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Swedish Radiation Safety Authority

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Review and evaluation of the Swedish Nuclear Fuel and Waste Management Company's RD&D Programme 2010

Statement to the Government and summary of the review report

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Strålsäkerhetsmyndigheten
Swedish Radiation Safety Authority

STATEMENT
10-03-2011

To the Government
Ministry of the Environment
103 33 Stockholm

Our reference SSM 2010/2116

The Swedish Radiation Safety Authority's Statement on the Swedish Nuclear Fuel and Waste Management Company's reporting of the RD&D programme 2010

The Swedish Radiation Safety Authority's statement

The Swedish Nuclear Fuel and Waste Management Company (SKB) has submitted the RD&D programme 2010 to the Swedish Radiation Safety Authority (SSM) for review, pursuant to Section 12 of the Act (1984:3) on Nuclear Activities (Nuclear Activities Act)

SSM proposes that the Government should decide that the reactor licensees, through SKB, have fulfilled their obligations in accordance with Section 12 of the Nuclear Activities Act but at the same time obligate the reactor licensees to consult with the Authority on matters relating to the programme for the final disposal of long-lived low and intermediate-level waste and decommissioning plans and dismantling studies, in preparation of the next RD&D programme.

Furthermore, SSM proposes that the Government requests the reactor licensees and SKB to consider the assessments and observations which are otherwise presented in the Authority's review report.

Matter

The reactor licensees have given SKB to the task of establishing the research, development and demonstration programme (RD&D programme) as

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required in accordance with Section 12 of the Nuclear Activities Act. SKB submitted, in accordance with Section 25 of the Ordinance (1984:14) on Nuclear Activities (Nuclear Activities Ordinance), the RD&D programme 2010 to the Authority for review and evaluation on 29 September 2010.

SSM has reviewed and evaluated the RD&D programme 2010 in accordance with Section 26 of the Nuclear Activities Ordinance. This statement and the related review report summarize the results of the review and evaluation.

The Authority has in connection with the review of the RD&D programme 2010 followed up on a number of issues remaining from the review of the RD&D programme 2007 and SKB's supplementation to this, in accordance with the government's conditional decision on RD&D programme 2007 (M2008/2772/Mk, M2008/2833/Mk, M2009/3591/Mk, M2009/3976/Mk).

The RD&D programme 2010 has been circulated for national consultation by SSM in order to obtain feedback, reaching approximately 70 organisations. The circulation resulted in 41 responses, 16 of which declined to comment or did not offer an opinion on the programme. The remaining organizations chose not to respond.

SSM's advisory board for issues relating to radioactive waste and spent nuclear fuel considered the main features of the SSM review at its meeting on 23 February 2011.

Reasons for the statement

Fulfilment of Section 12 of the Nuclear Activities Act.

In accordance with Section 12 of the Nuclear Activities Act, a party that holds a licence to possess or operate a nuclear power reactor shall, in consultation with other reactor operators, prepare or arrange the preparation of a programme for comprehensive research and development activities and other measures necessary for the safe handling of nuclear waste and spent nuclear fuel as well as the safe decommissioning and dismantling of nuclear facilities.

SKB has, upon commission of the reactor licensees, established and submitted an RD&D programme to the Authority in accordance with Section 25 of the Nuclear Activities Ordinance.

SSM has, in accordance with Section 26 of the Nuclear Activities Ordinance, conducted a review and assessment of the programme in terms of

1. planned research and development activity
2. reported research results,
3. alternative handling and storage methods
4. intended measures.

The Authority has drafted a review report, which contains detailed assessments of all sections in the RD&D programme 2010. The detailed assessments relating to points 1 and 2 above are contained in sections four to six of the review report. The detailed assessments relating to point 3 are reported in section seven of the review report. Point 4 is dealt with in section three of the review report.

On the basis of the detailed assessments of the review report, SSM provides the summary assessment that the reactor licensees have fulfilled the requirements, in accordance with Section 12 of the Nuclear Activities Act.

Conditions posed on the continuing development and research activity.

SSM is of the opinion that the reactor licensees, through SKB, have not sufficiently considered the issues presented by the Authority in the review of SKB's supplementation to the RD&D programme 2007 (SSM 2009/1365) concerning the programme for long-lived low and intermediate-level waste and the decommissioning and dismantling of nuclear installations.

SSM therefore deems it necessary for the reactor licensees to report on plans and strategies concerning the decommissioning and dismantling of the nuclear power plants and Ågesta reactor on a more detailed level in the upcoming RD&D program 2013 than was done for the RD&D programme 2010. The report should include a clear description of the assignments delegated by the reactor licensees in terms of planning and implementation of the various measures required. It should be possible to produce a more complete report by developing it in joint consultation with the reactor licensees and SKB, as well as by including in the programme additions to the knowledge base gained from the ongoing dismantling studies which are made available in an appropriate manner.

Furthermore, the Authority has made the assessment that the reactor licensees, through SKB, in the RD&D programme 2013 should provide more detailed statements of accounts for the programme for long-lived low and intermediate-level waste in view of the options for handling and disposal of waste and the more concrete account of the repository designs that SKB has begun to develop. The account must explicitly specify the conditions and choice of handling options with respect to a possible advancement of the date and a phased construction of a repository for long-lived low and intermediate-level waste.

SSM proposes on the basis of the above that the Government obligate the reactor licensees and SKB to consult with the Authority on a regular basis prior to the RD&D programme 2013, on matters relating to the programme

for the final disposal of long-lived low and intermediate-level waste and decommissioning plans and dismantling studies.

Other assessments and opinions

In the review report, SSM presents assessments and provides recommendations for all aspects of the RD&D programme 2010. SSM proposes that the government requests the reactor licensees and SKB to consider the opinions expressed in the review report for the further research and development initiatives.

The decision with regard to this statement has been taken by Director General Ann-Louise Eksborg. The following participated in the final processing of the matter: Department Director Johan Anderberg, Section Heads Josefin Päiviö Jonsson, Johanna Sandwall, Elisabeth André Turlind, Björn Hedberg and Erik Welleman, Senior Legal Adviser Pernilla Sandgren and Analyst Georg Lindgren, who was also the reporter.

THE SWEDISH RADIATION SAFETY AUTHORITY

Ann-Louise Eksborg

Georg Lindgren

Appendices:
Review report
National consultation

Copy:
Svensk Kärnbränslehantering AB
Barsebäck Kraft AB
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Vattenfall AB

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Review group:

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Review and evaluation of the Swedish Nuclear Fuel and Waste Management Company's RD&D Programme 2010

Summary of the review report

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Summary of the review report

Introduction

In accordance with Section 25 of the Ordinance (1984:14) on Nuclear Activities (Nuclear Activities Ordinance), the Swedish Radiation Safety Authority (SSM) shall review and assess the research, development and demonstration programme (RD&D programme) that the reactor licensees are obligated to establish in accordance with the Act (1984:3) on Nuclear Activities (Nuclear Activities Act). The Swedish Nuclear Fuel and Waste Management Company (SKB) has developed the RD&D programme 2010 (SKB, 2010) and, in accordance with the Nuclear Activities Ordinance, submitted it to the Authority in September 2010.

SSM has reviewed and evaluated the RD&D programme 2010, in terms of planned research and development activity, reported research results, alternative handling and storage methods, and intended measures (Section 26 of the Nuclear Activities Ordinance). This report presents the results of the review and the evaluation. The RD&D programme 2010 has been circulated for national consultation by SSM to approximately 70 organisations.

The Authority's statement regarding the RD&D programme 2007 was presented to the Government in June 2008 by the then Swedish Nuclear Power Inspectorate (SKI). The government decided on the terms for the continued research and development activity which meant that SKB would supplement the reporting in the RD&D programme 2007 on several points. SKB submitted a supplementation which was reviewed by SSM before being handed over to the Government in October 2009 along with a statement. The decision by SSM showed that the Authority expected further supplementation to be reported in the RD&D programme 2010.

The outline of the Authority's review is generally in accordance with the programme submitted by SKB, and includes the overall action plan, the programme for low and intermediate-level waste, the Nuclear Fuel Programme, research for the analysis of long-term safety and social science research. As a sub-category to the research on long-term safety, SKB furnishes an account of knowledge and research into methods of final disposal of spent nuclear fuel other than the planned geologic final repository in accordance with the KBS-3 method.

The major reference points in the programme are that SKB submits applications for the final disposal system for spent nuclear fuel to the

Authority and the Environmental Court in March 2011. In addition, the SKB programme includes plans to submit an application to expand the final repository for short-lived radioactive waste (SFR) 2013 as well as an application for the final disposal of long-lived operational and decommissioning waste (SFL) around 2030. The dismantling of the reactors at Barsebäck is planned to begin in 2020. The dismantling of the reactor at Ågesta is planned to begin at the earliest in 2020, when the current environmental permit expires. The other existing reactors are planned to be operational for another 40 to 60 years which means that the dismantling is estimated to take place between 2020 and 2050.

Overall opinions of the SKB programme

In this review, SSM has followed up on the outstanding issues in SKB's supplementation of the RD&D programme 2007 (SSM 2009/1365), which the Authority recommended SKB to include in the current programme. With regard to the issues in the programme for SFR, the Authority concludes that SKB has, on the whole, provided the requested clarifications in its report. However, SSM is of the opinion that the criticisms that were brought up regarding the programme for low and intermediate-level waste and for the decommissioning and dismantling of nuclear installations, have not been sufficiently considered. SSM furthermore, is of the opinion that the views on the alternative method of deep borehole disposal have not been fully considered. Detailed views are presented in each section.

SSM deems the structure of SKB's report to be clear and generally appropriate. The Authority views it as positive that SKB has developed the report on the programme for low and intermediate-level waste (the LILW programme). SSM furthermore notes that SKB's detailed report on the programme for the coming period is not specific in some areas and therefore recommends that SKB in the future writes tangible plans for all sections of RD&D programmes.

SSM finds that the RD&D programme 2010 lacks a report on SKB's work on record keeping and memory in connection with the final disposal of spent nuclear fuel.

Overall plan of action

SSM is of the opinion that the overall action plan reported by SKB constitutes a good introduction to the activities of SKB. Despite the fact that the section contains a great deal of information which is superfluous to that

which is relevant for an action plan, SSM finds that the information constitutes an important basis for the understanding of the current activities of SKB in a more general context.

SSM finds that the reporting of the action plan, in combination with the reporting of the programmes for LILW (part II of the SKB report) and nuclear fuel (part III of the SKB report), constitutes a sufficient insight to enable the Authority to assess the reasonableness of SKB's programmes. SSM is of the opinion that the action plan should be further developed, with regard to its grounds and underlying assumptions, in the RD&D programme 2013, in connection with SKB addressing the issues presented by the Authority concerning the sections on the handling of short and long-lived low and intermediate-level waste and on decommissioning and dismantling.

The programme for low and intermediate-level waste (LILW)

Short-lived low and intermediate-level waste

SSM deems SKB's report in the RD&D programme 2010 on the work to develop and find a place for final disposal of decommissioning waste to be too brief. SSM has viewed a preliminary version of the investigation regarding the siting of the facility referred to by SKB (SKB, 2010). SSM finds that the investigation is basically well structured, but that the analyses of the differences between the alternatives in terms of radiation safety need to be conducted in depth.

In the RD&D program 2010, SKB states that it will conduct a review of the rules for sending waste to different parts of SFR in connection with the submitting of an application to construct a final repository for short-lived decommissioning waste. SSM is of the opinion that this review should be broadened to include other types of final repositories, such as near surface disposals, and a future final repository for long-lived low and intermediate level waste (SFL). An important aspect to evaluate in this context is the application of current principals on recycling and conservation principles. SKB and the producers of waste should demonstrate clearly what measures are taken to, where feasible, minimize the amount of waste e.g., through clearance and other types of recycling.

Long-lived low and intermediate-level waste

SSM finds that SKB's reporting of plans and programmes for the final disposal of long-lived low and intermediate level waste is better structured and supported than in the RD&D Programme 2007. SKB plans to begin the

operation of this final disposal; SFL, in 2045. SSM is of the opinion that SKB needs to further investigate the issue of the SFL timetable. The possibility of an earlier implementation of a stepwise procedure should be analyzed in particular. SSM deems the ambition level for the continued development to be high, although it had expected a better description of the various possible designs for SFL. SSM is looking forward to seeing SKB's safety analyses and expects that these will be developed in such a way as to form the basis for the selection of a concept and the development of useful acceptance criteria for processing and packaging long-lived low and intermediate level waste. Research on corrosion processes in the repository is of particular importance for this kind of waste and SSM is of the opinion that SKB needs to improve its reporting in regards to this subject in future RD&D programs. SKB will continue to plan for the interim storage of long-lived waste in SFR; something that SSM, though in principle in favour of it, will not make a final decision on until reviewing an application for the expansion of SFR. At such a time, SSM expects to see an even a better report of alternatives to storage in SFR.

Decommissioning and dismantling.

SSM is of the opinion that the reactor licensees, through SKB, have not sufficiently considered the issues brought up by the Authority in the review of SKB's supplementation of the RD&D program 2007 (SSM 2009/1365) regarding the decommissioning and dismantling of nuclear installations.

SSM therefore deems it necessary for the reactor licensees to report plans and strategies regarding the decommissioning and dismantling of the nuclear power plants and Ågesta reactor on a more detailed level in the upcoming RD&D program 2013 than was done in the RD&D program 2010. The report should include a clear description of the assignments delegated by the reactor licensees in terms of planning and implementation of the various measures required. It should be possible to produce a more complete report by developing it in joint consultation by the reactor licensees and SKB, as well as by including appropriate results from ongoing dismantling studies in the programme.

The RD&D programme 2013 should also include a description of how, and to what extent, the accountability of the nuclear power companies has been delegated to SKB in accordance with Section 12 of the Nuclear Activities Act.

SSM is in favour of the nuclear power companies and SKB actively participating in the international work on dismantling and the fact that they

are carrying out an extensive cooperation in matters of planning and implementation of decommissioning.

Nuclear Fuel Programme

Overview – technology development

It is important to SSM that SKB is able to show that all requirements on the final disposal facility can be met and put into practice. The Authority is of the opinion that the continued technological development; its direction and reporting, is of vital importance in this context. Based on the RD&D programme 2010, SSM finds it difficult to get a comprehensive idea of SKB's requirements and management models and of how they pursue technological development. The Authority is of the opinion that SKB should continue the revision and clarification of the system defined by various management and control systems, models and reports. In the next RD&D programme, SKB should provide a comprehensive and clear report on how different models, requirements and reports relate to each other; how information is handled in the various systems and reports and how SKB ensures that the requirements lead to an appropriate programme of technological development.

Technological development – fuel handling

SSM sees it as positive that the technological development of fuel management has been emphasized and given a separate chapter in the RD&D programme 2010. The Authority deems it necessary for SKB to further develop the methods of fuel management that will be used for the encapsulation of fuel, e.g. methods for drying the fuel. SKB should furthermore develop an effective method for drying damaged fuel rods and PWR fuel control rods. Criteria for drying should also be determined. Another point is that SKB should develop an appropriate programme for combining fuel element types of different age and burnup in the encapsulation in order to limit the decay power in the canisters as well as to avoid criticality in the final repository.

Safeguards of nuclear materials

SSM is of the opinion that SKB should be prepared for upcoming requirements from international control agencies which may entail that existing conventional techniques no longer meet the requirements for certain requested information and thus, a technological development may be needed. International efforts are currently under way to formulate more detailed safeguard requirements for final disposal and encapsulating facilities. The Swedish Radiation Safety Authority suggests that SKB should closely

monitor the developments within the field and respond as early as possible to requests for data, i.e. have as good a forward planning as possible, given that technological development often takes time.

SKB plans to create the repository in a rolling schedule of simultaneous blasting, disposal and backfilling. SSM deems that SKB has a particular obligation to, at an early stage, show that procedures have been developed for how the requirements on safeguarding nuclear materials are intended to be met in the continuous extension stages of the disposal operation.

Technological development – canister

SSM feels that there is still work to be done in order to fulfil the requirements for the canister. For example, there are still no complete requirements associated with the damage tolerance analyses, material properties and the load cases for a dropped canister. SSM would like to point out that these basic conditions are vital for the development of testing systems and require that the work on the detailed design premises is completed in the near future. SSM furthermore recommends that SKB at an early stage establishes a qualification process containing detailed design premises in order to verify the reliability of the systems for non-destructive testing (NDT). The damage tolerance analyses are particularly important for the design premises of the defect size that the NDT system must be able to detect. In addition, SKB should conduct further examinations to verify the toughness and plasticity of the ductile cast iron as well as the choice of safety factor. SSM is of the opinion that SKB should make further efforts to show that the canister fulfils the design premises for all shearing included in the shear load case. An analysis should for example be made of shearing perpendicular to the longitudinal axis of the canister, in the horizontal plane close to the lid and the bottom of the copper cylinder, where the insert is not expected to give the same resistance as for shearing in the other areas. Additional opinions are provided below, in the section "research for the analysis of long-term safety".

Technological development – buffer

SSM is of the opinion that SKB should find a better way to integrate the technological development of the buffer with the research on the initial and long-term development of the buffer's properties in the final repository.

SSM finds that certain issues brought up by the Authorities (SKI and SSI) in the review of the RD&D programme 2007 regarding the fabrication of the buffer blocks still remain. SKB should develop a quality programme for the

fabrication of buffer blocks and a systematic method for tackling the fabrication development.

Technological development – backfilling

SSM is in favour of the cooperation SKB has had with Posiva in recent years through the Baclo project. However, the Authority recommends that SKB makes further efforts to demonstrate that the backfilling of the deposition tunnels can be made while fulfilling all requirements. SKB should also produce a detailed timetable for the continual technological development in connection to the backfilling, which is to be reported in the next RD&D programme.

SSM is of the opinion that SKB should carry out several full scale demonstrations of the reference design for the backfilling. SKB should be able to verify that the reference design is well adjusted to conditions similar to those in the repository environment at Forsmark.

SSM also recommends that SKB address the difficulties that may arise from so-called piping and erosion when installing the backfill.

Technological development – closure

SSM sees it as positive that SKB is planning additional measures in connection with the development of the closure concept. However, SSM deems it necessary for SKB to make further investigations regarding the feasibility of alternative closure concepts. Although the closure will not be carried out for a long time yet, it is of great importance for the entirety of the final disposal and thus for the requirements and technological development of other parts thereof. Additionally, SKB should examine the long-term stability of the closure in terms of concrete degradation and chemical erosion of bentonite as a result of exposure to glacial meltwater.

Technological development – rock

SSM is of the opinion that the design method chosen by SKB, including the method of observation, puts great demands on the requirement specification for the construction and follow-up of these requirements. The Authority would like to emphasize how important it is that the requirements on the project regarding long-term safety and environmental effects become an integral part of the design and construction processes. SKB should, as they continue the process, ensure that the processes are developed in such a way as to do so.

SSM recommends that SKB clarify the plans for development of the detailed characterization programme, adding more precise times for various types of investigations that connect back to different aims and requirements. The Authority finds that a report of SKB's plans for monitoring relevant parameters is lacking.

SSM is furthermore of the opinion that a method for detecting large fractures is important and that SKB should follow through on the reported plans. The Authority also believes that it is important that the uncertainties associated with the detection of these fractures be connected with the design premises in an appropriate manner.

Technological development – KBS-3H

SSM is of the opinion that much development and demonstration work remains before SKB is able to make an internal decision regarding whether or not they intend to continue the developmental work. In reference to the fact that SKB's application for the construction of a final repository for spent nuclear fuel is based on the reference design KBS-3V, SSM will not decide on SKB's plans regarding the development of KBS-3H at present.

Research for the assessment of long-term safety

Long-term tests at Äspö Hard Rock Laboratory and safety assessment

Extraction of the first part of the prototype repository is expected to begin in 2011. However, SSM demands a more complete report on the extraction of all long-term testing at Äspö (LOT, Minican, the prototype repository) and its link to the gradual process of constructing a spent nuclear fuel repository at Forsmark. This applies to the timetable for the completion of ongoing testing as well as to what measurements will be implemented and how this information can be used. In addition there is the question of whether new additional tests need to be initiated in order to address any knowledge gaps or to compensate for deficiencies in ongoing or previous testing.

Based on the examination of SR-Can and SAR-08, SSM has no objections to the basic components of SKB's method for safety assessment. SSM would however like to point out the need for measures in the area of safety assessment for low and intermediate-level waste. A great deal of work remains to be done to establish a report on the level prescribed by SKB's own method.

Climate evolution

SSM is in favour of SKB's Greenland Analogue Project (GAP) and the efforts to improve the conceptual understanding of hydrology and hydrogeology in glacial conditions. SSM believes that the study planned for transferring this knowledge to Scandinavian conditions is important in order to make the resultant information relevant to the safety analysis for the planned disposal facilities. The Authority believes that further studies regarding the future erosion at Forsmark may be warranted, depending on how SKB evaluates the effects of major glacial erosion in future safety assessments.

Short-lived low and intermediate-level waste

SSM finds that SKB's reporting in the section regarding short-lived low and intermediate-level waste, divided into initial states and processes, is greatly improved compared to the previous RD&D programmes. SKB's examination of the initial state of the waste clearly points to the need for SKB to develop acceptance criteria for waste disposed in SFR. This is a factor to consider when applying for the extension of the repository. SSM is in favour of SKB and nuclear power companies' work to improve the methods for nuclide determination in the waste and in particular in the organic C-14. The Authority is furthermore of the opinion that SKB should monitor the development of knowledge in terms of the water uptake in ion exchange resins and waste matrix and the volume expansion of cement-embedded waste. As has also been noted in the review of previous RD&D programs, SKB should develop a systematic method and models for managing the effects of complexation on the sorption of radionuclides in the final repository. Finally, SSM would like to point out to SKB that additional measures may need to be taken in regards to hydrogen formation due to corrosion of aluminium and the formation of colloids.

Technical barriers SFR

SSM is in favour of the reporting of processes relevant to the SFR and SFL, which is expanded and more detailed compared with previous RD&D programmes. The Authority notes that a number of projects important to the further development of the safety assessment for SFR, and the work on future repositories such as SFL, have been initiated. However, SSM finds that SKB's programme does not clearly show that they have dealt with all the issues brought up by the Authority in connection with the review of the SAR-08. SKB should therefore adhere to the detailed issues expressed in this report.

SSM has a positive view of the development of models for consequence analysis reported by SKB. However, the Authority finds the reporting to general in nature to be able to assess what will be achieved. SSM is furthermore of the opinion that SKB should be clearer in the reporting of flaws and uncertainties in the models used, and how these can be dealt with through model development. In addition, the Authority is of the opinion that SKB should ensure access to several modelling tools in order to achieve the goals of the safety assessment in the best way possible.

Fuel

SSM finds the SKB research programme regarding fuel issues to be appropriate and that meaningful work has been carried out by SKB by itself as well as in cooperation with concerned actors in other countries. SSM furthermore believes that SKB has reason to review the reporting and make it more systematic.

SKB should give a more detailed account on the properties of the fuel types that exist in relatively small quantities, such as MOX fuels, natural uranium fuel from the Ågesta reactor and fuel residues from Studsvik. The properties of MOX fuel may differ considerably from those of UO_2-fuel regarding the release of certain fission products.

SSM is also of the opinion that SKB should implement further measures to improve the understanding of the mechanisms involved in the effect of hydrogen gas on fuel dissolution. If the effect of water radiolysis cannot be disregarded, faster fuel dissolution may have to be assumed in the safety analysis. SKB should develop a coherent report of experimental data and model results. SKB should furthermore investigate whether there is a threshold value for the concentration of hydrogen gas in order to prevent water radiolysis, and if such a value can also be exceeded in cases of buffer erosion.

SSM is of the opinion that SKB should report the method of burnup credit and how it has been validated. Methods for burnup credit have not yet been used in Sweden for the calculation of criticality in fuel repositories. An exhaustive report is a prerequisite for the Authority to be able to assess the method in future reviews.

Canister

Regarding the barrier properties of the canister, SSM is of the opinion that SKB should focus on the creep and corrosion properties of the copper. SKB should thus continue the efforts to determine the impact of phosphorus and

sulphur on the creep properties of the copper. SKB should in addition show that phosphorus-doped copper is ductile even at very long creep times.

SSM is also of the opinion that SKB should conduct further research on copper corrosion in oxygen-free water representing the repository environment. The aim should be to increase the understanding of corrosion mechanisms, quantify corrosion rates representative of the repository environment, and verify the corrosion model used by SKB in the safety analysis.

SSM also feels that SKB should investigate the copper corrosion for the conditions prevailing before reaching the full saturation of the buffer. It is reported in the RD&D programme 2010 that the resaturation of the buffer can take up to 1200 years. Further studies should be conducted to examine the environment surrounding the canister during this period and how it affects copper corrosion.

New experimental results show that when oxygen-free copper (or 'OFP copper') is exposed to artificial ground water containing sulphite, at room temperature, sulphur seems to diffuse into the grain boundaries of the OFP copper and create precipitations primarily containing copper and sulphur. SKB should identify and describe the underlying mechanism which is currently unknown. Additionally, SKB should investigate what effects these internal precipitations of particles containing sulphur and copper in OFP copper have on both mechanical properties as well as corrosion properties.

Buffer and backfilling

SSM is of the opinion that SKB should improve the understanding of the mechanisms behind so called piping/erosion of the buffer and in connection to doing so, supplement the laboratory tests with theoretical studies.

SSM furthermore recommends that SKB continue the studies of buffer erosion and strive to improve the understanding of this process. SKB should also develop a model for chemical erosion based on more realistic systems. In addition, SKB should further study the effect of buffer erosion on the long-term safety of the buffer.

SSM is of the opinion that SKB should study the interaction between corrosion products from the copper canister and the bentonite buffer. SKB should also investigate the effect the corrosion products might have on the long-term geochemical, colloid-chemical and geomechanical properties of the buffer.

SSM recommends that SKB investigate the gas transport through a partially or completely eroded buffer.

The geosphere

SSM finds that SKB has come a long way in terms of developing models for discrete fracture networks and validation of outcrop, borehole and tunnel data. SKB should however make further efforts in the field of rock mechanics and coupled processes. In the models for the behaviour of the rock mass in the nearfield of the final repository, SKB should seek to quantify the impact of realistic fracture geometries on the conditions and processes relevant to the final repository's long-term safety. This should include simulations of possible changes of the fracture networks due to fracture propagation and interconnection of fractures and should take into consideration all relevant load cases.

SKB should make further efforts to highlight and try to reduce uncertainties in the measured data and conceptual models associated with the rock stress model in Forsmark. These uncertainties could affect the analysis of spalling and seismic activity as well as the concept of ‘respect distance’ to be kept from the deformation zones. SKB should seek a link between rock stress models in the repository scale and regional scale as well as the models for fault stability during a glacial cycle.

SKB should undertake further work regarding the possible effects of earthquakes on the final repository and its long-term safety. Important issues to be considered include how representative earthquakes with a magnitude of 6 are of larger quakes, the probability of large quakes, the probability of smaller quakes leading to shear movement, accumulated shear movement and understanding the impact of regional zones. In the next RD&D programme, the link between research on the concept of ‘respect distance’ and seismic issues should be reported.

SSM finds that SKB's programme regarding ground water flow is generally appropriate and SSM brings up a number of issues in detail related to the continual activity within this field.

Surface ecosystems

Earlier safety analyses for the repository of low and intermediate-level waste have shown that C-14 is the radionuclide that dominates the calculated doses for a human being. SSM recommends that SKB, in preparation of the application to expand SFR, carry out more detailed studies of doses in

connection with C-14 leakage than what has been presented in the RD&D programme 2010.

Alternative methods of partitioning and transmutation

SSM recommend that SKB continue to invest funds in partitioning and transmutation in accordance with what is proposed in the RD&D programme 2010. It is SSM's understanding that this is justified, especially in view of the important role this area has for maintaining an adequate level of research and training in technical areas central to the management and disposal of nuclear materials and nuclear fuel. Moreover, this is necessary to meet the requirements of versatility in SKB's program stated in the Nuclear Activities Act.

Alternative methods - deep boreholes

SSM deems that SKB's report on the salt water stability at great depths does not meet the Authority's expectations as reflected in the SSM's review report on the supplement to RD&D programme 2007. SKB estimates that a more thorough analysis of the ground water stability can only be made in qualitative terms. SSM on the other hand, is of the opinion that SKB should study the uncertainties related to salt water stability in great depths. SKB reports that an in-depth expert evaluation concerning the feasibility of disposal in deep boreholes will be presented in the application for a final repository for spent nuclear fuel. SSM will consider whether the report on alternative methods presented in the application is sufficient grounds for deciding on the issue of method choice, when reviewing the application.

Social science research

SSM is in favour of SKB carrying out social science research within the framework of their nuclear fuel programme. The research provides a better understanding of the economic and social dimension of the final disposal, thereby contributing to an overall picture of the disposal process.

The Authority however recommends that SKB show more clearly the role of the social science research programme in relation to SKB's other activities within the framework of the nuclear fuel programme, and how SKB benefits and has benefited from this research.

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The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 270 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

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