

**COMPLIANCE IN SELECTED ECOSYSTEMS
JUDGING COMPLIANCE EXPECTATION WITH THE SWEDISH HLW INDIVIDUAL
DOSE STANDARD BASED ON A SELECTION DIFFERENT ECOSYSTEMS**

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ABSTRACT

The Swedish nuclear waste program is implemented by the Swedish Nuclear Fuel and Waste Management Company, SKB. Its proposed concept implies in technical terms a deep geological disposal of fuel, enforced by steel frames and placed in copper canisters, and social science terms, a siting process accepted by the concerned municipalities. These two aspects implies that SKB must consult simultaneously with the scientific and political community, as the design and siting process evolve, and the two processes interact strongly.

SKB's performance analyses indicate an outflow from the repository can only be expected in the 100 000 year range. Clearly, if such results are accepted in the concerned municipalities, biosphere investigations will not be a priority. On the other hand, a number of confirmations remains to be done by SKB, and the authorities cannot today certify what must be subject to inspection and investigations in connection with SKB's license application, some ten years into the future. The value of biosphere studies is therefore an open question and must be debated between stakeholders before the next step, geological site characterization. The Swedish Radiation Protection Institute, SSI, suggests that SKB characterize the behavior of radionuclides in the biosphere within those municipalities which constitute a bases for further narrowing choices in the siting process.

SSI considers that in judging releases in the future, compliance may be decided by assuming number of selected ecosystems introduced as test cases in the areas experiencing a hypothetical outflow from the repository. Such an interpretation of the present health and environmental waste standard has several advantages. Biosphere concentrations can be related to both dose distributions and to protection of the natural environment. Also, such a general approach is well matched to the uncertainty of future developments.

INTRODUCTION

The licensing process of a repository for spent nuclear fuel poses a number of challenges to a broad range of stakeholders, e.g. implementers, regulators, potential host municipalities, environmental groups, political decision-makers on different levels and the public.

The Licensing Process

According to the Swedish Radiation Protection Act and to the Act on Nuclear Activities legislation, the Swedish nuclear power producers must construct and operate the facilities which

are necessary for the final disposal of spent nuclear fuel and nuclear waste. The producers have created a joint company, SKB, to implement this program.

SKB must every third year present its research and development program (hereafter called RD&D program; research, development and demonstration) to the Government, which may set conditions for SKB's future work. SSI and the Swedish Nuclear Power Inspectorate, SKI, both advise the Government, along with a number of other authorities and private bodies. SSI is defined as the competent regulatory authority in the ordinance related to the Radiation Protection Act, and SKI is appointed by a similar ordinance for the Nuclear Activities Act. SKI prepares and arranges the basis for the Government's decision in connection with nuclear installations, and SSI defines radiation protection conditions which may apply to the installation's operation.

The authorities must also clarify in their regulations the post-closure safety and radiation protection requirements for final disposal. SSI's radiation protection requirements have been delineated in a process through the past decade up to the present regulation, "The Swedish Radiation Protection Institute's Regulations concerning the Final Management of Spent Nuclear Fuel and Nuclear Waste", SSI FS 1998:1.

SKB's Suggested Process

The method

The Swedish program for managing nuclear waste and spent nuclear fuel has been in progress for about 25 years. Since the mid-80's the nuclear industry's strategy for managing the spent fuel is direct disposal in the bedrock, in accordance with the KBS-3 method. The method implies encapsulation of the spent fuel in copper canisters for corrosion resistance with cast iron inserts for mechanical strength. In the repository, at ca. 500 m depth, the canisters will be embedded in bentonite clay in individual deposition holes.

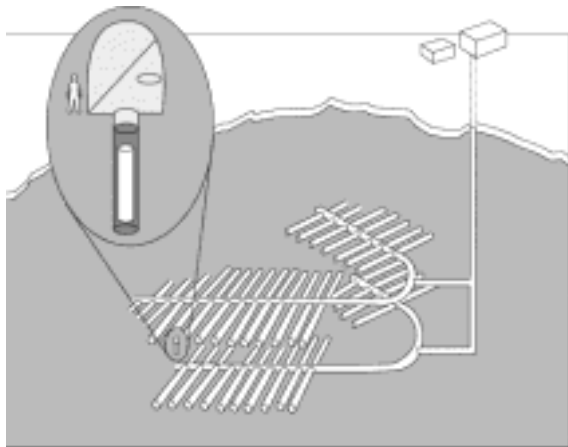


Fig. 1 Outline of a repository for spent nuclear fuel according to the KBS-3 concept. The fuel is placed in copper/iron canisters embedded in bentonite clay at ca. 500-m depth in the bedrock.

The phases in the siting program

SKB is currently conducting feasibility studies in five municipalities in order to find a suitable site for a repository. During this phase SKB has declared that no drilling will take place. In the next phase, SKB intends to, on the basis of 5-10 feasibility studies, select at least two sites which will be investigated by drilling from the ground surface (site investigations). This step will only be taken by SKB if it is supported by the concerned municipality. This will provide a basis for

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selecting one site where a tunnel or shaft will be excavated for detailed site characterization. At this stage a formal licensing is required, as outlined above, since the detailed characterization is considered as the first phase in the construction of a repository.

The RD&D Program 1997

SSI and SKI both consider it an important and prioritized task to support and engage in dialogue with the municipalities. This need is also very clear from the recently concluded review of SKB's latest program for research, development and demonstration, RD&D-98 (submitted by SKB in September 1998). All municipalities, as well as many other organizations, stressed the need for clear and unambiguous statements from authorities as well as from the Government. In an issue of national concern, it is not reasonable for a municipality to commit itself to a repository, or even site characterizations, without active support from the authorities.

In submitting its review of SKB's RD&D program, SSI made a number of observations, relevant for the municipalities. It was made clear in the review by both SSI and SKI, that SKB's

- *strategy of geological disposal* is fully supported
- *general technique, i.e. KBS-3 method*, as explained above, is deemed reasonable, as can be assessed by SKB's reporting so far, and that
- *sub-methods and variants of KBS-3* cannot be judged at present

It was further explained in the first part of 1999 when the authorities submitted their reviews, that observations regarding the safety analysis could not be made regarding the latest developments. SKB's safety report SR97 was available in December 1999, and it will be subject to a review by the authorities during year 2000. The authorities will be able to benefit from findings by an international review organized by OECD/NEA on behalf of the authorities.

The Time Table

The next major step in the siting process will consist of SKB's choice of two municipalities for site investigations. Before that choice, SKB must consult with the authorities regarding the investigation program, according to a decision from the Government following the review of SKB's RD&D program 1995.

In connection with this choice, the authorities will comment on the feasibility studies, the safety report SR97, and other reports from SKB, such as a report of the system analysis, covering both the preferred options and alternative methods.

BIOSPHERE ANALYSIS, EXPECTATIONS AND TECHNIQUES

Expectations

In a stepwise procedure, how much evidence must be available at the time of a certain step?

Clearly, all evidence must be available at the time of the final application. On the path leading up to this point in time, the background material must necessarily be supplied in parts. For instance,

site specific geological information cannot be available at this time, since SKB has committed itself not to drill before the next phase.

It is not obvious to decide how much information must be available at the time of the choice of two municipalities. The process is formalized by the Governments decisions regarding SKB's R&D program which covers siting issues. However, such requirements can only be seen as minimum requirements. SKB's decisions will be subject to the municipalities acceptance and SSI intends to supply background information and advice to the extent required. Regarding the biosphere studies, SSI has suggested in its review of RD&D 98 that SKB may describe the existing ecosystems for the 5 to 10 SKB's candidate municipalities and give picture of how radionuclides would perform in those systems.

Interdependence Of Safety And Biosphere Modeling

It is a natural requirement that some description of the ecosystems is given by SKB before the choice of two sites subject to the next step, site investigations, but the actual effort spent is also depending on the expectations of the municipality. Clearly, some municipality inhabitants will have a high confidence in SKB's work, and for them, biosphere modeling would be more of a formal requirement. Others may believe that outflow from the repository may threaten their children and grandchildren. For those, a detailed description is probably essential.

Such varying expectations are probably not new for the municipality decision-makers and other stakeholders. However, it is not easy for SSI to give a simple answer, to this general problem. For instance, SKB describes the ecosystem as relevant only in a distant future. According to most implementers internationally, their performance assessments imply that releases into the environment only occur many thousands of years into the future. This might seem to give a low priority for details in today's ecosystems. At the other side, the complete background for the justification for the late releases cannot by definition be available. Research on both canister quality and geology is included in ongoing and future activities.

JUDGING COMPLIANCE

SSI's Regulations

SSIs health and environmental standard [1] is focused on the final disposal of spent nuclear fuel, but also apply to some pre-disposal activities. The regulations contain fundamental radiation protection objectives, e.g.:

1. Optimization should be applied to the entire disposal system, and not only to individual activities and/or facilities. Proper attention should be paid to best available technique, BAT.
2. The collective dose should be used for comparing different management options.
3. The risk for an individual in the most exposed group should not exceed 10^{-6} .
4. Biodiversity and sustainable use of biological resources should be protected.
5. The consequences of human intrusion should be assessed.
6. The protective capability of a final repository should be assessed for two time-periods: in the order of a thousand years and the time beyond a thousand years.

In this work, only requirements 3 and 4 will be commented further.

The main focus of the standard, particularly in current discussions with international regulators, is the individual dose limit, or risk target.

The Suggested Compliance Tool

In assessing compliance with regulations which refer to endpoints in a distant future, will always require some interpretations. Some of these are closely related to the regulator. They define the regulator's tools in assessing compliance. Some steps are more related to the implementer, such as the steps following from the performance assessment.

What SSI investigates at present is to define a "ecosystem burden" or biosphere concentration of nuclides. This concept can be used to calculate both individual dose (and therefore risk) and the effect of the natural environment, two main components in SSI's regulations. The main idea is to account for an changing or unknown biosphere by a generalized approach.

In SKB's safety report SR97 [2], releases from the geosphere is calculated by an "ecosystem-specific dose conversion factor" converting activity outflow to dose rate. It is clear that such an approach is similar in concept to the approach now investigated by SSI. It may therefore be assumed that there is at least some similarity between SSI and SKB in the approach to dose calculation.

Other SSI Regulations

The concept of the most affected area is already used in SSIs proposed release limiting releases for nuclear installations [3]. For dose calculation purposes, the radionuclide concentration in the most affected area must be calculated and from this the dose to man will be assessed.

Biosphere Concentration From Repository Outflow

The release path from a nuclear reactor, i.e. via air to ground deposition, and further on to foodstuff etc, is not easily translated to a protocol for calculation of doses from nuclides in a hypothetical outflow from a repository. Every plume realization is connected with a probability, a concentration of a critical area. The critical area may be transformed to a dose, and the corresponding risk calculated as

Risk = $\gamma \int P(D)dD$, integrated from 0 to 1 mSv, where

- $P(D)$ = probability/year for a dose in the interval $\{D, D+dD\}$,
- γ = ICRP's factor 0,073/Sv [4], and
- Scenarios with $D > 1$ mSv to be reported separately.

Some problems related to the uncertainty of future societal behavior can be avoided using this approach. In addition, this approach may be used for taking into account the effect of a hypothetical outflow from the repository on biota, which is also required by the Swedish regulations.

Biosphere Concentration As A Concept In Its Own Right

SSI cannot today present calculated biosphere concentrations vs. individual dose levels for use in assessing compliance. The concept may be used in several different ways. In principle, a postulated outflow may be used to calculate doses within a certain biosphere, and from this dose to man. Doses are related to biosphere concentrations but the items in the biosphere are not developed and defined as general concepts.

Another, more fundamental approach is also possible, whereby different ecosystem components are explicitly defined and treated as a step, which is given a separate analysis. Some necessary ingredients in such a true middle step is to define strictly all biosphere components, limiting them from components in the geosphere-biosphere interface. Such a stringent verbiage is normally used in discussing the biosphere.

SUMMARY

In a voluntary siting process, such as the one underway in Sweden today, the radionuclide transport in the biosphere and its effect on man and the environment plays an important part in understanding the process and possibly has a key role in certain stages of the process, in addition to barrier safety considerations. The biosphere contains important assessment endpoints, and both qualitative and quantitative requirements are given in SSI's regulations. It is essential for the authorities and for public confidence that the authorities have the relevant theoretical tools for judging compliance. In order to bridge the gap between a formal assessment endpoint such as dose to man, and to facilitate assessment work for all parties, SSI suggests the idea of using biosphere concentration in different ecosystems of radionuclides from repository releases as a measure to demonstrate compliance. Compliance is achieved if a hypothetical release yields doses below regulatory limits in all ecosystems. The concept has the value of a system-oriented approach, which minimizes room for detailed speculation about a certain ecosystem the future.

REFERENCES

1. Regulations concerning the final management of spent nuclear fuel and nuclear waste, SSI FS 1998:1, available in English in SSI Report 99:22.
2. Swedish Nuclear Fuel and Waste Management Co., TR-99-06, SR97 Post-close safety, December 1999.
3. SSI's proposed regulations for releases for nuclear installations, distributed 1999 for comments, in Swedish
4. ICRP Publication No. 60, "Recommendations of ICRP", 1990