THE NEXT STEP IN THE SWEDISH PROGRAM - "ACCEPTANCE 2001"

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ABSTRACT

The Swedish program for management of spent nuclear fuel is presently focused on establishment of a general acceptance of the preferred method for final storage and SKB´s selection of candidate sites for a deep geological repository. Facilities for intermediate storage of spent fuel and HLW and for final disposal of ILW and LLW together with a system for sea transportation are in operation in Sweden since more then ten years. To complete the "back end system" the remaining parts are to build facilities for encapsulation and final storage of spent fuel and HLW.

The preferred method for final disposal of spent fuel is to encapsulate it in copper canisters and dispose them in a deep geological repository. SKB is planning to build an encapsulation plant adjacent to the central storage for spent fuel, CLAB. The location for the deep repository has not yet been selected. A siting program with feasibility studies in six communities is ongoing. The general goal for SKB´s activities for the period up to year 2001 is to nominate two candidate sites for the deep repository. Geological surveys are then planned to start on these sites. The program for this was presented in our RD&D Report 98 and has in general been accepted by the reviewing authorities.

A safety assessment report for the deep repository, SR 97, was published in the end of 1999. In the report safety assessments are presented for three different types of host rocks which can be regarded as typical examples for the Swedish bedrock. The Swedish authorities SKI and SSI as well as an international group of experts from OECD/NEA are at present reviewing the report. In the end of year 2000 SKB will present a report as a base for a Government decision about the siting process. This report shall give the background for the selection of two candidate sites. It shall also present the program for geological surveys of the candidate sites as well as the background for the choice of the method for final disposal of spent nuclear fuel and HLW.

The methods for pre-investigation of candidate sites have been tested at the Hard Rock Laboratory at the island of Äspö situated close to the Oskarshamn NPP. The Äspö HRL is today also used for development of detailed investigation methodology and tests of models for description of the barrier function of the host rock. Tests of construction methods as well as demonstrations of technology and function of important parts of the repository system are also conducted at Äspö HRL. A special "Prototype Repository" will be built in the laboratory during the coming years. Copper canisters, without active material but equipped with heaters, will be placed in deposition holes and embedded in bentonite clay. Also methods retrieval of canisters embedded in saturated bentonite clay will be tested.

SKB is also conducting a program for planning and testing methods for the encapsulation of spent nuclear fuel. At the time when the pre-investigations of sites for the repository have started

SKB plans to submit an application for construction of an encapsulation plant. The canister is planned to consist of an insert of e.g. iron, which provides mechanical strength, and an outer layer of copper, which provides corrosion protection. Trial fabrications of canisters have been performed during resent years for development of manufacturing methods. Design of a "canister factory" is also a part of our program.

The encapsulation is planned to take place in a new plant to be built in connection to the central storage for spent fuel, CLAB, which has been in operation since 1985. The fuel is stored in water pools situated in a rock cavern. The storage capacity today is 5000 tonnes of uranium. An extension of the storage capacity up to 8000 tonnes will be done by construction of a new rock cavern. In the encapsulation plant fuel from CLAB's storage pools will be placed in canisters after having been checked and dried. The encapsulation process then is carried out in a number of working stations. Finally the canister is sealed and checked from contamination and placed in a buffer storage before transport to the repository.

In order to test the methods for sealing and testing of canisters, SKB has built a laboratory for encapsulation techniques in Oskarshamn, the Canister laboratory. Electron beam welding is used for sealing of the copper-lids on the canisters. Ultrasonic- and x-ray-equipment is used for non-destructive testing. The first test series of seals are planned to be reported in the beginning of year 2000. The Canister Laboratory will also be used for testing of other parts of the encapsulation process.

INTRODUCTION

The Swedish government has decided to start shutting down reactors from political reasons. One reactor at Barsebäck NPP has been phased out in the end of 1999 after 25 years of operation. It is planned to also shut down the second reactor at Barsebäck in a few years if the power supply is secured.

Today about 50 % of the electricity in Sweden is generated by means of nuclear power from the remaining 11 reactors located at four sites and with a total capacity of 9 600 MW. Eight of the reactors are BWR and three PWR. The first commercial reactor was put in operation in 1972 and the latest in 1985. As of now about 3 700 tonnes U of fuel have been used in the power production. If all reactors are operated for 25 years, 6300 tonnes of spent fuel will be produced in total. If, on the other hand, they are operated for 40 years, it will result in a total amount of 9 000 tonnes.

The responsibility for the management of the spent nuclear fuel, as well as for other radioactive residues from nuclear power production, lies with the operators of the nuclear power plants, i.e. the four nuclear utilities. The utilities have jointly formed SKB, the Swedish Nuclear Fuel and Waste Management Company, to safely manage the spent fuel and radioactive waste from the reactors to final disposal. The task of SKB is thus to plan, construct, own and operate the systems and facilities necessary for transportation, interim storage and final disposal.

In Sweden the fundamental guidelines and the division of roles have been established during a long period starting more then twenty years ago. A general policy is that nuclear waste produced in Sweden must also be disposed of within the country. It is SKB's responsibility to take charge of waste management and find a method and a site for final disposal. The Swedish nuclear power inspectorate (SKI) and the radiation protection board (SSI) review SKB's proposals to make sure they meet the requirements on safety and radiation protection. The government issues permits and licences for siting, construction and operation. The municipalities where new facilities are to be built must approve the siting. Money for the activities is set aside in a special reserve fund via a charge based on the electricity production from the nuclear power plants.

SKB has developed a system that ensures the safe handling of all kinds of radioactive waste from the Swedish nuclear power plants for a long time period ahead. The keystones of this system are:
– A transport system with the ship M/S Sigyn which has been in operation since 1983.
– A central interim storage facility for spent nuclear fuel, CLAB, in operation since 1985.
– A final repository for short-lived, low and intermediate level waste, SFR, in operation since 1988.

In CLAB the fuel assemblies and core-components are stored in water pools in a storage cavern. The Government gave permission for the expansion of CLAB in August 1998. Construction of a second storage cavern has started and the work shall be finished in 2004.

The planning for final disposal of spent nuclear fuel is to encapsulate it in durable copper canisters to be placed in a deep repository. SKB is presently in an advanced stage of planning and of testing methods for the encapsulation of spent nuclear fuel. The testing of sealing methods for the canister is taking place in a recently commissioned plant, the Canister Laboratory. The future encapsulation of spent fuel is planned to take place in a new plant to be built adjacent to the CLAB. The remaining components of the system that are now being planned are (Fig. 1):
– A factory for canister production,
– An encapsulation facility for spent nuclear fuel and
– A deep disposal facility for encapsulated spent fuel and other long-lived radioactive wastes.

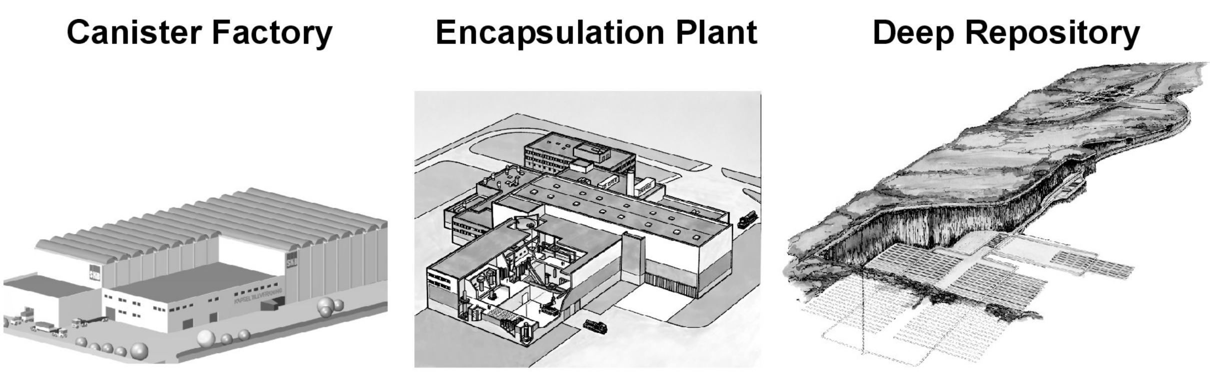

Figure 1. Remaining facilities for management and disposal of nuclear waste

SKB has been working for some years now on gathering the supporting documentation that is needed to apply for a siting permit for an encapsulation plant and the initial stage of a deep repository. In the RD&D Programme 98 (Research, Development & Demonstration) SKB has presented a step-by-step programme for implementing deep geologic disposal of encapsulated spent nuclear fuel. It also includes an active programme for research and development around central issues relating to technology and safety for the deep disposal method and for alternative methods.

It will take at least 40–50 years to carry out all measures needed to dispose of all long-lived and high-level nuclear waste in a safe manner. It is, therefore, appropriate to proceed in steps and keep the door open for technological development, changes and possibilities for retrieving already deposited waste. This will ensure freedom of choice for the future while at the same time demonstrating the deep disposal method on a full scale and under actual conditions. Decisions regarding siting, construction and operation of an encapsulation plant and a deep repository will also be taken in steps and based on progressively more detailed information.

An interim goal in SKB:s plan for implementing deep disposal is to be able to choose at least two sites for investigations by the end of year 2000. The regulatory authorities and the Government are then expected to make clear their views regarding the choice of sites and SKB's main method. Based on analysis of various methods it should be possible to take a clear stand on whether the method chosen by SKB represents the right strategy. In support of coming siting applications for an encapsulation plant and a deep repository, SKB will prepare environmental impact statements (EISs) based on environmental impact assessments (EIAs). Consultations have been initiated locally, regionally and nationally.

REPOSITORY DESIGN

The primary function of the deep repository is to *isolate* the waste. The canister provides direct isolation, but the buffer and the rock are also needed for the canister to fulfil its isolating function (fig 2). These barriers must satisfy a number of requirements to provide good isolation. If this isolation should be breached, the deep repository is also supposed to *retard* the transport of radionuclides from the fuel. The canister, the buffer and the rock work in conjunction to provide this function as well. The retarding function puts additional demands on the barriers.

The design process includes design of both facilities and equipment above and below ground, as well as planning of the activities during the construction and operating phases. The deep repository is designed in steps that represent a gradually increasing level of detail. In the course of the work, system studies are conducted to investigate layouts and sub-systems. Earlier phases of the design work have resulted in a facility description with examples of how the deep repository can be configured.

The next major step in the design work comes when site investigations have commenced. That is when the work of adapting the layout and design of the deep repository to conditions at the site being investigated begins. For each studied site, solutions for sub-systems are combined to form a complete facility. Construction analyses will be performed to evaluate the solutions as regards important construction-related factors, possible building methods, resource requirements, etc.

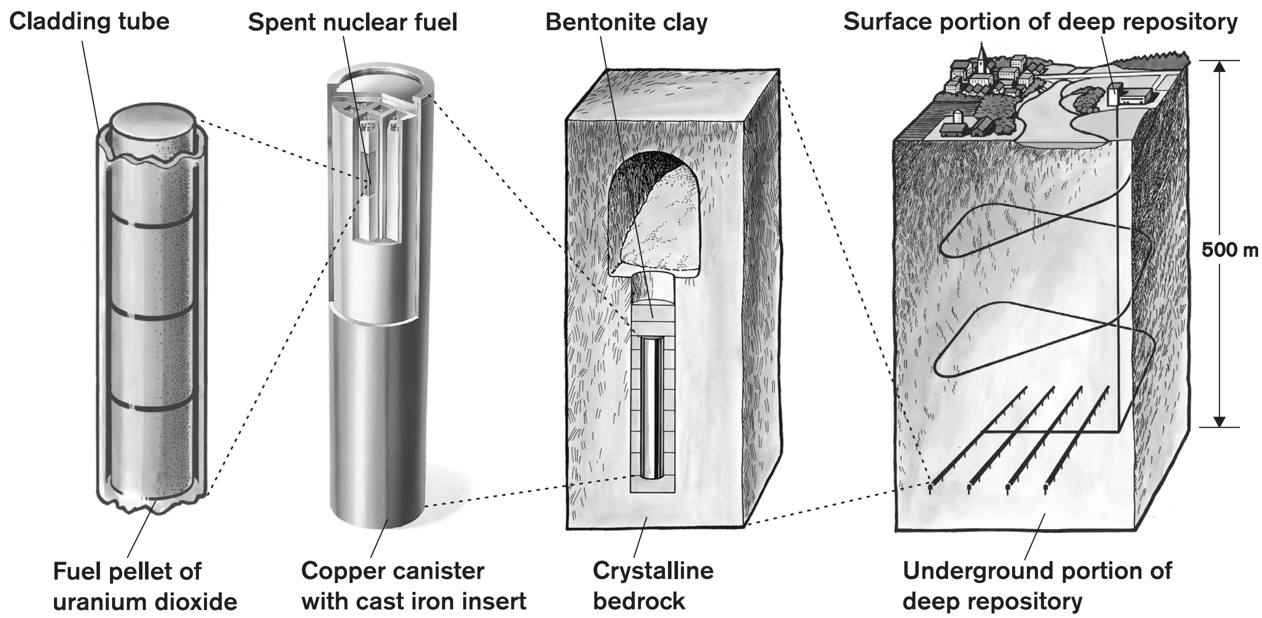

Figure 2. The barriers in the Deep Repository

The Canister

The canisters will be exposed to mechanical loads in the deep repository, caused by the pressure exerted by the groundwater and the swelling bentonite. Future ice ages or major rock movements can also give rise to mechanical stresses on the canisters. As long as the canisters are intact in the repository, all dispersal of radioactivity to the surrounding environment is prevented. If a penetration should occur in a canister, the other barriers will retard and reduce the dispersal of radionuclides to acceptable levels. To achieve isolation, the canisters must be leaktight on emplacement and be resistant to the chemical environment anticipated in the deep repository. They must withstand all known corrosion processes so that they can be expected to remain intact in the deep repository for at least 100,000 years. The canisters must also be designed so that there is no risk of criticality in connection with handling of the canister with fuel during the encapsulation process or in the long run in the final repository if water should enter the canister.

The Buffer

For the isolating function, the buffer must completely enclose and protect the canister for a long period of time. It shall also prevent groundwater from flowing through the buffer and thereby prevent corrosive substances from being transported to the canister in any other way than by diffusion. These requirements, in turn, require that the buffer should remain in the deposition hole and that it should be chemically stable over a long period of time. Another requirement is that the buffer should efficiently conduct heat away from the canister. Several of the requirements relating to the isolating function also relate to the buffer's retarding function. For this function, the buffer must create conditions where radionuclide transport takes place by diffusion and where radionuclides sorb on the surface of the clay particles. The buffer must also filter colloids that may form on dissolution of the fuel. Gas that may form inside a damaged canister must be allowed to escape.

The Bedrock

The host rock also has an isolating and a retarding function. For the isolating function, the bedrock must constitute a mechanically stable environment for the deep repository. It shall also provide a chemical environment that is stable in the long term and favourable with respect to the function of the other barriers. It will be chosen so as to reduce the risk of future intrusions and alternative uses (e.g. mines). For the retarding function, the composition of the groundwater must be such that the solubility of the radionuclides is limited. The bedrock must also limit the transport of the radionuclides with the groundwater to the biosphere. To the requirements relating to long-term safety are added requirements relating to construction and operation. The bedrock must possess such properties that the deep repository can be built and operated with adequate safety and known technology. This means, among other things, that it must be possible to construct stable rock caverns and that it must be possible to operate the repository with good control of rock-stability and groundwater seepage. The principle is to select a site, with the aid of increasingly detailed investigations, where the bedrock satisfies the fundamental requirements while also providing other favourable conditions, and to adapt the layout of the repository to conditions on the site.

The Backfill Material and Seals

When the canisters have been emplaced the deposition tunnels will be back-filled. The backfill material to be used should contribute to tunnel stability and hold the bentonite around the canisters in place. The backfill is also supposed to prevent or limit the flow of water around the canister positions. Furthermore, the backfill material should not cause deterioration of the quality of the groundwater and should remain chemically stable over a long time. The tunnels and shafts in the deep repository may need to be sealed, temporarily or permanently, with plugs. Temporary plugs will be needed during the operating phase to separate backfilled deposition tunnels or other areas that need to be temporarily separated from areas that are open and accessible. Permanent seals may be needed to reduce water flow in or along tunnels or to isolate tunnel sections that are intersected by water-bearing fracture zones.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

In accordance with to the Swedish Nuclear Act SKB every third year presents a programme for research, development and demonstration of encapsulation and geological disposal. The latest report was published in 1998, the RD&D Programme 98.

A central part of SKB's work in the years to come is to develop, test and demonstrate the different parts of the deep repository on a full scale and under realistic conditions. The tests will include the most important steps in fabrication and sealing of canisters as well as construction, operation and closure/sealing of the deep repository. Some tests, for example trial fabrication of canisters on a full scale, have already been going on for several years. SKB plans to expand the activities for development and testing of full-scale technology during the coming years. The majority of the tests will be performed at the Äspö HRL and the Canister Laboratory. In addition to the technical aspects of the full-scale tests, it is important to be able to practically demonstrate the various steps in encapsulation, transport, emplacement and retrieval to both specialists and the public. Demonstration of emplacement and retrieval will therefore be carried out at the Äspö HRL.

Repository Technology

SKB has for many years been working on the development of the method for boring of vertical deposition holes. Important milestones have been the choice of the downward dry full-face boring method and the initial field tests performed in Finland. At present, a program for boring of several deposition-holes for full-scale tests and technology demonstration is underway at the Äspö HRL. To test and demonstrate the technology for emplacement of canisters SKB is developing a deposition machine prototype (figure 3). The purpose is to acquire experience from design, manufacture and operation of such a machine. The main goals of the project are to develop and test methodology and equipment for emplacement of canisters. The various steps in emplacement and retrieval of canisters shall also be demonstrated to both specialists and the public.

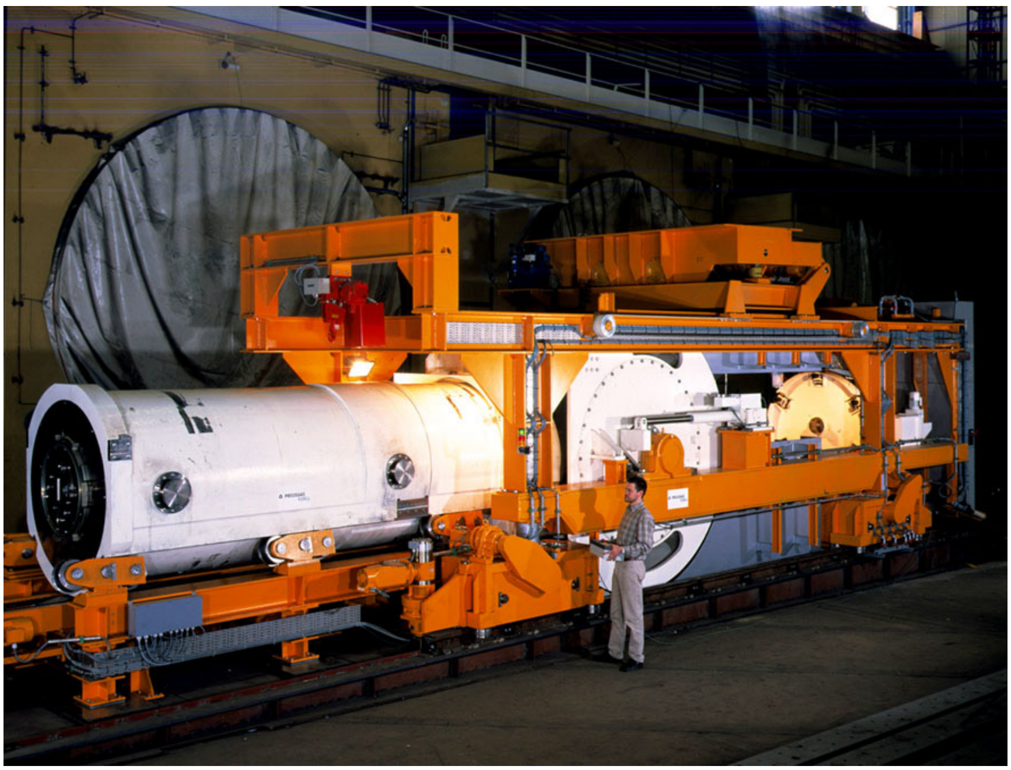

Figure 3. Testing of the canister handling machine at the workshop

SKB plans to test different backfill materials on a full scale at the Äspö HRL (Backfill and Plug Test). The main goals of the project are to test materials and methods for compaction of the backfill of tunnels and test the function and interaction with surrounding rock. The backfill is compacted in layers, with a technique developed in earlier tests. During the test, the sealing capacity of the backfill and the concrete plug will be measured. When the measurements are finished, the backfill will be removed for examination and analysis. Another objective is to develop and test methods for construction of concrete plugs for temporary sealing of deposition tunnels.

Since the deep repository is designed in such a way that it is possible to retrieve deposited canisters, it is necessary to develop and test the method for retrieval as well. The main goal for the test is to develop the method for freeing a canister from water-saturated and swollen bentonite. Two full-sized canisters will be placed in deposition holes and surrounded with bentonite. The canisters will be equipped with electric heaters and the bentonite blocks with some instrumentation. The deposition holes will be sealed with concrete plugs. The deposition holes will be left for 3–5 years to give the bentonite time to become saturated with water. During this time, equipment for freeing of canisters will be designed and manufactured. When the bentonite is saturated, the two test canisters will be freed and lifted out with the deposition machine.

Encapsulation Technology

Trial fabrication of full-sized canisters has shown that both forming from rolled plate and extrusion are possible methods for fabricating copper cylinders on a full scale. The operating period for the Encapsulation Plant will extend over a time span of more than 40 years. It is thus possible that several different fabrication methods will be used during this time if alternative methods are developed and become available.

A preliminary study of how a canister-factory could be designed has been performed. The location of the canister factory has not yet been decided. Questions that must be taken into consideration in siting of the factory include shipments to and from the factory as well as availability of labour and industrial infrastructure. Alternatives to be studied include a siting in the same region as the encapsulation plant or the deep repository, but other alternatives may also be considered.

The encapsulation plant can either be sited at CLAB, at the deep repository, at an existing nuclear installation, or at some other location. SKB's main alternative is co-siting of the encapsulation plant with CLAB, since this alternative offers a number of advantages. One of the advantages is that the experience of fuel handling possessed by the personnel at CLAB can best be used. Furthermore, several of the existing systems and plant sections in CLAB can also be utilised for the encapsulation process. During the first stage only spent fuel will be encapsulated in the plant but preparations will be made for the later addition of equipment for treating core components. In designing the Encapsulation Plant emphasis will be placed on radiation protection for the personnel and the environment. This means, among other things, that the actual encapsulation procedure will be performed by remote control in heavily radiation-shielded compartments (hot cells). A large part of the handling of canisters will also be done by remote control.

Transportation of filled and sealed canisters will be carried out with the same system that is used today for spent fuel and operational waste.

The Canister Laboratory will serve as a centre for development of encapsulation technology and training of personnel for the encapsulation plant. The main purpose is to test equipment for sealing and inspection of canisters on an industrial basis. This is needed to provide a good basis for the continued planning and design of the encapsulation plant. In the Canister Laboratory, SKB will demonstrate that canisters can be sealed with the stipulated quality at the production rate that will be required in the encapsulation plant. The results from the Canister Laboratory will comprise an important part of the application for a licence for the encapsulation plant.

To fulfil the stringent requirements on sealing of the copper canister, a method is being developed employing electron beam welding of the copper lid (figure 4). The same method is also employed to attach the bottom of the copper canister. Methods for non-destructive testing of the weld are being developed in parallel in order to verify that it complies with the stipulated requirements. Results obtained show that electron beam welding is a feasible method for fabricating and sealing copper canisters. Fully satisfactory results have not yet been obtained from the work of development of methods for non-destructive testing; this will require further efforts.

Figure 4. Vacuum chamber for electron beam welding of the copper lid

The equipment that is installed in the Canister Laboratory is designed in basically the same way as the equivalent equipment planned for the encapsulation plant. The Canister Laboratory will also be used for testing and demonstration of other parts of the encapsulation process, such as handling in the encapsulation plant's handling cell. Another important task is the training of operating and maintenance personnel for the encapsulation plant.

RESULT OF THE EVALUATION OF RD&D PROGRAMME 98

The Swedish Nuclear Power Inspectorate, SKI, has conducted evaluation review of the RD&D Programme and presented a report to the Government as usual. Over 40 instances as universities, organisations and other governmental bodies have participated in the review work. In April 1999 SKI presented the report with recommendations for a government decision. SKI proposes that the Government should state that SKB have so far fulfilled their obligations under § 12 of the Act on Nuclear Activities. Furthermore SKI proposed that the Government should stipulate that following material should have obtained government approval prior to the start of site investigations

- A supplement to the analysis of alternative system solutions, including the "zero-alternative". The aim is to verify, more clearly, that there is no method which is essentially more suitable than the KBS-3 concept, from the Swedish standpoint.

- An in-depth safety assessment of the KBS-3 method. The aim is to show, in a credible manner, that the KBS-3 method has the necessary conditions to comply with the safety and radiation protection criteria that SKI and SSI have stipulated in recent years. The safety assessment must be subjected to international peer review.

- A clear account of measurement programmes for the site investigations, based on insights from the safety assessment and other studies.

- Other material for the selection of sites for site investigation and SKB´s plans for achieving consultation in the different stages of siting.

- An integrated evaluation of implemented feasibility studies and other site selection material together with a judgement of the suitability of the sites investigated in the feasibility studies which are included in the body of material for the selection of sites for site investigation.

- The Government's approval of this additional material would entail approval, as a matter of principle, of the KBS-3 method as a basis for future technical development and site selection work. However, at the same time, it should be emphasised that such approval does not, in any way, anticipate or restrict the full evaluation and licensing of future facilities, under the Act on Nuclear Activities and the Environmental Code.

SKI also proposed that the Government should stipulate that SKB must consult with the municipalities concerned (i.e. the municipalities involved in feasibility studies), county administrative boards, authorities and other bodies with respect to the additional material that SKB must provide. The EIA forums established in the counties and municipalities concerned should be used as far as possible. An account of this process of consultation and what has emerged from it should be included in the additional material that SKB is to provide.

SAFETY REPORT ON POST-CLOSURE SAFETY

In preparation for the coming site investigations for siting of the deep repository, SKB presented in the end of 1999 a new safety report "SR 97 – Post-Closure Safety". The purpose of the SR97-report is to demonstrate by means of systematically conducted analysis that the performance of the repository complies with the acceptance criterion formulated by the Swedish regulatory authorities.

The assessment applies to a closed repository for spent nuclear fuel and thus does not include safety during operation. Geological data are taken from three sites in Sweden to shed light on different conditions in Swedish bedrock. The methodology in the assessment entails first describing the appearance of the repository when it has just been closed and then analyse how the system changes with time as a result of both internal processes in the repository and external forces. The future evolution of the repository system is analysed in the form of five scenarios. The first is a base scenario where it is postulated that the repository is built entirely according to specifications and where present-day conditions in the surroundings, including climate, are postulated to persist. The four other scenarios shows how the evolution of the repository differs from that in the base scenario if the repository contains a few initially defective canisters, in the event of climate change, in the event of earthquakes, and in the event of future inadvertent human intrusion.

Repository evolution is broken down into thermal, hydraulic, mechanical and chemical processes, and the ultimate purpose of the analyses is to evaluate the repository's capacity to isolate the waste in the canisters, and to retard any releases of radionuclides if canisters are damaged. The time horizon for the analyses is at most one million years, in accordance with preliminary regulations.

The overall conclusion of the analyses in the base scenario is that the copper canister's isolating capacity is not threatened by either the mechanical or chemical stresses to which it is subjected. The safety margins are great even in a million-year perspective.

Canister Defect Scenario

The internal evolution in initially defective canisters and the possible resultant migration of radionuclides in buffer, geosphere and biosphere are analysed in the canister defect scenario. The result is estimates of dose and risk that can be compared with the acceptance criterion for a deep repository. The scenario first shows that criticality cannot be expected to occur in the repository.

Analyses of the hydro-mechanical evolution in a damaged canister when water enters show that even the damaged canister prevents the release of radionuclides for a very long time, since intruding water is consumed by corrosion of the cast iron insert. Dissolution of the fuel and solubility conditions are studied in analyses of the chemical evolution in a damaged canister. Model calculations show that hydrogen gas generated by corrosion of the cast iron insert contributes towards keeping the rate of fuel dissolution low.

Groundwater flow is studied on a local scale on the three sites. The analyses show that variation in results stemming from the natural variability in the rock often overshadows the variation caused by both differences between model concepts and uncertainties in boundary conditions, fracture structure, etc. Releases from the geosphere are converted to doses in different ecosystems. Both reasonable and pessimistic values are estimated for all input data to the calculations Radionuclide flux in the biosphere is modelled for a number of ecosystems, e.g. well and peat-land. Peat-land gives relatively high doses as a consequence of accumulation of e.g. Ra-226.

With reasonable data, the doses on all sites lie far below the dose limits that can be derived from the official acceptance criteria. The influence of uncertainties in data is analysed by systematically substituting reasonable data for pessimistic data and studying the calculation result. The variation in flow-related data in the geosphere has the greatest impact on the result, followed by data uncertainties for the biosphere. Other conclusions are that our understanding of fuel dissolution needs to be improved, and that the probability and size of initial canister defects that escape quality-control-inspection is difficult to estimate.

In order to obtain a risk measure that can be directly compared with the acceptance criterion, risk analyses in the form of simplified probabilistic calculations are also performed. The risk analyses show that all sites lie well below the acceptance criterion. The maximum risk for release to a well is never more than 0.5 percent of the acceptance criterion, even when the calculations are extended a million years into the future. The same applies to releases to peat-land for times up to 100,000 years, while the maximum risk here grows to about one-tenth of the acceptance criterion at the least favourable site at times after 100,000 years.

Climate Scenario

The consequences of future climate change are explored in the climate scenario. Today's climate in Sweden is relatively warm by historical standards. Future changes are expected for the most part to lead to a colder climate as a consequence of cyclical variations in insulation. A conceivable sequence of events, including severe glaciation, on each of the three sites is sketched for the coming 150,000 years. The repository system's thermal, hydraulic, mechanical and chemical evolution under the changed conditions in the surroundings is studied in the form of a comparison with the evolution in the base scenario.

In the climate scenario as well, the overall conclusion is that the isolating capacity of the copper canister is not threatened by either mechanical or chemical stresses. The mechanical stresses are larger than in the base scenario, mainly due to higher rock and groundwater pressures in connection with a glaciation. The chemical stresses are roughly the same, partly because oxygen-containing groundwater is not expected to reach the canister. The strength calculations for the canister may need to be refined with more realistic, inhomogeneous properties of the material, and buffer erosion with extremely ion-poor groundwater compositions may require further study. As far as the retarding capacity of the repository is concerned, for example in the event of initial canister damage, the most important changes take place in the biosphere. It is expected that ice sheets or sea during long periods will cover the sites. The aggregate effect of climate change will therefore be a reduction of the dose consequences compared with a situation where the present-day climate persists.

Earthquake Scenario

In the earthquake scenario, the consequences of earthquakes are analyzed by means of model studies where site-specific data are used for the structure of the geosphere and for earthquake statistics. The analysis method is new and includes several highly pessimistic simplifications. The analyses show that the probability of canister damage is comparable with the probability assumed for initial damage in the canister defect scenario. In the evaluation of the analysis method, it is shown how less pessimistic assumptions should lead to no canister damage at all in the model studies. The method will be refined.

Intrusion Scenario

The scenario that deals with future inadvertent human actions that could conceivably affect the repository is surrounded by great uncertainties, chiefly because the evolution of human society is in principle unpredictable. SR 97 discusses how conceivable societal evolutions and future human actions that affect the repository can nevertheless be categorised to some extent. A situation is analysed where a rock drill unintentionally penetrates a canister in the repository. Dose and risk are calculated for the drilling personnel and for a family that settles on the site at a later point in time. The risk to both drilling personnel and family is judged to lie well below the acceptance criterion, since the probability of the analysed events is estimated to be very small.

CONCLUSIONS

The Swedish program for HLW and spent fuel management is now focused on the siting process for the deep repository. The nearest goal is to get acceptance for the repository design and to be able to start investigations on two sites in year 2002. SKB`s planning for the coming period includes the following activities:

- Report the results of general siting studies and the results of the feasibility studies performed in six communities with SKB's selection of at least two sites for site investigations.
- Present programs for geo-scientific site investigations and site evaluation with criteria.
- Present results from the work of technology development and planning/design of encapsulation and deep disposal.

The principal conclusion of the SR 97 safety assessment is that the prospects of building a safe deep repository for spent nuclear fuel in Swedish granitic bedrock are very good. The three analysed sites reflect reasonable variations of the conditions in granitic bedrock in Sweden.

- The methodology that is used in SR 97 comprises a good foundation for future safety assessments that will be based on data from completed site investigations.
- The results of the assessment also serve as a basis for formulating requirements and preferences regarding the bedrock in site investigations, for designing a programme for site investigations, for formulating functional requirements on the repository's barriers, and for prioritisation of research.
- The scope of the safety assessment and confidence in its results satisfy the requirements that should be made in preparation for the site investigations.

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