Note:
This is a translation of the statement entitled: STELLUNGNAHME zum Entwurf des BMU "Sicherheitsanforderungen an die Endlagerung wärmeentwickelnder radioaktiver Abfälle". In case of discrepancies between the English translation and the German original, the original shall prevail.

E S K

STATEMENT on the draft of the BMU
"Safety Requirements Governing the Final Disposal of Heat-Generating Waste"

CONTENTS

1 Reasons for the consultations, background of the statement

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) intends to define safety requirements for the final disposal of heat-generating radioactive waste. A draft of the safety requirements (in the following referred to as "BMU draft") [1] had been prepared at the BMU and published as of 29.07.2008. These safety requirements shall replace the safety criteria for the final disposal of radioactive waste in a mine [2] for such waste published in 1983 by the Federal Ministry of the Interior (BMI) after consultation with the Reactor Safety Commission (RSK), the Commission on Radiological Protection (SSK) and the *Länder* Committee for Nuclear Energy (LAA).

In 2002, the Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS) submitted a proposal on the further development and harmonisation of the German safety criteria on which RSK and SSK conducted consultations and adopted a joint statement [3] in 2002. In January 2007, GRS submitted a further proposal, the GRS report "Safety requirements on the final disposal of high-level radioactive waste in deep geological formations" [4] on which RSK and SSK also prepared a joint statement [5].

2 Request for advice

With letter RS III 2 – 17005/0 of 29.09.2008 [6], the BMU commissioned the Nuclear Waste Management Commission (ESK), i.e. the ESK Committee on FINAL DISPOSAL (EL), to prepare a statement on the following questions:

1. Is the draft published by the BMU complete insofar that in case of its consideration in the plan approval procedure under nuclear law it is to be assumed that all requirements relevant for the safety of the repository are covered in accordance with the state of the art in science and technology? In this respect, special attention is to be paid to the recommendations of the ICRP (ICRP 81 [7] and ICRP 103 [8]) and the IAEO (SF-1 [9], WS-R-4 [10] and DS 334 (Draft) [11]).

2. Are, according to the state of the art in science and technology, supplementary or other requirements to be posed, e.g. on the properties of barriers or on the gradual optimisation?

3. Are, as provided, guidelines for the calculation of the effective dose and of risk values (Section 8.3.2) and for the definition of reference scenarios for human intrusion (Section 8.7) adequate or is further specification by guidelines recommended?

3 Consultations

Within the framework of a two-day closed meeting on 06./07.10.2008, the ESK and the ESK Committee on FINAL DISPOSAL (EL) dealt with the BMU draft [1] in depth and collected initial comments and proposals for amendments. On the basis of these consultations, a draft statement was prepared at the 2nd and 3rd

meeting of the ESK Committee on FINAL DISPOSAL (EL) on 05.11.2008 and 14.01.2009. Moreover, members of the ESK and of the ESK Committee on FINAL DISPOSAL (EL) participated in the Final Repository Symposium 2008 of the BMU (30.10.2008 - 01.11.2008 in Berlin) in which the draft was presented to the public by the BMU. The ESK adopted the present statement at its 5th meeting on 29.01.2009.

4 Assessment basis

For some years, there have been discussions on assessment criteria for repositories at the international level. In 2006, the status of these discussions was laid down in the IAEA Safety Requirements WS-R-4 "Geological Disposal of Radioactive Waste" [10]. These safety requirements represent the frame for the international state of the art in science and technology. A number of documents of other international organisations also include contributions on today's state of the art in science and technology, e.g. NEA-3679 "Post-Closure Safety Case for Geological Repositories – Nature and Purpose" [12] and ICRP-81: "Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste" [7].

These international recommendations are more general than required for national application. At the national level, there are currently no explicit documents that specify the state of the art for a repository. Therefore, the ESK considered, in addition to the international status, the current status of the technical discussions in Germany in the assessment.

Further, it has to be considered that some of these international recommendations also deal with another topic (e.g. legal frame, site selection, public relations, safeguards) than the BMU draft [1]. Here, the ESK holds the view that distinction has to be drawn between topics that are appropriate to be dealt with in the planned safety requirements and topics that are not relevant for the safety requirements.

In the following Chapter 5 "General questions", general statements of the ESK on the BMU draft [1] are summarised which precede the assessment of the individual chapters of the BMU draft [1] in Chapter 6. Chapter 7 explicitly addresses the questions of the request for advice.

5 General questions

- The ESK sees the need to revise the safety criteria of 1983 [2] according to the state of the art in science and technology and welcomes the draft of the safety requirements governing the final disposal of heat-generating waste.
- The ESK pointed to the development process of the discussion and, in particular, to the RSK/SSK statement of 2008 [5] the contents of which are supported by it. Among others, the ESK points out that in case of application of the ICRP recommendations the risk limit provided in the BMU draft leads to a dose limit that is below the limit of 0.1 mSv per year [5], as recommended by RSK and SSK, by a factor of 4. The ESK recommends to continue to apply the RSK/SSK limit of 2008.

- The ESK considers it necessary to supplement the BMU draft by essential elements:

  · Safety management is of central importance for compliance with all conditions under which the safety of the repository can be established at all. A corresponding treatment of all questions of safety management in the safety requirements is necessary. Therefore, a separate chapter should be provided for this topic.

  · The topic of robustness is touched on several times in the BMU draft. For the safety statements, however, it is of central importance and should therefore be dealt with in a dedicated section. Here, attention is also to be paid that distinction is drawn between the robustness of the repository system and its components on the one hand, and the robustness of the safety cases on the other hand.

  · At various points in the BMU draft [1], individual aspects on the topic of human intrusion are dealt with. The topic is characterised by that the development of safety cases and their assessment are to be treated in another way than in case of other scenarios. Therefore, a separate section is required which presents all aspects relevant for this topic in a coherent manner.

  · The ESK strongly welcomes the pursuance of the concept of containment in the isolating rock zone in the safety requirements. However, it recommends to put the basic requirement on the safety concept in the post-closure phase, also involving the role of the isolating rock zone, more clear in a dedicated section and thus to derive specifications regarding the functioning of the repository system in terms of this safety requirements. Too detailed specifications on individual aspects are dispensable as these are object of guidelines. The proposal for a wording would be: "The safety concept must in principle include the following elements:" (followed by a corresponding listing).

  · According to the state of the art in science and technology, a long-term safety case covers elements in addition to the components required in the BMU draft [1]. The safety case is based on bringing together information, arguments and analyses on the safety of the repository system. The safety requirements should demand an integrated and quality-assured presentation of these information, arguments and analyses and state the elements necessary for it.

  · The ESK welcomes the introduction of a stepwise optimisation in the BMU draft. It recommends describing the stepwise approach in the repository development process in a dedicated chapter.

- Requirements regarding the safety concept and the repository construction should be stated within the respective chapters clearly separated from requirements on the safety case.

- The elements of the annexes representing requirements have to be incorporated into the main text. All other parts of the annexes should be considered in the development of guidelines.

- Some sections of the BMU draft have the character and the level of detail of provisions as typically applied in guidelines. However, this does not apply to the whole BMU draft but only to individual aspects. This leads to a strongly varying depth and level of detail of the BMU draft. The Commission recommends to dispense with these detailed specifications in the safety requirements and their consideration in the development of comprehensive and consistent guidelines. The basic principles, however, have to remain in the safety requirements.

- The ESK assumes that the texts in italics are to be understood as explanations. However, it is to be stated that some of these texts have the character of provision and in these cases not always being consistent with the provisions of the actual safety requirements. It is recommended to limit the parts in italics to an indispensable degree of explanations and justification or, better, to dispense with them entirely. However, relevant requirements included in the italicised text so far have to be maintained and therefore to be incorporated into the standard text (the individual cases are stated under Chapter 6 of this statement in the comments on the different chapters of the BMU draft).

- The ESK is of the opinion that a stepwise approach with defined breakpoints for repository development corresponds to the state of the art in science and technology and is to be strived for for Germany. A judgement on whether and, if so, in which form legal aspects of implementation of this proceeding can be fixed in safety requirements and to which degree such a fixation would require the amendment of applicable law is beyond the mandate and expertise of the Commission. However, the Commission sees the necessity of a fast clarification on this issue. Within the safety requirements, the result of the clarification has an influence on the details of the safety requirements regarding the stepwise approach.

- The ESK shares the RSK's and the SSK's view that an option of retrieval should not be provided [5, Section 4.1] and [3]. The ESK affirms the position of the BMU [1] that a general retrieval is not to be provided.

  Should an option for retrieval be specified, this would be, in the Commission's view, a political decision which then would have to involve actual provisions on the time frame of retrievability and the desired boundary conditions for maintenance of retrievability. These aspects would then also have to be subject matter of the safety requirements.

- According to the statements in the chapter "Objectives", the ESK assumes that the safety requirements for a repository shall be applicable at a predefined site. It therefore recommends, and also in order to guard against misunderstandings, to delete all text passages referring to the selection procedure. Likewise, all text passages referring to (geological or other) properties of the site should be deleted unless – e.g. with regard to the principle of containment in the isolating rock zone – they are directly related to concrete requirements on the safety concept, the repository design or the safety case. However, it should be stated in the safety requirements that the application documents also comprise the justification of the site selection.

- In several passages, reference is made to tasks concerning the “aftercare” or “supervision” of the repository after decommissioning. It is not clearly recognisable to which extent these statements are compatible with the requirement that the repository must reach a maintenance-free state after decommissioning. It should generally be straightened out that geological repositories must, as a rule, be designed to be maintenance-free and, under safety-related aspects, no credit must be taken from control and maintenance measures.

- Regarding the treatment of other legal fields (e.g. water, soil and mining legislation) the ESK considers it more systematic not to deal with them in the safety requirements but in separated documents. Should, however, the opinion prevail that aspects of other legal fields have to be treated in the safety requirements it would be necessary to treat these aspects completely and systematically. In this respect, all relevant protection objectives should be stated, i.e. protection objectives resulting from water, soil and mining legislation (protection against mining damage) and not only a selection of protection objectives. These objectives are legally regulated by corresponding ordinances and their compliance lies within the responsibility of the respective authorities.

6 Assessment of the different chapters of the BMU draft

The structure of the statement follows the structure of the BMU draft [1]. In the following, the results of the ESK consultations on the individual chapters of the BMU draft are presented.

6.1 Objectives

Issue

In Chapter 1 “Objectives”, the BMU explains what shall be specified in the safety requirements on the final disposal of heat-generating waste, their scope of validity and which relevant items they include. The BMU draft [1] refers to the requirements on a repository for heat-generating radioactive waste under nuclear legislation. Delimitation from other legal fields is addressed. Requirements governing the involvement of the public in the construction of a repository are explicitly not dealt with here.

Assessment

Chapter 1 should precisely describe the objectives of the safety requirements and – where required – explain them. It should be straightened out that the safety level is not only defined by the protection objectives but by implementation of the safety requirements in their entirety.

According to the opinion of the ESK, the safety requirements are not applicable for the site alone but it concerns requirements for the site selected, the repository system and for the organisations dealing with the realisation of the repository system. This should be included in the formulation.

The ESK considers a short explanatory description of the five items so far only included as “listed points” (safety principles, optimisation, protection criteria, safety cases, repository design) to be helpful.

The ESK holds the view that the safety requirements shall replace the safety criteria of the BMI of 1983 [2], taking into account the state of the art in science and technology and the recent development of international regulations and recommendations. This should clearly be pointed out in Chapter 1 of the safety requirements.

The ESK considers the italicised remarks on Chapter 1 dispensable.

6.2 Scope of validity

Issue

Chapter 2 describes the scope of validity of the safety requirements. They apply to the applicant and the operator of a repository for heat-generating radioactive waste and to the plan approval authority. It is stated that the safety requirements are applicable for planning, exploration, emplacement operation, repository decommissioning and the supervision of a repository after decommissioning.

Assessment

In the BMU draft, the scope of validity of the safety requirements is limited to the final disposal of heat-generating radioactive waste. The ESK recommends an additional clarification regarding the final disposal of waste not generating heat but that cannot be emplaced in the Konrad repository due to restrictions in the plan approval decision. Such special radioactive waste may has to be emplaced in a repository for heat-generating radioactive waste.

Further, the ESK recommends not stating offices and organisations by name but generally only stating the function of the offices or organisations, as e.g. applicant, operator, plan approval authority and supervisory authority.

Chapter 2 of the BMU draft refers to the tasks concerning the "supervision" of the repository after decommissioning. It is not clearly recognisable to which extent this statement is compatible with the requirement that the repository must reach a maintenance-free state after decommissioning. It should generally be straightened out that geological final disposal must be designed to be maintenance-free and, under safety-related aspects, no credit must be taken from control and maintenance measures. (cf. Chapter 5 of this statement). Here, it should read "… and also concern the measurements for preservation of evidence after decommissioning". Thus, the text would be consistent with the safety principle mentioned in Chapter 5.4 of the BMU draft.

The Commission recommends to delete the italicised test on Chapter 2 without replacement.

6.3 Definitions and explanations of terms

Issue

Chapter 3 lists definitions and explanations of terms. By way of introduction it is stated that there is not claim to be exhaustive. For further definitions and explanations, reference is made to the Atomic Energy Act and related regulations and to the final disposal conditions for the Konrad site of the Federal Office for Radiation Protection (BfS).

Assessment

The ESK is of the opinion that definition and explanation of relevant terms (e.g. isolating rock zone, optimisation) are of central importance for the safety requirements, in particular as some terms are used differently than in other national and international documents. However, it recommends to limit such deviating use to a minimum. Moreover, the Commission recommends a strict delimitation of definitions of

terms and their explanations.

6.4 Purpose and general protection objectives

Issue

In Chapter 4, the BMU addresses the purpose of the safety requirements and presents the following two general protection objectives being pursued with the final disposal of heat-generating radioactive waste:

- To permanently protect man and the environment from ionising radiation and other harmful effects of such waste (Section 4.1), and

- to avoid unreasonable burdens and obligations for future generations (Section 4.2).

Assessment

The protection objectives presented in the BMU draft [1] focus on aspects of nuclear law.

A problem is the interconnection with protection objectives from other legal fields ("… and other harmful effects of such waste"; "Man and the environment are considered to have been permanently protected from the other harmful effects of such waste provided the other quantities of materials derived from the final repository meet the relevant statutory requirements as outlined in water and soil legislation."). This contradicts the statement in Chapter 1 of the BMU draft "These Safety Requirements do not include requirements from other legal fields." From the point of view of the ESK, these formulations should be deleted especially because regulations subordinate to the Atomic Energy Act, such as the planned safety requirements, cannot explicitly interfere with the regulatory scope of other acts.

The present BMU draft does not clearly show to what extent Chapter 4 differs from Chapter 1. From the current text, objective and purpose of the safety requirements do not become apparent. Therefore, it should be checked whether these two chapters can either be merged or be more clearly delineated from each other.

The ESK recommends to clearly state here or in another appropriate section that there will be no "discharge" of "material quantities" from a sealed repository in the so-called "post-closure phase". The use of the term "discharge" in terms of the water law for potential release of inventory components in case of scenarios of future evolution needs to be explained.

It should generally be straightened out that "final geological disposal" must be designed to be maintenance-free and, under safety-related aspects, no credit must be taken from control and maintenance measures. (cf. Chapter 5 of this statement). The final sentence of Chapter 4 be formulated as follows: "Unreasonable

burdens and obligations for future generations are avoided by design and implementation of geological final disposal such that no technical aftercare measures will be required. This does not affect the appropriateness of a longer term measurement programme after sealing of the repository for comprehensive preservation of evidence."

6.5 Safety principles

Issue

On the basis von Chapter 4 "Purpose and general protection objectives", Chapter 5 of the BMU draft [1] presents the safety principles resulting in the formulation of requirements on final disposal in the following chapters. These principles are, in particular,

- limitation of the release of pollutants from the repository to amounts leading to only a negligible increase compared with the naturally occurring risk (Section 5.1),
- limitation of risks resulting from pollutant exposures in the future to currently accepted levels (Section 5.1),
- protection of species diversity (Section 5.2),
- protection of natural resources (Section 5.2),
- limitation of the effects of the repository in areas outside Germany to effects accepted in Germany (Section 5.3),
- specification that the long-term safety of the repository shall not be based on active monitoring and maintenance measures (excluding a period of 500 years during which it can be ensured that no human activities in the vicinity of the final repository will be performed which could threaten the permanent containment of the waste" (Section 5.4).

Assessment

The ESK is of the opinion that the principles formulated in the BMU draft comply with the principles mentioned in the relevant requirements and recommendations of the IAEA and, in particular, with those of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [14] and the IAEA Safety Requirements No. WS-R-4 [10]. This, however, does not apply to the specification of a 500-years period during which the knowledge about the existence of the repository shall be ensured (for justification, cf. the explanations at the end of this section).

The Commission recommends, in accordance with the IAEA Safety Requirements WS-R-4 [10], to also lay down the principle of concentration and containment of the waste in Chapter 5 in addition to the existing specifications.

Re: Section 5.1:

The ESK welcomes the establishment of the principle "… must ensure that any release of pollutants from the final repository only negligibly increases the risk to humans associated with radiation exposure and as a result of other effects compared with the naturally occurring risks …". However, it is to be pointed out that the passage "and as a result of other effects" refers beyond the scope of validity of the safety requirements (see also the explanations in Chapter 5 of this statement).

The term "only negligibly increases the risk … compared with the naturally occurring risks" should be defined more precisely. The Commission points out that this wording is contradictory to the radiological assessment criteria formulated further in the BMU draft.

Moreover, a structural separation of the two principles laid down in Section 5.1 (only negligible increase of naturally occurring risks, on the one hand, and protection of future generations, on the other hand) is recommended since it concerns two different aspects.

Further, the explanatory text on Section 5.1 in italics should be dispensed with.

Re: Section 5.2:

The ESK recommends a structural separation of the two principles laid down in Section 5.2 (species protection, on the one hand, and resource conservation, on the other hand) since it concerns two different aspects.

The ESK agrees with the assumption on which the italicised explanation on Section 5.2 in the BMU draft is based that according to current knowledge terrestrial ecosystems and other species are also protected from ionising radiation if man as an individual is protected. This point of view is also in line with the view of RSK and SSK [5]. However, this assumption should explicitly be adopted into the requirement text (in connection with the formulation of the protection criteria in Chapter 7 of the BMU draft).
The ESK does not consider the linkage of the concept of the isolating rock zone with the conservation of natural resources useful. According to the opinion of the Commission, final disposal means the thoroughly deliberate use of a resource. The selection of an isolating rock zone as small as possible limits this use, but nevertheless may come into conflict with other requirements, e.g. those of safety relevance. The ESK recommends a respective reference to the optimisation process. A conservation of resources regarding their use by future generations is not considered realisable by the Commission since it cannot be predicted what will be applicable as resource for future generations. The implementation of a weighing process between

safety and resource conservation is not recommended by the Commission. Instead, it should be explained explicitly that final disposal – just like raw material extraction – means the use of geological resources.

Except for the above consideration to be adopted into the main text, the italicised part of Section 5.2 should be deleted.

Re: Section 5.3:

The italicised part of Section 5.3 should be deleted. If not, the ESK recommends to dispense with the term "Verseuchung" (*contamination*) and to rather use the term "Belastung" (*impact*).

Re: Section 5.4:

The ESK refers to the basic principle of passive safety as formulated in the first sentence of Section 5.4 which must apply without restrictions – already in the first years after sealing of the repository. Wordings that could be understood as a restriction of this principally should absolutely be avoided.

Therefore, it should read after the first sentence as follows:

"This does not affect the appropriateness of a longer term measurement programme after sealing of the repository for comprehensive preservation of evidence. Moreover, it is to be ensured that the information about the repository will be maintained as far as possible for a time horizon of 500 years."

The Commission is of the opinion that ensuring a period of 500 years for which "the competent offices will be able to preclude all human activities in the vicinity of the final repository which could threaten the permanent containment of the waste" (Section 5.4) cannot be demonstrated in view of the short lives of organisations, institutions and states. Thus, the ESK recommends requiring maintenance of information about the repository and measures for later use of this information, applying diverse techniques and methods according to the state of the art in science and technology.
From the point of view of the ESK, the topic of human intrusion should not explicitly be dealt with here together with the safety requirements but in a separate Section (see Chapter 5). There, it should also be pointed out that the derivation of scenarios for human intrusion is often based on the assumption that this intrusion does not take place earlier than some hundreds years after sealing of the repository. This proceeding is justified with experiences in the use of records, such as those on former mining but not with an obligation to provide guarantee or proof.

The italicised part of Section 5.4 should be dispensed with.

6.6 Stepwise optimisation

Issue

In Chapter 6 of the BMU draft [1], the stepwise optimisation is dealt with. Under Section 6.1 it is required that the risks associated with final disposal will be kept as low as reasonably possible. In this respect, main attention should be paid to the compliance with the radiological protection criteria. Section 6.2 specifies ahead of which different decision-making stages safety cases should be drawn up and should be submitted to the licensing authority in certain cases. The safety cases also have to cover optimisation regarding the protection of man and the environment. Section 6.3 deals with the content-related disclosure obligation of the applicant within the framework of site designation and also requires outlining the topic of unintentional human intrusion. Section 6.4 establishes the requirement that the operator shall review safety and safety-relevant changes at ten-year intervals.

Assessment

The Commission generally considers it appropriate to require stepwise optimisation in the safety requirements. However, the Commission deplores the fact that the separation of the different aspects of

- optimisation regarding the safety culture at the applicant's or operator's,
- optimisation regarding radiation protection during repository operation, and
- optimisation of the repository regarding long-term safety,

as required in the statement of RSK and SSK of 2008 [5], had not been realised in the BMU draft [1].

The separation of optimisation issues regarding radiation protection during repository operation from those on repository optimisation regarding long-term safety is, by the way, also found in the IAEA Safety Requirements WS-R-4 [10]. There, these aspects are dealt with in separate chapters and with a differently described approach to optimisation.

The Commission recommends that a clear separation between the three aspects will be included in the safety requirements.

The statement of the RSK and SSK [5] contains clear requirements regarding what has to be considered for the organisation of optimisation regarding long-term safety:

"From the point of view of RSK and SSK, optimisation must, with regard to long-term safety, consider factors, such as calculated radiation exposure of man, robustness of the assumptions, geological predictability, degree of difficulty in realising certain facilities and the influence of certain circumstances on safety. This means that optimisation is to be understood as weighing between the different factors. In the rules and regulations to be set up, the proceeding for optimisation and the factors considered in the weighing

should be defined. Moreover, the weighing principles are to be stated. Optimisation regarding long-term safety cannot consist of the minimisation of the calculated individual dose, even below specified reference levels and limits. The calculated individual dose represents a single value based on a number of individual model assumptions. A modelling of other relevant factors being relevant for safety is only contained in the individual dose to a very limited degree. The same applies to other indicators for assessing the safety of the repository."

The ESK shares this view in full and, moreover, recommends to explicitly state the objectives of optimisation in the safety requirements.

Accordingly, in the international discussion – e.g. in more recent papers of the OECD-NEA – a distinction is now being made whether optimisation only takes place in terms of radiation protection or whether optimisation takes place with regard to long-term safety. The explanations in ICRP-81 [7] and WS-R-4 [10] contain a rather unclear description of optimisation required there. However, it can be seen from the explanations that optimisation in terms of radiation protection shall only start to apply if it is guaranteed that all systems and equipment are implemented on a reliable engineering basis and if there is quality assurance.

Neither the recommendations of the RSK and the SSK nor the considerations from the international discussion have been incorporated into Chapter 6 "Stepwise optimisation" of the BMU draft. Section 6.1 rather requires a close coupling of optimisation to pure mathematical values, i.e. the protection criteria defined in Chapter 7. The Commission shares the view of the RSK and the SSK of 2008 [5] in full and considers it necessary to revise Chapter 6 according to the recommendations formulated there. Otherwise, there is a danger that in case of the proceeding recommended in Section 6.1, the safety of the repository is removing from the focus of consideration and supposed "optimisations" are performed that actually impair the safety of the repository.

In addition, "inadmissible radiation exposure or contamination" (italicised part of Section 6.1) cannot be dealt with via optimisation stages but it must be possible to principally exclude them. This is to be demonstrated in the safety case.

In Chapter 6, several passages, in particular in Section 6.3, mainly deal with other requirements on site designation or the design against unintentional human intrusion, and the topic of "optimisation" is only touched on. These passages do not fit under the chapter heading "Stepwise optimisation". The explanations on human intrusion should be shifted to a separate section of safety requirements and dealt there in depth (see Chapter 5 of this statement).

For Section 6.3, the question arises whether the topic "site designation" in the safety requirements which shall apply for "sites … where the Federal Government, in its capacity as the body responsible for the construction of facilities for the final disposal of radioactive waste, has opted for a plan approval procedure" and thus after site designation should be contained at all (see Chapter 5 of this statement).

Another representation problem in Chapter 6 is that here both the stepwise approach and optimisation shall

be regulated. For the sake of a clear representation, these two aspects should be treated separately.

Due to the common treatment in one chapter, contradictions arise, e.g. regarding the schedule for certain exploration measures and plan approval steps. For example, the question arises how underground exploration or excavation of the shafts is to be understood in temporal and legal relation to the steps stated in Chapter 6. Here, it should be formulated in unambiguous terms when the plan approval procedure will be initiated and which steps of the project will be subject of a nuclear plan approval procedure.

Further, it remains unclear whether the terms “phase”, “optimisation stage” and “decision-making stage” are used synonymously. Therefore, only one of the terms should be used or differences should be made clear..

Altogether, the ESK holds the view that the italicised texts in Chapter 6 should be deleted but all passages that represent requirements must be adopted into the normal text. This concerns, for example, the requirement of submitting the decommissioning concept in due time before start of operation, which is considered very important by the ESK.

6.7 Protection criteria

Issue

Chapter 7 “Protection criteria” of the BMU draft [1] presents the legal framework for the protection from damage caused by the repository (Section 7.1) and the protection criteria the compliance of which shall ensure protection of man (Sections 7.2 to 7.4). Section 7.5 concludes that the consequences of repository for water and soil should be assessed in accordance with the relevant provisions of water and soil legislation. Corresponding requirements on protection of groundwater and soil according to the protection criteria for man can be found in Section 8.3.4. The biotic environment is not explicitly mentioned Chapter 7 as object of protection. However, according to the explanations in Section 5.2, the biotic environment is to be regarded as protected if man is protected.

The main specifications in Chapter 7 concern the level of protection of man against damage caused by ionising radiation to be kept. It is defined as an additional risk of man emanating from a repository suffering serious health damage during his lifetime as a result of radionuclides released from the isolating rock zone (Section 7.2). As a parameter for the additional risk, the conditional probability to suffer serious health damage during ones lifetime as a result of radionuclides released from the isolating rock zone is used. In this respect, an exposure during the entire lifetime (assumed: 70 years) is referred to.

The degree of the admissible additional risk depends on whether the evolution of the repository is assessed to be probable or extraordinary when determining the risk. For probable evolutions, it has been defined at $< 10^{-4}$ with reference to the drinking water reference level of the World Health Organization (WHO) (Section 7.2). For extraordinary evolutions it is $\leq 10^{-3}$ (Section 7.3).

Here, repository evolutions are considered as probable whose occurrence probability in relation to the specified reference period exceeds 10^{-1} (Section 7.2), as extraordinary those with a "probability of occurrence" less than 10^{-1} and not significantly below 10^{-2}"(Section 7.3). Evolutions considered as "improbable" to be excluded from further consideration are those whose occurrence probability in relation to the reference period is less than 10^{-2} and/or whose immediate effects far exceed the effects of a repository (Section 7.4).

Assessment

The ESK deplores that the conceptual considerations initiated by the AkEnd [15] and followed up in the draft of the safety requirements of GRS from 2007 [4] and the related joint statement of RSK and SSK of July 2008 [5] on the function of the isolating rock zone is only reflected in the BMU draft [1] to some extent. By this, the basic idea of containment of the pollutants in the isolating rock zone as a part of the facility "repository" decreases in stringency. The fact that the protection criteria refer to the radionuclides released from the isolating rock zone or other pollutants does not change this. Therefore, the ESK recommends to also require criteria for the containment of the radionuclides and pollutants in the isolating rock zone in addition to the protection criteria contained in Chapter 7 and to define them within the framework of guideline development (cf. Section 6.8 of this statement).

Unclear are the procedure-related function and significance of the protection criteria and the relation ship between the protection criteria and the test values and requirements described elsewhere in the safety requirements, in particular in Chapter 8. In addition, derivation and justification of the criteria for assessing the effects of radionuclides released from the isolating rock zone are unconvincing. This applies both to the use of the risk as criterion for assessing the effects emanating from a repository and the degree of the admissible risk.

Regarding the use of risk-based assessment criteria, the ESK explicitly refers to the explanation in the joint statements of RSK and SSK of 2002 and 2008 [3, 5] on the risk-based assessment of associated problems and the advantages of applying dose criteria.

The quantitative relation established in the explanation on Section 7.2 in the BMU draft to the definition of the drinking water reference level of the WHO is not convincing in view of the differences between the calculation approach of the WHO [16] and the radioecological practice regarding long-term safety analyses. While in the WHO model only the drinking water path is considered for exposure calculation, all relevant exposure paths are to be considered for the final disposal of radioactive waste.

In its recommendations on drinking water quality [16], the WHO specified a reference level for the maximum admissible effective dose of 0.1 mSv per year and, on this basis, calculated in the justification for this value, with reference to the risk coefficient stated in [17] (7.3×10^{-2} Sv^{-1}) of the International Commission on Radiological Protection (ICRP), the additional lifetime risk for serious health damage of

more than 10^{-4} adopted in the BMU draft [1]. The current risk coefficient (2007) specified by the ICRP is 5.7 x 10^{-2} Sv^{-1} [8]. Regarding the general problems of converting dose into risk values, the ESK explicitly refers to the corresponding remarks in the joint statement of RSK and SSK of 2008 [5]. Accordingly, it has to be specified before definition of a binding maximum risk value on which basis the dose-effect relationship is determined, which effects are included and how these may have to be weighted. Recommendations of the ICRP as regard the quantitative level of the risk coefficients have already repeatedly been assessed by the SSK as not being appropriate. Thus, at present, there are no corresponding recommendations of the ICRP or other bodies that can be recommended without any reservations.

In this connection, the ESK also points out that the limit for the probable evolutions of 10^{-4} specified in the BMU draft for the lifetime risk with an assumed lifetime of 70 years and the application of the one mentioned in the italicised text following Section 8.3.2 of the BMU draft "in ICRP Publication No. 103 for the detriment-adjusted nominal risk for cancer and hereditary effects of 0.057 per Sievert in total" leads to a limitation of the annual dose of approx. 0.025 mSv. This value falls below the value of 0.1 mSv per year recommended by RSK and SSK [5] by a factor of 4. The ESK recommends maintaining the RSK/SSK value of 2008.

The ESK recommends regulating the application of the protection criteria in a guideline.

The ESK favours the approach to asses the potential radiological effects of a repository caused by different repository evolutions differentiatedly in dependence of the probability of occurrence of the respective evolution within the specified reference period. It is principally in compliance with the current proceeding at the international level. However, the assignment of potential repository evolutions to three quantitatively defined probability categories, described in the BMU draft in Section 7.2 to 7.4, involves serious methodological problems:

According to the BMU draft, the classification of potential evolutions of the repository according to probable evolutions, extraordinary evolutions and improbable evolutions shall be performed according to cardinal (quantitative) occurrence probabilities. These occurrence probabilities reflect uncertainties whose assessment contains a significant subjective component. Only some aspects (e.g. the frequency of earthquakes of a certain specified intensity) can be covered by statistics, others can only be described by subjective statements. It is possible to quantify such statements by means of formal protocols for the survey of expert judgements in form of probabilities. The result then depends both on the opinion of the experts surveyed and on the protocol chosen. In some protocols, in particular in case of diverging expert statements, assessments and actions of the one carrying out the survey are also taken into account (e.g. assessments regarding the reliability of the individual experts involved or actions within the framework of a moderation activity). None of these protocols is universally accepted; the differences in the approaches and thus in the result are significant. Therefore, the Commission is of the opinion that such approaches may well be used in safety analyses but that the specification of numerical criteria for the assignment of scenarios to probability categories gives the impression of accuracy and objectivity which is not given. It concerns subjective estimates and thus ordinally scaled probabilities for which only statements such as "more probable" or "less probable" are appropriate. Therefore, statement of quantitative probabilities for potential repository

evolutions should not be done. At the same time, an inconsistency between Sections 7.3 and 7.4 (probability of occurrence "not significantly below 10^{-2}" in case of extraordinary and "less than 10^{-2}" in case of improbable evolutions) would be removed by it.

The concerns about quantitatively defined probability categories apply particularly to those evolutions not requiring further consideration (Section 7.4); since the exclusion of an improbable evolution from further consideration involves a decision with far-reaching consequences, i.e. not to deal with the impacts of this evolution. Therefore, the exclusion of an evolution from further consideration must be fully justified and with convincing arguments. If this cannot be done without any doubt, the respective evolution must not be classified "improbable".
Altogether, the ESK considers it appropriate to pursue the concept with three categories of probability. However, the three categories should be differentiated, e.g., according to the following qualitative criteria:

- "Probable evolutions" are those resulting if the situation on site develops according to the know "normal" geological evolution tendencies for such sites and on the basis of predictions on the technical and geotechnical components (evolution according to the "textbook").

- "Less probable evolutions" are those resulting if the situation on site develops in another way than to be expected from the probable evolutions. Such evolutions are possible from all processes not to be expected at the site but, according to the state of the art in science and technology cannot be safely excluded either. – The term "extraordinary evolution" should be dispensed with in favour of the "less probable evolution" since such evolutions do not result from extraordinary circumstances.

- Only those impacts on site can be classified "improbable evolutions" whose occurrence at the site can safely be excluded according to the state of the art in science and technology.

The classification of potential and conceivable evolutions according to three probability categories and the differentiated assessment based on it can thus not be made according to numerical values but only on the basis of qualitative estimates/assessments. This, however, has to be done according to objective criteria to the largest possible extent and be documented accordingly. For this reason alone, the procedure for classification of the evolutions according to probability categories requires regulation in a guideline. In addition, there are the following reasons:

- the great importance of classification of an evolution according to a probability category for the result of the assessment of an evolution for the fulfilment of the protection criterion,

- the necessity to limit the influence of individual statements/specifications on occurrence probabilities on the result.

The guideline has to ensure that the classification of the evolutions according to probability categories is performed verbally argumentative by means of meaningful allocation criteria and according to the state of the art in science and technology on a broad scientific basis.

Section 7.5 should be deleted. As explained in Chapter 5 of this statement, this does not belong to the area that can be regulated by the safety requirements.

Regarding the contents of the italicised text following Section 7.2 of the BMU draft, reference is to be made on the comments in Chapter 5 of this statement. The text in italics referring to Sections 7.3 and 7.4 of the BMU draft should be dispensed with.

6.8 Safety cases

Issue

Chapter 8 of the BMU draft [1] describes which safety cases are to be submitted for the different phases of the repository evolution and requirements on these safety cases are formulated. In particular, the following proofs are required:

- "Plant-specific safety analyses" for the periods of emplacement operation and decommissioning (Section 8.1),
- the proof that for the periods of emplacement operation and decommissioning, an influx of water can be excluded (Section 8.2),
- a "comprehensive, site-specific long-term safety case for the period after decommissioning of the repository (Section 8.3), and
- the exclusion of criticality (Section 8.4).

Further, the chapter includes statements

- on the specified reference period (Section 8.5),
- on the performance of calculations, in particular in view of uncertainties regarding the parameters, models and scenarios used (Section 8.6),
- on the treatment of unintentional human intrusion (Section 8.7),
- on the "review of the safety assessments" by means of a measurement programme (Section 8.8),
- on the derivation of emplacement conditions and on quality assurance measures (*Produktkontrolle*) (Section 8.9),

- on data acquisition (Section 8.10), and

- on the separate treatment of releases of "radionuclides from naturally occurring materials (backfill and rock)" on the one hand, and "from the emplaced waste" on the other hand in the long-term safety case (Section 8.11).

Assessment

The ESK is of the opinion that sections 8.1 - 8.4 in the BMU draft [1] state the elements necessary for a safety case and are, as far as that goes, generally appropriate and principally covering. However, the statements in Chapter 8 of the BMU draft should be specified and complemented as follows:

- It is to be made clear that Section 8.1 exclusively refers to safety-related issues in the phases of repository operation and decommissioning. In the current formulation, Section 8.1 also contains passages referring to aspects of long-term safety or at least can be interpreted in this way (optimisation, robustness). Reference is to be made to the requirements on the safety of nuclear installations and, in particular, to the Radiation Protection Ordinance (*Strahlenschutzverordnung - StrlSchV*) as well as to the relevant provisions of mining law. As already stated by RSK and SSK [5], the operation of the repository is to be assessed analogous to the requirements for the operation of other nuclear installations. This means, among other things, that the statements in Section 8.1 on safety analysis based on probability considerations should be dispensed with since in Germany, priority is given to the deterministic consideration for assessing the safety of nuclear installations.

  Altogether, there is no clear stipulation that the overall spectrum of all potential operational failures, incidents and accidents during the operating phase is to be identified and to be considered and that for all cases identified, their control or their exclusion is to be demonstrated. Mentioning of the uncontrollable influx of water in Section 8.2 (see below) alone would have to be interpreted to mean that other severe cases have not to be considered.

  The italicised text in Section 8.1 should be dispensed with.

- Details on the operational safety of the repository are to be regulated in a guideline. Regarding questions related to operational safety, the Commission also refers to Chapter 5.1 of the RSK/SSK-statement of 2008 [5], its statements on the development of a guideline, on the use of the proceeding in the Konrad plan approval procedure and on the requirement of reduction according to § 6 StrlSchV. The ESK shares the views of RSK und SSK set out in [5].

- The detailed statements on the uncontrollable influx of water in Section 8.2 should be made in the above mentioned guideline on operational safety. The respective specifications in the guideline should generally deal with the problems associated with water influx in addition to other operational failures, incidents and accidents (see above) and not only be limited to uncontrollable water influx. Section 8.2

should therefore be dispensed with. The general requirements mentioned should be integrated into Section 8.1.

- According to the state of the art in science and technology, a long-term safety case comprises elements in addition to the components required in Section 8.3. The safety case is based on the collation of information, arguments and analyses relevant for the safety of the repository system. The safety requirements should demand an integrated and quality-assured representation of these information, arguments and analyses. In addition to the components already stated in the BMU draft, the ESK is of the opinion that in particular the following should be included:

  · Quality-assured acquisition of data and information from site exploration and research and development,

  · demonstration that the requirements on the technical and geotechnical barriers can be implemented,

  · identification, characterisation and modelling of safety-relevant process together with confidence-building in this regard and qualification of the models,

  · the comprehensive identification of safety-relevant scenarios (on the basis of above mentioned components and the long-term geological prognosis mentioned in Section 8.3.1 of the BMU draft) and, on this basis,

  · the analysis of scenarios then leading to statements regarding the requirements formulated in Sections 8.3.2 – 8.3.7 and on the compliance with the criteria (Chapter 7),

  · the representation and implementation of a systematic strategy for the identification of the uncertainties and insecurities to be considered in the safety case and their handling. This also has to be an integral part of the safety management regarding planning, construction and operation of the repository, and

  · the comprehensive demonstration that the applicant has implemented a safety management that had been and will be operable during the entire repository development process through to the completion of decommissioning.

- The italicised text of Section 8.3 should be dispensed with.

- For the demonstration of long-term safety, the BMU draft [1] requires, among other things, the performance of a "long-term geological prognosis" (Section 8.3.1), of a "long-term radiological prognosis" (Section 8.3.2) and of a "long-term prognosis of containment" (Section 8.3.3, optionally instead of the long-term radiological prognosis). The long-term geological prognosis shall serve to demonstrate the integrity of the isolating rock zone (under consideration of disturbances due to the

repository and waste) while the long-term radiological prognosis and the long-term prognosis of containment shall be based on release models. In this respect, it first has to be mentioned that the use of the terms "long-term radiological prognosis" (Section 8.3.2) and "long-term prognosis of containment" (Section 8.3.3) are misleading since these elements are no prognoses and have a principally other character than the "long-term geological prognosis" (Section 8.3.1).

- The ESK considers the statement in Section 8.3.1 "Long-term geological prognosis" to be inconsistent with the perceptions on the isolating rock zone introduced elsewhere (Chapters 3 und 5 of the BMU draft [1]). This applies, in particular, to the criteria comprised under the bullet points by means of which the isolation rock zone is to be defined. Since containment shall be reached by the isolating rock zone and the sealing structures, a clear and unambiguous procedure for specifying the isolating rock zone. Further, it has to be specified which functions the isolating rock zone has to fulfil to be able to draw conclusions on the required properties of the geosystem. While a clear definition of the isolating rock zone and the requirements to be made for it have to be part of the safety requirements, the requirements on the detailed design of repository within the isolating rock zone may be compiled in a long-term safety guideline.

- Regarding the bullet points in Section 8.3.1, there is a need for the following improvements:

  · In the first bullet point, the term in brackets should be dispensed with since the specification of the procedure for developing a safety case is too detailed for safety requirements and the concrete formulation does not lead to optimum and comprehensive safety case procedures. Moreover, the use of the term "hydrogeological cycle" is not appropriate. The statements appear to refer to the hydrological cycle.

  · In the second bullet point, it is not possible to deal with transport processes in the isolating rock zone in general but only with such transport processes being able to transport the contaminants from inside to the border of the isolating rock zone because only these could lead to a release from the isolation rock zone. A corresponding amendment is necessary. By this, the first paragraph following the bullet points ("Provided the waste …") and the paragraph in italics ("After decommissioning …") can be dispensed with which, as they are currently worded, lead to uncertainty about the extent of the safety case to be established.

  · The third bullet point should be worded more general and clearer. The formation of pathways resulting in a violation or impairment of the containment effect of the isolating rock zone must be excluded.

  · The italicised text must be dispensed with, a temporarily violation of requirements is not possible. The requirements would then rather have to be formulated differently.

- The underlying requirements in the Sections 8.3.2 and 8.3.3 of the BMU draft "Long-term radiological prognosis" and "Long-term prognosis of containment" regarding the performance and assessment of

release calculations leave it to the applicant to choose between a "classical" modelling under consideration of the overburden and the biosphere (Section 8.3.2, confinement to water path and reference biosphere models) and an assessment of the calculated release from the isolating rock zone according to a dose criterion (Section 8.3.3).

The proceeding outlined in Section 8.3.3, first paragraph, is aimed at the demonstration of containment of the radionuclides in the isolating rock zone but, instead of it, also allows a safety case in which the containment properties of the isolating rock zone do not play a relevant role (choice between Section 8.3.2 and Section 8.3.3). From the view of the ESK, the latter is not expedient and needlessly gives up the gain in safety and robustness of the repository achieved by the introduction of the isolating rock zone. The ESK sees the necessity to focus on the containment for the proofs and to develop appropriate procedures and criteria for the safety case. Also in this regard, the Commission follows the recommendations of the statement of RSK and SSK [5] on the role of the isolating rock zone and on the safety case (see Chapter 5 of this statement). This applies, in particular, to the comments on the indicator system in Chapter 5.2.2 of the RSK/SSK statement [5] and the research and development still required for it. In the view of the ESK, the possibility to develop an indicator system on the containment in the isolating rock zone will get lost with the limitation to dose constraints in the BMU draft. However, the ESK considers such a development to be necessary and promising, just as RSK and SSK do, and recommends its realisation within the framework of the development of a guideline on the long-term safety case.

The requirements on the calculations required in Section 8.3.2 should be presented in a guideline. Such a guideline should, among other things, regulate the proceeding for the application of radiological models (general administrative provision on long-term prognosis repository "AVV Langzeitprognose Endlager"). In this respect, it should be taken into account that the limitation of modelling to the water pathway is not comprehensible and should be dispensed with. The italicised explanations in Section 8.3.2 contain elements of such guideline but are incomplete and should therefore be supplemented for the guideline. However, in the safety requirements, they should be deleted. This also applies to the corresponding statements on the modelling in Section 8.3.3 both in the normal and the italicised text. The statements starting with the second paragraph of the normal text including the italicised text should be included in guidelines.

- Section 8.3.4 is to be deleted according to the recommendation given in Chapter 5.

- The demand that the geotechnical barriers shall be functionally equivalent to the geological barrier in Section 8.3.6 is neither appropriate nor can it be fulfilled. Both barriers together have to ensure the containment of the wastes in the isolating rock zone and therefore have to satisfy clear minimum requirements but they do not necessarily have to be functionally equivalent. Otherwise, it would mean: the better the existing geological barrier at the site, the higher the requirements a geotechnical barrier would have to meet. For this reason, the wording should aim at the specification of minimum requirements for the geotechnical barriers. The text in italics is to be deleted.

- The ESK is of the opinion, that the demand in Section 8.3.7 for waste containers to offer stability and corrosion resistance for a period of 500 years is not appropriate for several reasons:

  · The requirement is justified, among other things, by arguing that a potential retrieval of the wastes must not be rendered unnecessarily difficult for future generations. The ESK shares the view of RSK and SSK that the option of retrieval is not to be provided [5].

  Therefore, requirements can only be derived from the generally formulated objective of "must not be rendered unnecessarily difficult" generally formulated in the BMU draft [1]. However, for the formulation of requirements, detailed and concrete objectives (e.g. detectability, manageability) would first have to be defined, but these are not identifiable in the BMU draft. Therefore, the ESK cannot take a position on whether the objectives are appropriate. On the basis of the objectives, it would then have to be clearly defined in the safety requirements what has to be proven for it. In particular, questions arise regarding the required properties of the containers after 500 years. So, for example, it is unclear whether in this context containment means gastightness or tight containment of the solids or only retainment of the major part of the waste components in the container and whether corrosion resistance refers to surface corrosion or also to pitting. It is necessary to clearly define, on the one hand, the requirements to be fulfilled and, on the other hand, the proofs to be provided.

  · In Sections 3.30 and 3.31, the IAEA Safety Requirements WS-R-4 [10] assume containment in the waste form and packaging for a period of several hundreds to thousands of years in order to take the physically and chemically instable phase after emplacement into account. The draft of the Swiss guideline G03/e [19] also requires that the containers for high-level waste have to be designed to ensure containment of the contents for a period of more than thousand years. However, the Commission shares the view of RSK and SSK [5] that the desired containment in this period is not necessarily to be ensured by the containers, in particular in case of disposal in salt rock. It considers the respective requirement to be an inappropriate limitation of conceptual optimisation possibilities (e.g. the consideration of emplacement of fuel elements and canisters for vitrified in boreholes). Such an optimisation has to consider a number of safety-relevant aspects that have not been considered in the present BMU draft [1]. One safety-relevant aspect is the size and kind of the cavities to be driven (e.g. regarding cavity minimisation and the demands on technical and geotechnical barriers), another one the emplacement of large amounts of metallic materials which may lead to gas formation. In addition, the material introduced via the containers has in influence on the chemical environment. This, in turn, may have an influence on the safety functions and the transport behaviour of radionuclides.

  Against this background, the Commission is of the opinion that the demand in Section 8.3.7 for containment of the wastes at the repository site for a period of 1000 years is sufficient to adequately cope with the problems of the "early transient phase" (β/γ emitters, strong heat generation, chemical, hydraulic and mechanical imbalance) in accordance with the international recommendations [10, 11]. However, the ESK is also of the opinion that such a requirement has

to be worded precisely, in particular regarding the definition of the term “repository site” since otherwise the requirements on the safety case will be unclear.

- However, regarding the requirements on the containers, a general specification of 500 years is not appropriate. For a certain period, the container has to fulfil additional requirements a barrier. The period depends on the site and the repository concept. For this reason, the ESK repeats the recommendation for the specification of the respective requirements on the containers of the RSK and SSK statement [5]:"Within the framework of the long-term safety analysis, the fulfilment of the protection objectives is to be proven at any time. This proof shall be furnished by consideration of the overall concept consisting of technical, geological and geotechnical barriers. In this respect, containment has to be ensured the so-called transition phase, in which, on the one hand, there is still the major part of the fission products and a relatively high heat load but, on the other hand, the geotechnical barrier has - depending on the rock type - not yet reached its final condition. It is to be analysed and specified site- and concept-specifically which additional requirements arise for containers in the transition phase.”

- The italicised paragraphs in Section 8.3.7 should be dispensed with.

- The italicised text in Section 8.4 should be dispensed with.

- The Commission agrees to the specification of a reference period of one million years. However, from the point of view of the ESK, the statements on another reference period of up to ten million years are not expedient. The Commission holds the view that for selected sites in Germany, a scientifically sound prognosis on the evolution of the isolating rock zone and its properties over a period of one million years is possible. Further, it has to be demonstrated for the site that – according to experts’ opinions – no abrupt change of the evolution of the isolating rock zone with drastically changed impacts is expected beyond this time. The ESK holds the view that this requirement should already be considered for site selection and respective statements should be included in the site justification of the applicant. For safety cases submitted later, the ESK is of the opinion that it has to be justified that these statements are valid also against the background of the respectively current state of knowledge. The respective requirements should therefore define corresponding boundary conditions for the applicant’s safety case.

  The italicised text in Section 8.5 should be dispensed with.

- The requirements formulated in Section 8.6 on calculations to be performed in addition to the deterministic analyses are hard to understand. The relevance of deterministic analyses compared to the obviously meant probabilistic analyses remains unclear. Here, the general requirements on calculations should be presented in full. The detailed specifications on the performance of calculations, however, should be made in a guideline. The ESK holds the view that the orientation of the proofs towards the 95^{th} percentile (19 out of 20 cases) for probabilistic calculations provided in the BMU draft is appropriate.

- In Section 8.7, the special status of human intrusion scenarios with regard to the safety case is to be made clear (see also Chapter 5 of this statement), in particular that they are not assessed according to the same criteria as the scenarios for the probable and less probable evolutions. The statements in the italicised text are not suitable to generate clear perceptions about the requirements on the safety case regarding human intrusion scenarios. The Commission considers the specification of radiological limits for human intrusion scenarios to be problematic and recommends dispensing with them completely. In connection with this issue, it refers to a position paper [18] prepared by a working group staffed by BfS, BGR, DBE Technology, FZK-INE, GRS and TU Clausthal. Die Commission shares the view of the BMU that a guideline should be drawn up for human intrusion scenarios.

- The ESK holds the view that it should be made clear in Section 8.8 that the statements only refer to a programme for monitoring and preservation of evidence. The impression must be avoided that this programme is required to ensure the safety of the repository.

  Moreover, Section 8.8 contains no specification who is responsible for the measurement programme. Implicitly, the wording is such that this is the former repository operator. This, however, requires that this organisation has to continue to exist also after sealing of the repository for a sufficiently long period.

  The ESK considers such a measurement programme to be useful; it is, however, not required to now specify an organisation for it. The wording should therefore be such that the programme for monitoring and preservation of evidence is to be specified in good time before sealing of the repository. The same applies to the organisations then responsible for the realisation and maintenance of the necessary facilities. In addition, it then has to be specified which authority (authorities) has (have) to react in case of indications from the programme for monitoring and preservation of evidence.

- According to the opinion of the ESK, the contents of Section 8.9 should be presented more clearly, in particular, the idea of the requirement on the waste packages have to be separated from the aspect of control. Starting point for the requirements on the waste packages has to be that the wastes to be stored in a repository for heat-generating wastes exist and have to be disposed of in a repository. An exclusion of a part of these wastes via emplacement conditions is not compatible with the aim of disposal of all radioactive wastes in a repository. Adequate waste packages enabling positive results of the safety analyses are rather to be developed for all existing wastes that have to be disposed of in a repository for high active waste.

With regard to ensuring the properties of the waste packages, the principles are to be laid down in the safety requirements themselves, i.e.

- that the waste originators shall ensure that the waste packages comply with the required properties and that the respective proof is provided,

- that, in addition, independent product control shall be conducted, and

- that incoming inspections shall be performed in the repository.

These requirements cannot be left in italics but have to be included in the main text.

Moreover, a corresponding safety management is to be established for all of these processes.

Details on the regulations can be laid down in a guideline.

6.9 Design of the repository

Issue

Chapter 9 of the BMU draft [1] sets out the requirements to be placed on the repository design. No distinction is made between requirements on the operation of the repository and on the design of technical and geotechnical barriers for ensuring long-term safety. In particular, requirements are formulated regarding

- the safety in the operating phase by a four-level safety concept,
- the reliability and robustness of safety functions, comparable to the nuclear rules and regulations,
- the testing of technical and geotechnical components,
- the performance of exploration drilling and exploratory shafts,
- the specification of limits of the isolating rock zone in the geosystem,
- the separation of emplacement operation and drilling operation,
- the emplacement fields and emplacement areas, their loading, backfilling and sealing,
- the ensurance of safety by a passive and maintenance-free barrier system,
- the proper functioning of the barrier system,
- the provision of a decommissioning concept as of the ensurance that the concept can be implemented when required,
- the organisational structure of the operator,
- the management system of those involved in the procedure, and
- the documentation of the safety-relevant data about the repository system.

Assessment

Regarding the issue of completeness of the requirements in the BMU draft [1] to be dealt with within the request for advice, the Commission is of the opinion that Chapter 9 “Design of the repository” is not homogenous as regards the depth of regulations. Moreover, requirements are formulated in Sections 9.9 - 9.12 whose contents are not to be assigned to the repository design and should be regulated in other chapters

or guidelines.

In particular, the ESK is of the opinion that within the framework of restructuring of the chapter at least a distinction is to be made between operational requirements and design requirements for the ensurance of long-term safety. Regarding the completeness of the requirements on the repository design, the following aspects should be considered supplementary:

- Basic requirements on the repository design on the basis of the safety concept,
- requirements regarding the definition of the isolating rock zone,
- requirements on the wastes and the containers,
- requirements on the construction of the repository mine,
- requirements on the operation of the repository, and
- requirements on the decommissioning and sealing of the repository.

The requirements contained in Chapter 9 are in particular assessed as follows:

- In Section 9.1, "Measures limit environmental impacts" is to be replaced by "Measures limit environmental impacts" for the 4th level of the defence-in-depth concept (beyond-design basis accidents/incidents).

- Section 9.2 requires fundamental revision and clarification. A clear distinction has to be made which of the requirements address the operation of the repository and which one the design of the technical and geotechnical systems for the ensurance of long-term safety.

  Furthermore, the demand for testing of safety-relevant components must not be linked to the terms robustness and safety reserves in this way. The demand for testing ensues from the safety relevance of the components. The terms of robustness and safety reserves require clear definition. The main elements of robustness have to be explained. Likewise, it has to be explained what constitutes a safety reserve in a safety assessment and what belongs to it. It also has to be explained what is to be understood by testing in terms of the requirement and which requirements are placed on an alternative furnishing of proofs.

  The requirement on the testing of components has to be structured more clearly and set out more precise as regards content against the background of the expectations placed on them of long-term operability.

- The requirement "Exploratory drillings and exploratory shafts should be designed to have minimal possible impact on the rock and should be sealed in such a way that the barrier properties of the isolating rock zone, including the required massive hard rock, are preserved" formulated in Section 9.3 is not to be seen in direct relation to repository design. It is rather to be assigned to the process stage of repository exploration. The requirement of a design with minimal possible impact is also to be placed on the construction phase. The parenthesis "including the required massive hard rock" must be

dispensed with since the safety barriers are derived from considerations under mining-related aspects and are not related to considerations on the isolating rock zone.

- In Section 9.4, the requirements on the limits of the isolating rock zone are derived without clearly defining or explaining it in the safety requirements. The demand for an adequate depth is only included in the italicised text. The ESK is of the opinion that the isolating rock zone clearly and precisely has to be set out as a central element of the repository system (see Chapter 5).

- The ESK holds the view that the central requirement "The safety of the final repository after decommissioning must be ensured by means of a graduated barrier system which fulfils its functions in a passive, maintenance-free manner." formulated in Section 9.7 constitutes a safety principle and should also be placed there (in Chapter 5 of the Safety Requirements).

- The ESK holds the view that the statements on a robust barrier system and the requirement on the containment capability of this barrier system in Section 9.8 require revision and clarification what is to be understood by barrier system, individual barriers, proper functioning and effect and in which way the interdependence has to be interpreted so that a clear requirement can be derived. In this respect, the Commission refers, in particular, to the statements in Chapter 4 of the RSK and SSK statement [5].

- As regards the content, parts of Sections 9.9 - 9.12 are to be assigned to the safety management. However, they are generally not sufficient. The ESK considers a dedicated chapter with systematic requirements on the safety management in the safety requirements to be absolutely necessary (see Chapter 5). There, the requirements regarding the safety management from Sections 9.9 - 9.12 are to be integrated.

- As regards the decommissioning concept required Section 9.9, design requirements have to be formulated.

- As regards the documentation required in Section 9.12, the design requirements on the documentation system have to be formulated in addition. Moreover, the requirement on filing formulated in the last sentence is too limited. From the point of view of the ESK, it is necessary that the central design requirement constitutes information being available as good as possible in the future. For the documentation system, appropriate proof must be provided which cannot only refer to the places of storage but, e.g., also has to deal with accessibility.

7 Answers to the questions of the BMU

The first question in the request of advice of the BMU [6] is as follows:

Is the draft published by the BMU complete insofar that in case of its consideration in the plan approval procedure under nuclear law it is to be assumed that all requirements relevant for the safety of the

repository are covered in accordance with the state of the art in science and technology? In this respect, special attention is to be paid to the recommendations of the ICRP (ICRP 81 [7] and ICRP 103 [8]) and the IAEO (SF-1 [9], WS-R-4 [10] and DS 334 (Draft) [11]).

The ESK concludes that the BMU draft includes many essential requirements on the safety of a repository for radioactive waste. Chapters 5 and 6 of this statement deal with several deficiencies. If these deficiencies are removed in the way proposed by the ESK, the completeness of safety requirements in terms of the question of the BMU is reached from the point of view of the ESK.

On behalf of the ESK, the GRS checked in a synopsis [20] to which extent the recommendations mentioned in the question had been considered in the BMU draft. For the evaluation of the results from [20] it has to be considered that these international recommendations in parts deal with other topics (e.g. legal and organisational framework, site selection, public relations, safeguards) than the BMU draft for the safety requirements [1].

Regarding the topics that should appropriately dealt with in the safety requirements, the ESK holds the view that there are significant deficiencies compared to international recommendations. The following is not or only in parts included in the BMU draft:

- An explicit requirement for description of the safety concept,
- requirements on the operator, as in WS-R-4 [10, Sections 3.11 to 3.13] (only in parts),
- requirements on the documentation, as included in WS-R-4 [10, Section 3.14],
- general and generic requirements on safety and understanding for achieving safety, as included in WS-R-4,
- a clear demand for proving operational safety, as included in international recommendations,
- explicit dealing with uncertainties or requirements regarding uncertainty management,
- requirements on the safety case and its documentation (not to the extent required); in particular – compared to WS-R-4 [10] – the descriptions in which way confidence in the safety cases shall be documented are not concrete enough,
- requirements on the safety management to a depth comparable to IAEA document WS-R-4 [10, Sections 3.82 ff].

These items generally overlap with items dealt with in Chapters 5 and 6 of this statement.

The second question in the request of advice of the BMU [6] is as follows:

Are, according to the state of the art in science and technology, supplementary or other requirements to be posed, e.g. on the properties of barriers or on the gradual optimisation?

From the point of view of the ESK, a number of supplementary or other requirements are to be placed as done in the BMU draft. They are particularly dealt with in Chapters 5 and 6 of this statement. It concerns, above all, the following topics:

- Safety management,
- robustness,
- human intrusion,
- resource conservation,
- gradual process,
- stepwise optimisation,
- allocation to probability categories,
- verification and demonstration of long-term safety (safety case),
- properties of barriers,
- isolating rock zone,
- verification of operational safety, and
- documentation.

The third question in the request of advice of the BMU [6] is as follows:

Are, as provided, guidelines for the calculation of the effective dose and of risk values (Section 8.3.2) and for the definition of reference scenarios for human intrusion (Section 8.7) adequate or is further specification by guidelines recommended?

The ESK supports the approach to regulate the procedure for applying radiological models to calculate the theoretical long-term evolutions of a repository in a guideline. The italicised explanations in Section 8.3.2 should be transferred into such a guideline detailed and completed.

Further, the ESK agrees with the demand of the BMU for a guideline in which the procedure for the definition of reference scenarios on human intrusion (Section 8.7) is regulated.

In addition, the ESK recommends developing a number of other guidelines. This is derived and justified in the relevant sections of Chapter 6 of this statement and concerns guidelines on the following topics:

- Guarantee of the properties of the waste packages and product control (cf. Chapter 6.8 of this statement),

- safe operation of the repository including accident prevention and control (cf. Chapter 6.8 of this statement),

- demonstration of long-term safety of the repository including the indicator system to be used for it (cf. Chapter 6.8 of this statement),

- classification of potential and conceivable evolutions according to three probability categories (cf. Chapter 6.7 of this statement),

- detailed specifications on the performance of safety assessment calculations (cf. Chapter 6.8 of this statement).

In this respect, it has to be checked to which extent it will be appropriate to jointly deal with some of the topics mentioned in one guideline.

After development of a chapter on safety management, as required by the ESK, it may be required to decide whether on this topic a specifying guideline is also required.

8 List of reference documents

[1] Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU)
Sicherheitsanforderungen an die Endlagerung wärmeentwickelnder radioaktiver Abfälle – Entwurf
Bonn, 29. Juli 2008

[2] Bundesministerium des Innern (BMI)
Sicherheitskriterien für die Endlagerung radioaktiver Abfälle in einem Bergwerk
Rdschr. d. BMI v. 20.04.1983 – RS - AGK 3 - 515 790/2

[3] Gemeinsame Stellungnahme der RSK und der SSK betreffend BMU-Fragen zur Fortschreibung der Endlager-Sicherheitskriterien
Anlage 2 zum Ergebnisprotokoll der 357. Sitzung der Reaktor-Sicherheitskommission am 05.12.2002 (einschließlich der Beratungsergebnisse der 182. Sitzung der Strahlenschutzkommission am 04. – 06.12.2002)

[4] Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS)
Sicherheitsanforderungen an die Endlagerung hochradioaktiver Abfälle in tiefen geologischen Formationen
GRS-A-3358, Januar 2007

[5] Gemeinsame Stellungnahme der RSK und der SSK zum GRS-Bericht „Sicherheitsanforderungen an die Endlagerung hochradioaktiver Abfälle in tiefen geologischen Formationen“ vom 03.07.2008

[6] Schreiben RS III 2 – 17005/0 des Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) vom 29.09.2008
Sicherheitsanforderungen an die Endlagerung wärmeentwickelnder radioaktiver Abfälle
Beratungsauftrag

[7] ICRP-81: Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste, Sep. 1999

[8] ICRP-103: The 2007 Recommendations of the International Commission on Radiological Protection Annex A, ICRP publication 103 - Annals of the ICRP, 37, 2-4 (2007)

[9] IAEA: Fundamental Safety Principles, Safety Fundamentals No. SF-1 – IAEA, Vienna, 2006

[10] IAEA: Geological Disposal of Radioactive Waste, Safety Requirements No. WS-R-4 – IAEA, 2006

[11] IAEA: Geological Disposal of Radioactive Waste, Draft Safety Guide DS 334, 2008-04-30

[12] OECD/NEA: Post-Closure Safety Case for Geological Repositories – Nature and Purpose. – NEA-3679, 2004

[13] ICRP-101: The Optimisation of Radiological Protection – Broadening the Process. Jan. 2007

[14] Gemeinsames Übereinkommen über die Sicherheit der Behandlung abgebrannter Brennelemente und über die Sicherheit der Behandlung radioaktiver Abfälle – Übereinkommen über nukleare Entsorgung (Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, INFCIRC/546) vom 05.09.1997, in Kraft seit 18.06.2001;
Gesetz hierzu vom 13.08.1998 (BGBl. II 1998, Nr. 31, S. 1752), in Kraft für Deutschland seit 18.06.2001 (BGBl. II 2001, Nr. 36. S. 1283)

[15] Arbeitskreis Auswahlverfahren Endlagerstandorte (2002):
Auswahlverfahren für Endlagerstandorte, Empfehlungen des AkEnd – Arbeitskreis Auswahlverfahren Endlagerstandorte.

[16] WHO – World Health Organization (2006)
Guidelines for drinking-water quality, Vol. 1, Recommendations: addendum.- 3rd edition

[17] ICRP (1991): 1990 Recommendations of the International Commission on Radiological Protection. ICRP Publication 60 – Annals of the ICRP, 21, 1-3

[18] Position des Arbeitskreises „Szenarienentwicklung”:
Behandlung des menschlichen Eindringens in ein Endlager für radioaktive Abfälle in tiefen geologischen Formationen
Atw 53. Jg (2008), Heft 8/9 – August/September

[19] Specific design principles for deep geological repositories and requirements for the safety case, draft: 18th March 2008
Guideline for Swiss Nuclear Installations, G03/e

[20] Synoptische Gegenüberstellung der Aussagen in:
IAEA SAFETY STANDARDS SERIES No. WS-R-4
GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE SAFETY REQUIREMENTS
und
Sicherheitsanforderungen an die Endlagerung wärmeentwickelnder radioaktiver Abfälle, Entwurf: 29. Juli 2008
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
Arbeitsbericht
A. Kindt, B. Baltes, Dezember 2008