Ongoing Revision of the German Safety Criteria for Geological Disposal of Radioactive Waste

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1 INTRODUCTION

In 1983, following consultations with the Reactor Safety Commission and the Commission on Radiological Protection, the Federal Minister of the Interior (BMI) drew up safety criteria for the final storage of radioactive waste in a mine /BMI 83/. These criteria were published in the Federal Bulletin. Since then, there have been important developments in Germany and abroad in the fields of final radioactive waste disposal and repository performance assessment.

GRS was commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to draft proposals on the further development and harmonisation of the German safety criteria for the final disposal of radioactive waste in deep geological formations. They shall comply with the international state of the art in science and technology and be consistent with the international development. The safety criteria presented here were submitted to the customer as GRS proposal.

2 LEGAL SIGNIFICANCE OF THE SAFETY CRITERIA

Fundamental principles for the safe handling with radioactive wastes have been defined by the IAEA in its Principles of Radioactive Waste Management /IAE 95/ and by the international community in the act on Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management /GNE 98/. These were the basis for the development of the national waste management programmes on handling, transport and disposal of the wastes.

In Germany, radioactive wastes shall be disposed of by final disposal in a mine. Type and volume of the radioactive wastes as well as the demonstration of long-term safety of the repository at the site are essential prerequisites for the development of a safety strategy and basis for the licensing of a repository. Regarding the safety of such a facility, the German law /ATG 02/ stipulates that the necessary precautions against possible damage have to be taken in accordance with the state of the art in science and technology.

As sub legal regulation, the safety criteria specify the safety principles and protection objectives of final disposal to be demanded and the general requirements for a repository resulting from it. They are exclusively related to the radiological protection objectives and requirements which specify the damage precaution required according

to the Section 1, No. 2 und Section 7, Para. 2 Clause 1, No. 3 of the Atomic Energy Act (AtG).

The safety criteria are applicable to the plan approval procedure to be performed for a mine at a selected site for the final disposal of radioactive wastes according to Section 9b, Para 1 AtG.

3 GRS PROPOSAL ON SAFETY CRITERIA

The proposal of GRS on the safety criteria presented here contains the definition of the safety principles, protection objectives and fundamental requirements applicable to the demonstration of operational safety and long-term safety of repositories. The requirements applicable to the selection of a repository site are defined separately /BRE 02/. Likewise, non-radiological requirements and requirements regarding the protection against interference by third parties are not object of these safety criteria. In accordance with Art. 2 of the joint convention /GNE 98/, the retrievability of the radioactive wastes is not taken into consideration.

On the basis of the fundamental safety principles of final disposal, safety principles are specified, protection objectives are defined for the operational and post-operational phase, principles are formulated for the planning, construction and operation of a repository and requirements are specified for the demonstration of long-term safety.

In the following, the focal points of the safety criteria proposed by GRS are presented.

3.1 Safety principles of final disposal

The safety criteria are based on the fundamental principles of final disposal to ensure the long-term protection of man and the environment against the potentially hazardous effects of the stored waste and not to impose undue burdens on future generations

These general requirements are specified by safety principles for the final disposal in deep geological formations:

- The radiation exposure for man and the environment resulting from final disposal shall be low compared to the natural radiation.
- Also in future, the potential effects on man and the environment resulting from final disposal must not exceed the degree of effects accepted today.
- Outside the boundaries of Germany, the potential effects on man and the environment from final disposal of radioactive material in Germany must not exceed those admissible within Germany.
- Safety has to be demonstrated for the operational, decommissioning and post-operational phases of the repository. These safety demonstrations have to include site-specific safety analyses according to the state of the art in science and technology.

- The selection of the site and the design of the repository have to ensure long-term safety. The demonstration of safety in the post-operational phase of the repository has to cover a period of one million years.
- The safety of a repository in the post-operational phase must not be based on active measures after sealing.

3.2 Radiological protection objectives

The radiological protection objectives for the final disposal of radioactive material are defined in the Atomic Energy Act, in the Radiological Protection Ordinance and the act on the convention on nuclear waste management.

For the operational phase of a repository, radiological protection objectives (Table 1) are derived from Radiological Protection Ordinance /StrlSchV 02/. Radiological protection objective for man is the limitation of the individual dose under consideration of the requirements for the prevention of unnecessary radiation exposure and dose reduction.

For the optimisation of radiation protection in the operational phase with very small dose contributions, GRS proposes a cut-off criterion of about 0.03 mSv per calendar year with reference to the concept of the trivial dose. Below this dose, further optimisation is not required.

The German rules and regulations do not contain protection objectives for the post-operational phase of repositories. On the basis of the safety principles, the limitation of the risk of an individual to suffer severe damages to health caused by radiation exposure (individual dose) is defined in the safety criteria as radiological protection objective for the post-operational phase. The individual dose refers to the human behaviour patterns of today.

3.3 The safety strategy

The safety criteria are based on the safety strategy to achieve the required safety by the identification of a suitable site and target-oriented planning and design of the repository. Planning principles and the requirements are formulated for quality assurance, design, construction, planning of the emplacement operations, the monitoring programme, radioactive wastes, decommissioning of the repository and for the monitoring, identification and documentation in the post-operational phase in accordance with the state of the art in science and technology.

The site properties have to be determined and evaluated in an investigation programme according to qualified methods in order to obtain sufficient information about the site characteristics regarding the suitability of the site and the assessment of safety. The safety-relevant site properties have to be presented on the basis of the results from the investigation. The results of the site investigation and a site characterisation have to be presented both with regard to the operational safety and the long-term safety. The applicant has to describe the potential future developments of the geological barrier system resulting from internal and external impacts in a geoscientific long-term prognosis. Here, the anthropogenic impact on the geological

barrier system by the construction of a repository mine and the disposal of radioactive wastes have to be considered in this prognosis.

The planning principles are focussed on the establishment of a safety concept and its technical performance by the applicant, the requirement of robust repository system, the construction of a repository as mine at a minimum depth of some hundred metres, the construction of repository as multi-barrier system with sufficient safety margins where the effectiveness of the barriers must not depend on maintenance work or controls and maintenance measures in the post-operational phase, the testing of the components used and the application of suitable management principles.

The design of a repository has to be based on site-specific analyses. It has to be specified in the safety concept on which safety analyses the design has been based regarding the normal operation and anticipated operational occurrences, the decommissioning and the post-operational phase and which accidents are considered in the design basis of the repository.

The technical barriers are to be designed to fulfil the safety requirements together with the geological and geochemical conditions. Their barrier effectiveness is to be described in a geotechnical long-term prognosis, considering the development of the geological barrier system predicted in the geological long-term prognosis.

A comprehensive quality assurance programme has to be developed and adhered to both for the operational and the post-operational phase.

Moreover, fundamental requirements for the safe operation of the plant are formulated. These are, in particular, requirements for the safe enclosure of the radioactive material, such as criticality, heat removal, radiation protection, fire and explosion protection, external and internal impacts and the plant management.

3.4 Demonstration of long-term safety

The demonstration of safety in the post-operational phase has to be performed as comprehensive safety assessments of the repository system. Basis of the safety assessment are the findings form the site characterisation, the geoscientific long-term prognosis and the long-term safety analyses. The results of the long-term safety analyses are evaluated according to the protection objectives. In addition, indicators on the assessment of the isolation capacity of the repository system and on the assessment of system properties shall be taken into consideration.

The long-term analyses are to be based on the potential developments of the repository system caused by internal or external impacts. Moreover, developments which can be caused by human activities are to taken into consideration. The existing uncertainties, such as the scenario, data and model uncertainties are taken into account in the long-term safety demonstration. It is required that the consequences are to be determined under explicit consideration of data uncertainties. For the assessment of the results, a confidence interval is specified for a percentile of the dose or the risk, respectively.

The demonstration of long-term safety has to cover a period for which scientifically substantiated predictions on the site development can be made. Based on the

requirements of site selection /BRE 02/, the long-term safety assessment shall cover a period of one million years.

3.5 Scenarios and protection objectives

The potential developments of the site to be considered are classified according to probable and less probable scenarios. Scenarios with a very low probability of occurrence do not have to be considered. In addition, inadvertent human intrusion into a repository has to be taken into account separately.

The groups of scenarios are classified according to protection objectives. The radiation exposure of an individual of the population determined in the consequence analysis for the most probable scenario must not exceed the effective dose of 0,3 mSv per calendar year.

The protection objective has been chosen so that the admitted radiation exposure is within the medium fluctuation range of the natural radiation exposure in Germany (2.4 mSv per calendar year). Likewise, the limit value for the population is below the 1 mSv effective dose per calendar year of EU Basic Safety Standard /KEG 96/.

For the less probable scenarios the calculated consequences must in total not exceed the risk of 10^{-5} per calendar year of suffering a severe damage to health from radiation exposure. If the demonstration for one scenario is performed representatively for one group of scenarios, it has to been based on the total occurrence probability for this group.

With regard to the planning and design of the repository, the possibility of inadvertent human intrusion into the repository has to be taken into consideration and analysed. The calculated potential radiological effects shall be evaluated according to ICRP recommendation 81. If required, measures are to be provided which reduce such occurrence possibilities or limit their potential radiological effects. This evaluation shall also consider the number of persons affected, the spatial extent of a potential contamination and the possibilities of limiting the consequences and taking of countermeasures.

4 STATUS AND OUTLOOK

The draft of updated safety criteria was submitted to the BMU and is currently under review by its advisory committees. The results of this review will be considered by BMU in order to establish and issue updated safety criteria.

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Table 1: Radiation protection objectives for the public mSv/a

Dose limit for members of the public: 1 mSv/a eff. dose

PHASE	CONDITION	EXPOSURE	RAD.PROTECTION ORDINANCE	SAFETY CRITERIA
OPERATIONAL PHASE	NORMAL OPERATION	AIR	0.3	0.3
		WATER	0.3	0.3
		DIRECT	1.0	1.0
	INCIDENT		50	50
POST OPERATIONAL PHASE	LIKELY SCENARIOS			0.3
	LESS LIKELY SCENARIOS			RISK 10^{-5}/a