalition agreement of October 20, 1998, nuclear energy is intended to be phased out in Germany. Thus, the new radioactive waste management policy comprises important disposal-related alterations and changes.

INTRODUCTION

The status and future prospects of the Morsleben repository as well as the Konrad and Gorleben repository projects are strongly influenced by technical, legal and political aspects. At present, due to the decrease of radioactive waste amounts to be emplaced in a repository, there is no time pressure for the disposal of wastes. Sufficient interim storage capacity is available. Therefore, questions concerning the realization of the German waste management concept and, in particular, the necessity of more than one repository have arisen.

In addition, the German repository concept plays one of the key roles in the debate on Germany's future energy policy. Since the federal elections which took place on September 27, 1998, a new Federal Coalition Government of Social Democrats and Greens has agreed to phase out of nuclear energy in Germany. Thus, alterations and changes in radioactive waste management and disposal will have to be dealt with.

RADIOACTIVE WASTE MANAGEMENT

The German radioactive waste management and disposal concept of 1979 has originally been agreed upon by the heads of the federal government and the governments of the federal states. It was especially updated with the 1994 amendment of the Atomic Energy Act providing the legal basis for direct disposal of spent nuclear fuel. Insofar, both options for reprocessing of spent fuel elements and their direct disposal subsequent to an appropriate conditioning are offered to the waste generators. This concept is mainly featured by the re-use without detrimental effects of residual radioactive material and/or components, the treatment and conditioning of radioactive waste, its interim storage in engineered facilities and its disposal in repositories constructed and operated in deep geological formations.

Conditioning

Conditioning of radioactive waste includes processing and/or packing of the waste, eventually after an appropriate pretreatment or sorting. Various strategies and techniques are applied in Germany. The

selection of a conditioning process is dependent on factors like the requirements for interim storage and disposal, acceptance of the process, and volume of the resulting waste packages. Therefore, it is not surprising that different conditioning techniques for the same type of waste may be applied. Furthermore, in particular in the eighties, the necessity to minimise the volume of the conditioned waste because of the lack of repositories as well as the type and the available capacity of interim storage facilities stimulated the development of new and advanced conditioning techniques, e.g. the high-force compaction with 1,500 tons to 2,000 tons compactors (stationary or mobile), drying of liquid radioactive waste or just packing radioactive waste in superior packagings made of cast iron. Such techniques lead to waste packages complying with interim storage and repository project-related waste acceptance requirements. These efforts contribute to the avoidance or reduction of waste amounts to be disposed of and have already been successfully applied to waste to be disposed of.

In addition to the waste treatment and conditioning facilities being available in Germany, there is a close co-operation between German waste generators and European waste conditioners and reprocessors, respectively. Low and intermediate level waste, in particular originating from the operation of nuclear power plants, has been conditioned in Belgian and Swedish facilities, e.g. by incineration. Spent fuel elements are reprocessed in France and in Great Britain; the resulting radioactive waste is to be taken back to Germany. Such co-operation has been performed since many years. However, the treatment and conditioning of German radioactive waste in foreign facilities should be considered as a supplementary possibility and shall not replace national efforts and tasks in radioactive waste management.

Interim Storage

There exists a large number of different interim storage facilities in Germany. The major part of them are on-site, the minor part is operated as centralized facilities. The waste generators, with the exception of the small waste generators, are responsible for the safe interim storage of their radioactive wastes. The nuclear power plants have to guarantee measures for the safe management of spent fuel elements for six years (Entsorgungsvorsorgenachweis). Apart from reprocessing, both the storage ponds of the nuclear power plants and the central interim storage facilities in Gorleben, Ahaus and Jülich are available, offering appropriate storage capacities. For example, the Gorleben facility accepts both waste packages and spent nuclear fuel in casks (dry storage). The Federal States must construct and operate collecting depots for the interim storage of radioactive waste particularly originating from radioisotope application in industry, in universities or in medicine, i.e. radioactive waste from small waste generators.

According to recent assessments of the arising of radioactive waste with negligible heat generation to be expected in future, the present interim storage capacities will be exhausted about 20 years after the turn of the century. At that time either new interim storage facilities must be available or a repository must become operational. As to heat-generating radioactive waste originating in particular from reprocessing and spent nuclear fuel, the available interim storage capacities will allow similar periods of time for storage.

As both waste packages and spent fuel in casks can be stored over long periods of time, there is basically no urgent time pressure for their emplacement in a repository. The availability of waste acceptance requirements for disposal is, however, useful for the respective interim storage requirements.

Reprocessing and Direct Disposal

The Atomic Energy Act of 1976 stipulates the re-use of residual substances and thus upholds the principle of reprocessing for spent fuel elements. This has been taken up in the German radioactive waste management and disposal concept which originally included the construction of a reprocessing plant. In 1989, the utilities renounced the construction of the planned German reprocessing plant and, instead of this, they decided upon the reprocessing of spent nuclear fuel in the COGEMA and BNFL facilities in France and Great Britain, respectively.

Independently of this development, the emplacement of spent fuel elements in a repository (so-called direct disposal) has basically been developed to maturity, based upon a decision of the Federal Government in 1985. The aim of this development was to demonstrate the feasibility of this technology and its licensibility; the performed respective research and development work succeeded in reaching this goal. Thus, the Atomic Energy act was amended in 1994 providing the legal basis for direct disposal of spent nuclear fuel.

BASIC ASPECTS OF RADIOACTIVE WASTE DISPOSAL

Legal Principles

The disposal of radioactive waste in a repository is in particular governed by the following specific acts and regulations:

- (a) Atomgesetz (Atomic Energy Act),
- (b) Strahlenschutzverordnung (Radiation Protection Ordinance),
- (c) Bundesberggesetz (Federal Mining Act),
- (d) Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk (Safety Criteria for the Disposal of Radioactive Wastes in a Mine).
- (e) International recommendations (e.g. IAEA Safety Criteria) and regulations (e.g. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management of September 5, 1997).

The protection objective of radioactive waste disposal in a repository is prescribed by the Atomic Energy Act and the Radiation Protection Ordinance. The Federal Mining Act regulates all aspects concerning the operation of a disposal mine. The Safety Criteria specify the measures to be taken in order to achieve that this objective has been reached.

The peaceful use of nuclear energy in Germany is regulated by the Atomic Energy Act. On September 5, 1976, its Fourth Amendment was enacted. It provided the legal basis for the disposal of radioactive waste. According to section 9a of this act, the Federal Government has to establish installations for the engineered storage and disposal of radioactive waste, i. e. disposal of radioactive waste is assigned to the Federal Government as a sovereign task. On November 1, 1989, this competency was assigned to the Bundesamt für Strahlenschutz (BfS, Federal Office for Radiation Protection). Accordingly, the BfS is responsible for the establishment and operation of those federal installations, acting on behalf of the Federal Government.

The legal competences for the licensing of the construction and operation of a repository are regulated in such a way that two procedures must be performed: the procedure under atomic law on the one hand and the procedure under mining law on the other. For the establishment of a repository, pursuant to section 9b of the Atomic Energy Act, the initiation of a plan-approval procedure, i. e. a special kind of a licensing procedure, has to be applied to the respective licensing authority of the federal state [1]. The BfS is the authorized applicant.

Safety Criteria

The objective of radioactive waste disposal in repositories is the handling and storage of wastes in such a way that the protection of man and environment is reasonably assured. Basic aspects which must be taken into account to achieve the objective of disposal are compiled in the "Safety Criteria for the Disposal of Radioactive Waste in a Mine" [2]. Their scope implies all types of radioactive waste to be disposed of. The safety criteria qualitatively specify the measures to be taken in order to achieve the protection

objective of disposal and define the principles by which it must be demonstrated that this objective has been reached, i. e. technical measures and methods of procedure are to be adjusted to one another. The importance of the site selection, the system consisting of geology/repository/waste packages, the multibarrier concept, and the use of state-of-the-art technology are emphasized. In detail, the safety criteria comprise the following items:

- Introduction
- Protection objectives
- Measures to achieve the protection objectives
- Site requirements
- Prerequisites for construction and operation of a repository
- Site exploration
- Construction and operation
- Radioactive wastes
- Decommissioning
- Post-closure phase.

Of this, the following criteria are considered to be the most important ones:

- (a) The required safety of a repository constructed in a geological formation must be demonstrated by a site-specific safety assessment which includes the respective geological situation, the technical concept of the repository including its scheduled mode of operation and the waste packages to be disposed of.
- (b) In the post-closure phase, the radionuclides which might reach the biosphere via the water path as a result of transport processes not completely excludable must not lead to individual dose rates which exceed the limiting values specified in section 45 of the Radiation Protection Ordinance (0.3 mSv/a concept).

The safety criteria permit a certain latitude of judgement. Such margins gradually diminish in the realization of a repository project. This process is predominantly determined by a site-specific safety assessment within the scope of which the required safety of the repository must quantitatively be demonstrated including the derivation of requirements on the design of the facility as well as on the waste packages to be disposed of.

Nevertheless, the protection objective can only be achieved by an iterative process drawing together more and more detailed information obtained as the respective repository project progresses through its various phases of investigation, planning, detailed design and performance assessment, thus assuming more and more concrete forms.

The safety criteria comprise the most important features characterizing the German approach to disposal (basic concept) and the respective philosophy employed:

- (a) In order to reasonably assure the long-term and safe isolation of the radioactive waste from the biosphere, disposal of radioactive waste takes place in a suitable deep geological formation.
- (b) Only this form of disposal is discussed in the Safety Criteria for the Disposal of Radioactive Wastes in a Mine. Under these assumptions, basically, no other measures will be necessary after completion of waste package emplacement, backfilling and sealing, as well as after closing the repository.
- (c) The safety criteria relate to disposal of radioactive wastes which is defined as maintenance-free, temporally unlimited, and safe disposal of these wastes. In the case of disposal on a large

technological scale, procedures and methods are to be applied in which retrievability of the waste is not necessary. Thus, retrievability is not considered within German radioactive waste disposal.

- (d) The concept to renounce retrievability is in particularly advantageous for radiation protection. The backfilling and sealing of individual disposal rooms or disposal fields, filled with waste packages, already contributes in the operational phase of a repository to a reduction of the radionuclide concentration in the exhaust air thus reducing the radiation exposure to the staff of a repository and its vicinity. This concept can also be adjusted to (future) safeguards requirements.

Revision of the Safety Criteria

The Safety Criteria for the Disposal of Radioactive Wastes in a Mine issued in 1983 [2] are at present revised on behalf of the Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU, Federal Ministry of Environment, Nature Protection and Nuclear Safety) being the competent federal authority for nuclear safety, radiation protection and waste management in Germany.

The overall aim of this revision may be outlined as follows:

- (a) Survey on the international status of the development of safety criteria for the disposal of radioactive waste and its evaluation as compared to the German situation.
- (b) Consideration of respective activities being performed by international organisations such as IAEA (e.g., the RADWASS programme and the above-mentioned Joint Convention of September 5, 1997), the OECD-NEA (e.g. Radiation Protection Principles for the Disposal of Solid Radioactive Waste, Publication 46 of 1986 and its present review) and the ICRP.
- (c) Actualization and harmonization of the safety criteria.

In detail, among other things, the following topics are investigated:

- Legal principles
- Time frame, i.e. period of time for which the safety in the post-closure phase of a repository has to be demonstrated
- Potential radiological impacts upon man in geological periods of time
- Protection of the biosphere
- Consideration of site-specific safety indicators
- Ethical and social aspects
- Environmental impact analysis and its procedure
- Discussion of general environmental protection aspects including the management and disposal of radioactive wastes.

It is intended to prepare appropriate proposals for a (partly) revision of the 1983 Safety Criteria until the end of 1999.

Radiation Protection in the Post-closure Phase

The radiation protection objectives for a repository are prescribed and quantified in the Strahlenschutzverordnung (Ordinance on Radiological Protection). According to the revised ordinance of 1989,

- (a) section 28 para. 1 states that the radiation exposure has to be kept as low as reasonably achievable,
- (b) section 45 para. 1 states that the radiation exposure for individuals arising from the respective facility under consideration is to be limited, i. e., to 0.3 mSv/a (effective dose rate) and to 0.9 mSv/a (organ dose rate), being the sum of all relevant exposure pathways, respectively.

Thus, regulatory dose limits have been set which must be complied with. Evidence of this protection objective, according to the safety criteria [2], must be demonstrated within the radiological long-term safety assessment. By this means, possible radiation exposures to individuals will be kept within the variability of natural radiation rates. Nevertheless, such a procedure is only reasonable for periods of time for which changes in the geological barriers and in man's environment can still be forecast with sufficient reliability.

To reasonably assure the long-term safety of a geological repository including the demonstration of compliance with the individual dose limits of 0.3 mSv/a or 0.9 mSv/a, any possible release of radionuclides must be assessed and the respective dose rates calculated. For this purpose it is necessary to determine all the relevant basic data required for the performance of the long-term safety assessment. This includes, among other things, the results of the underground investigation of the respective site.

Decommissioning and Post-closure

A geological repository will be decommissioned after its operational phase. Parts of the underground facility, e. g. disposal rooms filled with waste packages, will already be shut down and backfilled during the operational phase. The decommissioning will be completed with the filling and sealing of the shafts. Filling and closing off the mine openings have as a goal the increased stability by means of reduction of remaining voids, thereby delaying or hindering the access of transport media (e. g., water or brines) to the radioactive wastes, and minimizing an eventually possible radionuclide release to a permissible level. As to the safety criteria [2], these measures are the final contribution to the long-term safety of a geological repository.

The safety criteria require that construction, operation, and decommissioning of the repository are to be performed and monitored such that no particular control or monitoring programme is necessary in the post-closure phase. Routinely performed, general environmental measurements as well as topographic measurements will give information on the radiology and the long-term thermo-mechanical behavior of, e. g., the host rock and the overburden.

Data on the repository, the waste packages disposed of, and the essential technical measures taken during construction, operation and decommissioning should be documented. Complete documentation should be maintained at suitably separate locations. A surface marker for a geological repository is not necessary taking the normal environmental protection and topographical measurements into consideration. Knowledge of the site's location should be guaranteed sufficiently by the documentation.

GERMAN RADIOACTIVE WASTE DISPOSAL POLICY

In the Federal Republic of Germany, the peaceful use of nuclear energy started with the operation of the first nuclear power plant in 1960. Since the early sixties, i. e. from its very beginning, the German radioactive waste disposal policy has been based on the decision that all types of radioactive waste are to

be disposed of in deep geological formations. As liquid and gaseous wastes are excluded from disposal in such a repository, only solid or solidified radioactive waste is accepted. Near-surface disposal or shallow land burial is not practised in Germany because of high population density, climatic conditions and existing appropriate deep geological formations.

In compliance with the German disposal concept, all radioactive waste has to be emplaced in a repository constructed and operated in deep geological formations. According to the 1979 German radioactive waste management concept two sites have been considered for disposal:

- (a) The abandoned Konrad iron ore mine in the Federal State of Lower Saxony has been investigated for disposal of radioactive waste with negligible heat generation, i. e. waste packages which do not increase the host rock temperature by more than 3 K on an average. At a depth of 800 m to 1,300 m waste packages are planned to be emplaced in disposal rooms using the stacking technique. The emplacement of up to 650,000 m³ waste package volume has been planned. Operation of the repository is scheduled for at least 40 years. A total activity in the order of 10¹⁸ Bq and an alpha emitter activity of about 10¹⁷ Bq are anticipated for this facility.
- (b) The Gorleben salt dome in the north-east of Lower Saxony is being investigated for its suitability to host a repository at depths between 840 m and 1,200 m for all types of radioactive waste, mainly for heat-generating radioactive waste originating from reprocessing and spent fuel elements. The accumulated inventory of beta/gamma and alpha emitters to be emplaced was estimated to be in the order of magnitude of 10²¹ Bq and 10¹⁹ Bq, respectively.

Short-lived low and intermediate level radioactive waste with an alpha emitter concentrations of up to $4,0 \cdot 10^8$ Bq/m³ originating from the operation of nuclear power plants and the application of radionuclides in research, medicine and industry in the former German Democratic Republic was disposed of in the Morsleben repository, an abandoned salt mine located near the village of Morsleben in Sachsen-Anhalt. Until 1991, radioactive waste with a total volume of approximately 14,500 m³ and about 6,700 spent sealed radiation sources were disposed of. Since German unity which took place on October 03, 1990, the Morsleben facility has the status of a federal repository in the sense of section 9a (3) of the Atomic Energy Act.

Emplacement of radioactive waste in the Morsleben repository was stopped in February 1991 because questions with regard to safety and licensing had been raised. On January 13, 1994, emplacement was resumed. From that time through September 28, 1998, radioactive waste with a total volume of 22,320 m³ and 394 spent sealed radiation sources were disposed of. The activity of beta/gamma emitters emplaced in that period of time totals to $9.1 \cdot 10^{13}$ Bq, that of alpha emitters to $8.0 \cdot 10^{10}$ Bq.

According to the order of the Superior Administrative Court of the federal state of Sachsen-Anhalt issued on September 25, 1998, BfS has immediately to stop further radioactive waste disposal in the so-called eastern emplacement field of the Morsleben repository. This will be effective until the final court decision will be made. However, as a precaution, it was decided to stop all waste emplacement in the Morsleben facility for the time being. Thus, last waste emplacement operations were carried out on September 28, 1998. Since that time no waste packages have been disposed of in the Morsleben repository.

NEW DEVELOPMENTS IN RADIOACTIVE WASTE MANAGEMENT AND DISPOSAL

In Germany, federal elections took place on September 27, 1998. As a result, a coalition government of the Social Democrats and the Greens has been formed. The political aims of this Government are given in the coalition agreement of October 20, 1998 [4]. The most important feature of the new energy policy is the abandoning or phasing out of nuclear energy. Thus, the new Federal Government makes a pronounced change in energy policy. It is intended to irreversibly phase out of nuclear energy use for electricity

generation. This shall be performed in a stepwise procedure: In a first step respective legislative measures are to be taken. In a second step, consensus talks with representatives of the utilities are envisaged for 1999 aiming at unanimous decisions on a new energy policy, further steps to definitely terminate the use of nuclear energy for electricity production, and to establish an appropriate radioactive waste management and disposal concept.

COALITION AGREEMENT AS OF OCTOBER 20, 1998

Energy policy is in particular addressed in chapter 3 "Modern Energy Policy" of the coalition agreement [4]. Given below are subchapters 3.1 "Securing of an Energy Supply Complying with Future Needs" and 3.2 "Abandoning Nuclear Energy".

Securing of an Energy Supply Complying with Future Needs

The new Federal Government will guarantee an environmentally tolerable and economic energy supply which will comply with future needs. Renewable energies and energy economy are of priority, this includes also a 100,000-roof- programme (note: installation of solar energy conversion units on the roofs of 100,000 buildings).

The reorganization of energy supply must take into account technological, ecological and energy-economical requirements. Because of its great safety risks with the risk of inestimable damages, nuclear energy is irresponsible. Therefore, the new Federal Government will undertake everything to terminate the use of nuclear energy as soon as possible.

Already in this year, the new Federal Government will invite for discussions on a new energy consensus (note: a first meeting was held on December 14, 1998). In cooperation with the energy suppliers, course shall be set for a path leading to a new energy mix without nuclear energy, which will comply with future needs.

The new Federal Government will support the development of energy-supplying systems complying with future needs and efficient measures to save energy. It is convinced that the implementation of new energy structures will be marked by increasing economic dynamism which will even be increased by a reorganization of energy law. This will particularly involve access to the net free of discrimination through a clear legal regulation and the creation and security of fair chances on the market for regenerative and native energies as well as a just distribution of the costs of these energies complying with future needs. The new Federal Government will implement the coal compromise of 1997 which excluded occupational dismissals.

According to its principle "Precedence of savings over generation", the new Federal Government will dedicate itself with a broad bundle of measures to economizing technologies, not only because of the great chances for export.

The new Federal Government will remove the impediments which today still hinder an increased use of regenerative energies and the broad use of combined heat and power generation.

The new Federal Government will develop instruments leading to the adjustment of energy prices in East- and Westgermany.

Abandoning Nuclear Energy

Abandoning the peaceful use of nuclear energy will be regulated by law comprehensively and irreversibly within this parliamentary term. For this, the coalition parties agree upon the following stepwise procedure.

In a first step, a first amendment of the Atomic Energy Act will be introduced as part of the 100-day-programme with the following content:

- (a) Cancellation of the support purpose
- (b) Introduction of an obligation for a safety check, to be submitted within one year
- (c) Clarification of a regulation regarding the burden of proof in the case of proven suspicion of danger
- (d) Restriction of waste management to direct disposal
- (e) Cancellation of the 1998 amendment of the Atomic Energy Act (with the exception of the implementation of European Union law)
- (f) Increase of financial security.

In a second step, the new Federal Government will invite the utilities for discussions to agree upon a new energy policy, steps for the abandoning of nuclear energy and waste management issues, and - if possible - to find a consensus. The new Federal Government sets itself a time schedule of one year following inauguration.

As a third step, the coalition will introduce a law with which the abandoning of the use of nuclear energy will be regulated without compensation; to achieve this, the operating licences will be temporally limited. Measures required for waste management will be adapted.

As to waste management, the coalition parties agreed on the following:

- (a) The coalition parties agree that the previous waste management concept has failed with regard to its content and does no more have a technical basis. A national waste management plan for the legacy of radioactive waste will be elaborated.
- (b) A single repository in deep geological formations is sufficient for the disposal of all types of radioactive waste.
- (c) The disposal of high-level waste by the year 2030 is the time-dependent target for the disposal of all types of radioactive waste.
- (d) There are doubts with regard to the suitability of the Gorleben salt dome. Therefore, its exploration shall be interrupted and further sites in various host rocks shall be investigated for their suitability. The final site shall be selected based on a comparison of the sites.
- (e) The emplacement of radioactive waste in Morsleben will be terminated. The plan-approval (licensing) procedure remains restricted to decommissioning.
- (f) Basically, each operator of a nuclear power plant is obliged to construct interim storage capacities on site. Spent nuclear fuel may only be transported if no licenced interim storage capacities exist at the nuclear power plant site and if the power plant operator is not responsible for this. The interim storage facilities shall not be used for disposal purposes.

REFERENCES

- [1] H. Rösel
"Legal Prerequisites for the Disposal of Radioactive Waste - Competences and Responsibilities"
Kerntechnik 51 (1987) no. 2, p. 83-86
- [2] Bundesministerium des Innern
"Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk"
(Safety Criteria for the Disposal of Radioactive Wastes in a Mine)
Bundesanzeiger 35 (1983) no. 2, p. 45-46
- [3] P. Brennecke/H. Illi/H. Röthemeyer
"Final Disposal In Germany"
Kerntechnik 59 (1994) no. 1/2, p. 23-27
- [4] SPD Aktuell
"Aufbruch und Erneuerung - Deutschlands Weg ins 21. Jahrhundert
Koalitionsvereinbarung zwischen der Sozialdemokratischen Partei Deutschlands
und Bündnis 90/ Die Grünen"
<http://www.spd.de/aktuell/programmatisches/vertrag.htm>, October 20, 1998