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The Swedish Radiation Protection Institute´s Regulations Concerning the Final Management of Spent Nuclear Fuel and Nuclear Waste

with background and comments

Statens strålskyddsinstitut
Swedish Radiation Protection Institute

AVDELNIG/ DIVISION: Avdelningen för Avfall och Miljö./ Division of Waste Management and Environmental Protection.

TITLE: The Swedish Radiation Protection Institute´s Regulations Concerning the Final Management of Spent Nuclear Fuel and Nuclear Waste -with background and comments

SAMMANFATTNING: Statens strålskyddsinstituts (SSI) föreskrifter (1998:1) om skydd av människors hälsa och miljön vid slutligt omhändertagande av använt kärnbränsle och kärnavfall med bakgrund och kommentarer

SUMMARY: This report presents and comments on the Swedish Radiation Protection Institute´s Regulations concerning the Protection of Human Health and the Environment in connection with the Final Management of Spent Nuclear Fuel or Nuclear Waste, SSI FS 1998:1.

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Swedish Radiation Protection Institute

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SSI REGULATIONS

The Swedish Radiation Protection Institute's Regulations concerning the Protection of Human Health and the Environment in connection with the Final Management of Spent Nuclear Fuel or Nuclear Waste;

decided on September 28, 1998.

On the basis of 7 and 8 §§ of the Radiation Protection Ordinance (1988:293), the Swedish Radiation Protection Institute stipulates the following.

1 § These regulations are to be applied to the final management of spent nuclear fuel or nuclear waste. The regulations do not apply to landfills for low-level nuclear waste in accordance with 19 § of the Ordinance (1984:14) on Nuclear Activities.

Definitions

2 § In these regulations, concepts are defined as follows:

- *best available technique:* the most effective measure available to limit the release of radioactive substances and the harmful effects of the releases on human health and the environment which does not entail unreasonable costs,
- *intrusion:* human intrusion into a repository which can affect its protective capability,
- *optimisation:* keeping the radiation doses to mankind as low as reasonably achievable, economic and social factors taken into account,
- *harmful effects:* cancer (fatal and non-fatal) as well as hereditary defects in humans caused by ionising radiation in accordance with paragraphs 47-51 of the International Radiation Protection Commission's Publication 60, 1990,
- *protective capability:* the capability to protect human health and the environment from the harmful effects of ionising radiation,
- *final management:* handling, treatment, transportation, interim storage prior to, and in connection with final disposal as well as the final disposal,
- *risk:* the product of the probability of receiving a radiation dose and the harmful effects of the radiation dose.

Terms and concepts used in the Radiation Protection Act (1988:220) and the Act (1984:3) on Nuclear Activities have the same meanings in these regulations.

Holistic Approach etc.

3 § Human health and the environment shall be protected from the harmful effects of ionising radiation, during the time when the various stages of the final management of spent nuclear fuel or nuclear waste are being implemented as well as in the future. The final management may not cause impacts on human health and the environment outside Sweden's borders that are more severe those accepted inside Sweden.

4 § Optimisation must be achieved and the best available technique shall be taken into consideration in the final management of spent nuclear fuel or nuclear waste.
The collective dose, as a result of the expected outflow of radioactive substances during a period of 1,000 years after closure of a repository for spent nuclear fuel or nuclear waste shall be estimated as the sum, over 10,000 years, of the annual collective dose. The estimate shall be reported in accordance with 10 -12 §§.

Protection of human health
5 § A repository for spent nuclear fuel or nuclear waste shall be designed so that the annual risk of harmful effects after closure does not exceed 10^{-6} for a representative individual in the group exposed to the greatest risk[1].

The probability of harmful effects as a result of a radiation dose shall be calculated using the probability coefficients provided in the International Radiation Protection Commission's Publication 60, 1990.

Environmental Protection
6 § The final management of spent nuclear fuel or nuclear waste shall be implemented so that biodiversity and the sustainable use of biological resources are protected against the harmful effects of ionising radiation.

7 § Biological effects of ionising radiation in living environments and ecosystems concerned shall be described. The report shall be based on available knowledge concerning the ecosystems concerned and shall take particular account of the existence of genetically distinctive populations such as isolated populations, endemic species and species threatened with extinction) and in general any organisms worth protecting.

Intrusion and Access
8 § A repository shall be primarily designed with respect to its protective capability. If measures are adopted to make access easier or to make intrusion difficult, the effects on the protective capability of the repository shall be reported.

9 § The consequences of intrusion into a repository shall be reported for the different time periods specified in 11 **-** 12 §§.
The protective capability of the repository after intrusion shall be described.

Time Periods
10 § An assessment of a repository's protective capability shall be reported for two time periods of orders of magnitude specified in 11 **-**12 §§. The description shall include a case, which is based on the assumption that the biospheric conditions which exist at the time that an application for a licence to operate the repository is submitted will not change. Uncertainties in the assumptions made shall be described and taken into account in the assessment of the protective capability.

The first thousand years following repository closure
11 § For the first thousand years following repository closure, the assessment of the repository's protective capability shall be based on quantitative analyses of the impact on human health and the environment.

Period after the first thousand years following repository closure
12 § For the period after the first thousand years following repository closure, the assessment of the repository's protective capability shall be based on various possible sequences for the development of the repository's properties, its environment and the biosphere.

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[1] With respect to facilities in operation, the limitations and instructions that apply are provided in the Swedish Radiation Protection Institute's regulations (SSI FS 1991:5, amended 1997:2) concerning the limitation of releases of radioactive substances from nuclear power plants and the Swedish Radiation Protection Institute's regulations (SSI FS 1994:2, amended 1997:3) concerning health physics for activities involving ionising radiation at nuclear facilities.

Exceptions
13 § If special grounds exist, the Swedish Radiation Protection Institute may announce exceptions from these regulations.

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These regulations enter into force on February 1, 1999.

On behalf of the Board of the Swedish Radiation Protection Institute

LARS-ERIK HOLM

Carl-Magnus Larsson

BACKGROUND AND COMMENTS

1 General Background

The Swedish Radiation Protection Institute's (SSI) regulations (1999:1) concerning the protection of human health and the environment in connection with the final management of spent nuclear fuel and nuclear waste stipulate the health and environmental protection requirements that SSI makes for the planning, design and construction of facilities in a final management system. The purpose of the regulations is to contribute to limiting, as far as reasonably achievable, health and environmental risks in connection with the final management of spent nuclear fuel and nuclear waste, also in the remote future. The regulations supplement the statutes previously issued by SSI or which are currently being promulgated within the area of nuclear energy.

The regulations are based on the Swedish Radiation Protection Act [1988:220] where, in § 1, it is stated that the "aim of this act is to protect humans, animals and the environment from the harmful effects of radiation". SSI has also taken into account the Environmental Code [1998:808]. The connection between the Radiation Protection Act and the Environmental Code with respect to reference regulations, licensing issues and environmental impact statements was investigated by SSI during the final handling of the Environmental Code [SSI Rapport 97-18].

The regulations are based on considerations which SSI has previously reported in different contexts and which have also been subjected to formal review by other bodies. The main publications concerned are the "Swedish Radiation Protection Institute's Protection Criteria for the Management of Spent Nuclear Fuel" [SSI Rapport 97:07], as well as proposed requirements for the final management of spent nuclear fuel or nuclear waste [Dnr 042/942/97]. SSI's reviews of the Swedish Nuclear Fuel and Waste Management Co's (SKB) research programmes also include such considerations, especially the review of the 1992 programme, of the programme supplement submitted in 1993 and of the 1995 programme [Dnr 8205/2702/95].

In the latest review round [Dnr 042/942/97], SSI solicited the opinion 75 organizations, of which about 20 are abroad. SSI has continuously consulted the Swedish Nuclear Power Inspectorate (SKI) where a similar promulgation process, concerning safety-related issues, is under way.

The regulations contain both material and formal requirements. The material requirements concern, e.g. levels of protection, optimisation and the best available technique, which will determine the design basis criteria and/or system criteria. The formal requirements relate to the reporting in a licence application or an environmental impact statement.

The following comments on the regulations describe the radiation protection background and the legislative history of the regulations.

2 Comments to the Regulations

2.1 Application (§ 1)

The Act [1984:3] on Nuclear Activities stipulates (§ 10) that the holder of a licence to conduct nuclear activities shall adopt the measures necessary to “in a safe manner, handle and dispose of waste generated by the activity or ... nuclear substances which are not re-used”. The Radiation Protection Act contains similar provisions concerning responsibility. § 13 stipulates that anyone who is conducting or has conducted activities involving radiation shall “be responsible for ensuring that radioactive waste generated by the activity is handled and, when necessary, disposed of in a manner that is satisfactory from the standpoint of radiation protection.”

Examples of facilities which are affected by the regulations are the planned extension of the repository for low- and medium-level waste (e.g. SFR-3 at Forsmark) and a planned geological repository for high-level and long-lived waste.

The regulations do not apply to such landfills for low-level nuclear waste referred to in § 19 of the Ordinance [1984:14] on Nuclear Activities. The landfills which currently exist (at the Oskarshamn, Forsmark and Ringhals nuclear power plants as well as at the nuclear facilities at Studsvik) are different in several ways from other existing or planned repositories. SSI requires, e.g. that the waste which is deposited in landfills should be such that there is no serious risk to individuals or to society 100 years after the waste has been completely deposited, regardless of how the site is used. This means that waste with mainly short-lived radioactive substances may be deposited in landfills. SSI does not consider that it is necessary to stipulate any requirements in addition to those provided in the Ordinance on Nuclear Activities, in licences for existing landfills or in SSI's decisions concerning principles to be applied (minutes from the board meeting of November 29, 1982) with respect to landfills. Furthermore, certain requirements in the existing regulations could entail unjustified expenses if they are applied to landfills. For example, there is no reason to require that consequences should be described for the perspective of thousands of years, since the risks are considered to be insignificant already after 100 years.

Furthermore, the regulations do not deal with the process and the requirements on openness, clarity and accessibility (transparency) relating to the preparation of an environmental impact statement. The process-related issues are dealt with in the Environmental Code and in EC directives [Council Directives 85/337 and 97/11 and other documents]. Participation in this process is an important task for SSI, in order to clarify which radiation protection requirements have been formulated for the final management of spent nuclear fuel and nuclear waste.

2.2 Definitions (§ 2)

2.2.1 BEST AVAILABLE TECHNIQUE

The definition of "best available technique" (BAT) is largely based on the preparatory work for the Environmental Code [including bill 1997/98:45 and SOU 1996:103]. The definition means that an assessment of the best available technique to limit the outflow of radioactive substances to the environment must take into account the benefits as well as the cost of the measures. Therefore, the measures must be both technically and economically feasible.

The "best available technique" shall be used when facilities are designed, constructed, operated, maintained and decommissioned. "Best available technique" also includes competence and management-related issues. The use of the term and its relation to optimisation is discussed in Section 2.3 Holistic Approach etc.

2.2.2 INTRUSION

Intrusion refers to any unintentional action that disturbs a repository or the immediate vicinity of a repository and which can, thereby, affect the protective capability. The problems relating to intrusion are dealt with in Section 2.6 Intrusion and Access.

2.2.3 OPTIMISATION

Optimisation is one of the International Commission on Radiological Protection's (ICRP) three basic principles for all radiation protection (the other two are justification and dose limitation). The internationally accepted definition is used in these regulations. The meaning and application of the concept are discussed in Section 2.3 Holistic Approach etc. The other two principles are also discussed in that section.

2.2.4 HARMFUL EFFECTS

Ionising radiation can, at high doses, result in acute effects and can also - even at low doses - result in cancer and hereditary effects in the long term. When an assessment is made of long-term effects, the severity of the harmful effects, which the ICRP calls the *detriment*, is also taken into consideration. In this context, harmful effects refers to cancer (fatal and non-fatal) as well as hereditary effects, caused by ionising radiation. When calculating the harmful effects, the probability coefficients specified in ICRP's Publication 60 must be used. For all types of cancer and hereditary effects combined, the ICRP specifies a probability coefficient of 0.073 per sievert. This is examined in greater detail in Section 2.4 Protection of Human Health.

No corresponding identification of long-term effects and probabilities has been made with respect to the harmful effects on other organisms besides mankind. Therefore, no corresponding quantitative limit has been specified. This is discussed in greater detail in Section 2.5 Environmental Protection

2.2.5 PROTECTIVE CAPABILITY

The objective of limiting risk specified in this regulation applies in the case of a repository which is undisturbed by human activity. However, the protective capability, i.e. the capability of protecting human health and the environment, must also be investigated with respect to other situations, e.g. during and after a disturbance in the form of intrusion. These issues are examined in greater detail in Section 2.6 Intrusion and Access.

2.2.6 FINAL MANAGEMENT

The regulations apply to all activities which may be required to manage spent nuclear fuel or nuclear waste, including continued interim storage at the Central Interim Storage Facility for Spent Nuclear Fuel (CLAB) located next to Oskarshamn nuclear power plant. The regulations are not restricted to any particular method, such as the KBS-3 method proposed by SKB for the final management of spent nuclear fuel or long-lived radioactive waste.

2.2.7 RISK

The probability of damage after a certain exposure can be estimated using probability factors, as described above. Since these regulations mainly concern future, potential exposures, the probability of ever receiving a dose, i.e. the scenario probability, is taken into consideration. Both of these probabilities are included in the total risk assessment. This is examined in greater detail in Section 2.4 Protection of Human Health.

2.3 Holistic Approach etc. (§§ 3 - 4)

2.3.1 INTERNATIONAL PRINCIPLES FOR RADIOACTIVE WASTE MANAGEMENT

The general reference regulations that apply to the final management of spent nuclear fuel or nuclear waste are dealt with in § 3 of the regulations. The paragraph is based on an international consensus concerning ethical principles for final management. These principles have been summarised in the IAEA's publication “The Principles of Radioactive Waste Management” [IAEA 1995] and in the “Collective Opinion” concerning the environmental and ethical principles of geological final disposal prepared by the Radioactive Waste Management Commission (RWMC) of the OECD's Nuclear Energy Agency [OECD-NEA 1995].

The principles have also served as guidelines for the preparation of the “Joint Convention on the Safety of Spent Nuclear Fuel Management and on the Safety of Radioactive Waste Management” (the so called Waste Convention). The main aim of the Convention is to protect individuals, the society and the environment, now and in the future, against the harmful effects of radiation. The Convention was drawn up on the initiative of the IAEA. The Convention contains provisions concerning legislation, regulations and administrative measures as well as liability-related issues concerning the ultimate legal liability for the management of the waste. The Convention also includes the principle of not placing unreasonable burdens on future generations. Finally, the Convention regulates joint meetings between and reporting from the parties that have signed the Convention. Sweden signed the Convention in 1997 and it was ratified in 1999 [bill 1997/98:145].

The United Nations Conference on Environment and Development (UNCED) which was held in 1992 in Rio de Janeiro, resulted in the adoption of certain positions which are of importance for the management of radioactive waste and spent nuclear fuel. The Rio Declaration [UNCED 1992] emphasises that environmental protection should be an integral part of the development process, that development shall be sustainable and that it shall be possible for the public to participate in the decision-making process. The Agenda 21 Programme of Action [UNCED 1992], states that the objective, with respect to radioactive waste is (Programme Area 22): “ensure that radioactive wastes are safely managed, transported, stored and disposed of, with a view to protecting human health and the environment, within a wider framework of an interactive and integrated approach to radioactive waste management and safety”.

The general reference regulations and requirements (in italics below) are included in the regulations or in another form, as shown below.

Principle 1: Protection of human health. Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for human health. General requirements are formulated in § 3 of the regulation and detailed in § 5.

Principle 2 Protection of the environment. Radioactive waste shall be managed in such a way as to provide an acceptable level of protection of the environment. General requirements are formulated in § 3 of the regulation and developed in §§ 6 – 7.

Principle 3 Protection across national borders. Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account. The management of the waste may not lead to effects on health and the environment in another country that are more severe than those accepted inside the country. Protection against cross-border environmental impact is also taken into account in certain international agreements, e.g. the Espoo Convention [SÖ 1992:1], the Nordic Environmental Protection Convention [SÖ 1974:99] and in the EC directive on environmental impact statements [Council Directive 85/337 and 97/11]. General requirements are formulated in § 3 of these regulations.

Principle 4 Protection of future generations. Radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today. General requirements are formulated in § 3 of the regulation and detailed in § 5. Reporting requirements for various time periods are dealt with in §§ 10 - 12.

Principle 5 Burdens on future generations. Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations. Burdens on future generations can be avoided through the implementation of planning of the final management and by initiating the management as well as through requirements which limit future releases as a result of the final management, and finally, through the allocation of funds so that the completion of the final management in the future does not become an economic burden. Radiation protection requirements for management are specified in the regulations and the allocation of funds is covered by the Act [1992:1537] on the Financing of Future Expenses for Spent Nuclear Fuel etc.

Principle 6 National legal framework. Radioactive waste shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions. This principle is not applicable to these regulations which should instead be considered as a consequence of the fact that a framework of regulations already exists in Sweden where a division of responsibilities and the allocation of specific authority are defined.

Principle 7 Control of the quantity of radioactive waste generated. Generation of radioactive waste shall be kept to the minimum practicable. This principle does not fall within the scope of the regulations.

Principle 8: The generation of radioactive waste and mutual dependence in connection with management. Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account. For SSI, this principle means that the radiation protection aspects of all stages of the generation and final management of radioactive waste and the links between these stages must be taken into account. General requirements with this meaning are formulated in § 3 with additional specifications in § 4.

Principle 9: Plant safety. The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime. The regulations refer to the regulations that regulate the radiation protection of facilities in operation. Safety requirements for nuclear facilities are formulated by the Swedish Nuclear Power Inspectorate, SKI.

2.3.2 THE INTERNATIONAL RADIATION PROTECTION COMMISSION'S BASIC PRINCIPLES FOR RADIATION PROTECTION.

The International Radiation Protection Commission (ICRP) has specified three basic radiation protection principles that are of central importance in all radiation protection contexts and, thereby, for SSI's activities. These are:

Justification. No activity is to be introduced until it has been shown to provide greater advantages than disadvantages to society. In this context, "activity" means the nuclear activity that has generated the waste. The basic principle of justification with regard to the management of nuclear waste can therefore not be questioned at this stage. The waste has been generated as a result of previous decisions and, under the Act on Nuclear Activities and the Radiation Protection Act, the licensee (the nuclear power utility) is obliged to manage the waste.

Optimisation: All radiation doses to individuals, the number of exposed individuals as well as the probability of receiving doses must be kept as low as reasonably achievable, taking into account economic and social factors. This is often called the ALARA principle (i.e. As Low As Reasonably Achievable).

Dose limitation. The individual exposure to radiation ("dose") must not exceed the established limits for the particular circumstances. The dose limit or dose constraint can be seen as a limit for optimisation; thus, the individual doses must not exceed the established limits, even if the collective dose would be reduced as a result.

2.3.3 OPTIMISATION IN CONNECTION WITH WASTE STORAGE

Since 1977, when the ICRP's general recommendations were published [ICRP 26; revised in the form of ICRP 60], optimisation has been considered to be the overriding principle. Optimisation is often used as an instrument to judge whether or not it is reasonable to further reduce the collective dose (the average dose to a population multiplied by the number of individuals in the population, specified in terms of mansievert, manSv) in cases where the level of protection is already high. In such cases, optimisation involves an estimate of the cost of a possible additional measure in the form of further protection work, balanced against the reduction of the collective dose as a measure of the improvement in radiation protection.

SSI's board has found it reasonable that measures to prevent a statistical fatality may cost MSEK 5-25, which corresponds to about MSEK 0.4-2 per saved manSv. Following SSI's decision, the Swedish nuclear utilities decided to apply a norm of MSEK 4 per saved manSv, which corresponds to about MSEK 80 for a saved statistical fatality.

In § 4 of the regulations, requirements are made that optimisation must be achieved in connection with final management. Thus, the various radiation protection measures must be reasonably balanced in comparison with each other as well as optimised as a whole. This means that doses to personnel and the general public inside and outside Sweden as well as during and after implementation shall be taken into account in the optimisation.

The ICRP [Publication 46] has stated that optimisation for waste management can be applied in connection with:

- "A comparison of design alternatives for a specific facility such as a waste repository.
- A comparison of different disposal options for particular waste streams.
- A comparison of different overall management systems for particular waste streams.
- A comparison of complete waste management systems, including conditioning, storage, transport and disposal alternatives for a given source or practice".

The ICRP has recently [Publication 77] further clarified its policy within the waste area.

It is worth taking all of the above points into consideration. However, SSI is aware of several limitations with respect to the possibility of fully optimising final management as a whole. Internationally agreed requirements comprise one such limitation, e.g. for the transport of waste and spent nuclear fuel outside the facility, which is sometimes higher than an optimisation of the activity as a whole would require. Formal reasons for such an implication can thus limit the possibility of allocating resources so that transport, e.g. inside the repository, is allocated more resources at the cost of external transport.

Dose limits for personnel and the general public as well as requirements concerning optimisation in connection with the operation of nuclear facilities are established in SSI's regulations concerning health physics and the limiting of releases [SSI FS 1994:2 and 1991:5]. In addition to this, there may be, depending on the proposed solution of the proponent, the need in connection with optimisation to balance doses from operation against doses received after the closure of a repository. In order for such an optimisation to be meaningful, it is only possible to take into account the collective dose contribution that can be expected with an accuracy that is in reasonable proportion to the well-known conditions of the operating stage. Doses from a repository in a remote future, of an order of magnitude of 10,000 years or more, cannot be taken into account with an accuracy which is in proportion to the relatively accurate forecasts of operation.

In order to be able to use the collective dose as a tool in connection with the optimisation of radiation protection, necessary conditions for the calculation must exist. In § 4 of the regulation, it is specified that the outflow of radioactive substances for a period of 1,000 years after repository closure must be included in the collective dose calculation. The selection of the time-scale of 1,000 years is connected to the classification into time periods (§§ 10 – 12). In order to take into account the possibility that an outflow of radioactive substances can also result in doses in the future from radioactive elements with long half-lives, dispersed globally, the dose calculation must be carried out for a longer period of time than 1,000 years and in § 4, 10,000 years is therefore specified as the upper boundary for the calculation. Thus, the annual global collective dose (as a result of an outflow over a period of 1,000 years) is calculated and totalled for a period of 10,000 years.

For releases of e.g. carbon-14 from nuclear facilities, relatively accurate calculations can be performed of the additional dose over 10,000 years. However, for certain releases, limited knowledge of the biosphere can limit the possibility of the proponent performing realistic calculations. Thus, the result of collective dose calculations must not be considered as an accurate prediction of the collective dose but as a tool to compare different alternatives. For this reason, SSI does not require that the collective dose should be limited. Results of dose calculations for the outflow of radioactive substances can be compared with each other and the calculations can be used as arguments by the proponents in the safety report. If several alternative solutions are considered to be equal from other standpoints, the collective dose can serve as a guideline. In such cases, the deciding factor will be the optimisation principle rather than a collective dose limit.

2.3.4 BEST AVAILABLE TECHNIQUE

Within certain areas, SSI wishes to issue general requirements regarding the quality of work relating to technical solutions and designs (§ 4 of the regulations). SSI has adopted the concept of best available technique (BAT) in these regulations. This concept is already used internationally in various environmental protection contexts, including in the Helsingfors and Oslo/Paris conventions to protect the marine environment of the Baltic Sea and the Northeast Atlantic [SÖ 1976:13, SÖ 1994:25], and is of central importance to the Environmental Code. The application of the best available technique to specified release sources contributes to ensuring that the state of the environment does not show any negative deviation from the environmental quality norm, i.e. the highest accepted impact on the environment from all sources. This reasoning recalls the reasoning behind dose limits and dose constraints within radiation protection. However, it also has other implications, which are examined in greater detail in Section 2.3.5 Relationship between the Best Available Technique and Optimisation.

The term "best available technique" must not be interpreted in a strict sense to mean the efficiency or cost of the technique, e.g. through requirements that an endless number of cleaning systems should be connected to each other to prevent releases. Furthermore, the "best technique" does not concern requirements with respect to techniques that may exist in the future. Instead, what is meant is techniques that have been tried and tested in accordance with accepted scientific methods. However, the "best available technique" can also mean techniques that are considered to have development potential with an economic input that is reasonable in relation to the benefit to be gained from the development.

The provisions of the Environmental Code mean that an assessment of what is the best available technique must take into account both the benefits and the cost of the implemented measures, which is also stated in the definition used in this regulation (§ 2). In the Environmental Code, the benefits from the implemented measures are given a more prominent place than, e.g. in the Helsingfors and Oslo/Paris Conventions.

2.3.5 RELATIONSHIP BETWEEN THE BEST AVAILABLE TECHNIQUE AND OPTIMISATION

At an early stage in radiation protection history, when protection measures were formulated for X-rays and laboratory sources such as radium, there was a straightforward relationship between protection measures implemented at source and reduced doses. However, when releases from nuclear power plants are to be regulated, a complex event sequence must be studied. New concepts, such as "critical group", were formulated and became important within radiation protection. The dose to the critical group is a measure of doses to the individuals who are most exposed to a certain radiation source. According to the ICRP, the group can be an actual group of people, or a hypothetical group.

In particular, the need for abstract concepts as a link between releases and doses shows that the chain from radiation protection measure to dose reduction has become more difficult to predict in certain cases. When hypothetical releases from a repository in a remote future are assessed, the situation is even more complex. The individual receiving the dose can, depending upon the calculation, be a person living 50,000 or one million years in the future. Furthermore, when such a time span is involved, there may also be reason to reflect on uncertainties regarding the existence of the human species. In such circumstances, it is reasonable to implement certain radiation protection measures already at present, even if the results – in the form of reduced doses – cannot be assumed to manifest themselves until sometime in the remote future. In these cases, SSI considers that the concepts of best available technique and optimisation should be applied in parallel.

Optimisation assumes an object whose protection can be placed in relation to the cost of the work, i.e. that an exposed group of people can be identified and that the effects can be quantified so that the benefits of the protection measures can be converted into costs. Such an analysis can provide a basis for optimisation. However, keeping doses as low as reasonably achievable (ALARA) may also mean making an effort to limit doses even if no strict calculation is possible. Nevertheless, below, optimisation is equated – somewhat simplified - with radiation protection which is based on a strict cost/benefit analysis.

In connection with routine releases from an existing plant, the collective dose can be calculated relatively simply. If other effects can be considered to be negligible, the best available technique and optimisation concepts will acquire similar meanings. An optimisation cannot be carried out as simply when the benefit from protection cannot be quantified, e.g. in connection with a release, the probability of which is difficult to define, or whose consequences affect the environment in a way that cannot be quantified using the collective dose. On the other hand, the best available technique can be used to achieve a generally high level in the work involving environmental and health protection which is considered to be valuable to society without it being possible to quantify the value in greater detail.

The difficulties of predicting the development of society in a long-term perspective are another obstacle to optimisation, as a matter of principle, in the context of final management. It is not possible to predict what the biosphere will look like within a remote future. Our lack of knowledge makes it impossible to achieve an optimisation of a repository (or an optimisation of any other part of the final management system) for these time spans. At the same time, it is possible to apply the general premise that a minor release under all conditions is better than a major release, even if the society which is affected is unknown. For this reason, a reasonable requirement for a repository should be that the barrier system must be as robust as possible. Such an analysis is also possible – certain components in the analysis of a repository, e.g. the analysis of geological conditions, may be relevant even in a million-year perspective. A repository whose barriers fulfil reasonable safety requirements can be said to meet the BAT requirement.

Table 1: Overview of the meanings of the best available technique

	Present day, well-known conditions	**Remote future**
Protection of human health	BAT ≈ optimisation, cost/benefit analysis	BAT ≈ good protective capabilities and robustness
Protection of the environment	BAT ≈ good protective capabilities and robustness	BAT ≈ good protective capabilities and robustness

2.3.6 SUMMARY OF THE HOLISTIC APPROACH ETC.

- The final management of spent nuclear fuel and nuclear waste must be optimised and must take into account the best available technique.

- There are limitations on the possibility of optimising radiation protection in a long-term perspective.

- A collective dose calculation must be presented for the solution proposed in the application.

2.4 Protection of Human Health (§ 5)

2.4.1 GENERAL

Radiation from the cosmos, the ground and from the radioactive substances naturally occurring in the body, results in a dose which is on the order of magnitude of 1 mSv (millisievert) per year. Radiation from the ground varies and human beings are also exposed to other types of radiation, e.g. from radon in indoor air and from the medical use of radiation in connection with examinations and treatment. The average value of the individual dose in Sweden, from all sources, is on the order of magnitude of 4 mSv per year.

The dose limit recommended by the ICRP for individual members of the general public as a result of activities involving radiation is 1 mSv per year. This recommendation has obtained legal status within the EU through the Council Directive 96/29/EURATOM. This directive must be implemented in the member states no later than by May, 2000. However, in Sweden, this dose limit has applied for about ten years through SSI's regulations concerning dose limits in connection with activities involving ionising radiation [SSI FS 1989:1].

A licensee cannot be responsible for the consequences of releases from facilities other than those that it owns. In order to take into account the possibility of the exposure of one and the same individual to releases from several facilities, special dose constraints can be determined for individual activities. The dose constraint is set so that individuals will not receive radiation doses exceeding the dose limit, i.e. 1 mSv per year for individual members of the general public, even if several sources should contribute to the exposure. Thus, SSI has a limited release from nuclear power plants so that normally, the dose does not have to exceed one-tenths of the dose limit, i.e. 0.1 mSv per year [SSI FS 1991:5]. This means that the licensee must demonstrate, using radio-ecological dispersion models, that individual members of the general public are not exposed to higher radiation doses than 0.1 mSv per year, as a result of releases from its own activity. The constraint concerns the dose to the group of people who, as a result of age, living habits and place of domicile, receive the highest radiation dose, i.e. the critical group [ICRP 43].

Even if ten facilities existed in the same region, it would be improbable that all of the facilities would have identical critical groups. Therefore, the constraint of one-tenths of 1 mSv/year entails a high protection level.

2.4.2 PROTECTION OF HUMAN HEALTH FROM OPERATIONAL ACTIVITIES

The same release regulations as for the operation of nuclear power plants, i.e. that the dose to the critical group should not exceed 0.1 mSv per year, apply with respect to operational activities which may be needed for the management of waste or spent nuclear fuel, such as an encapsulation plant for spent nuclear fuel. These regulations are also applicable for activities at a repository prior to closure. This is stated in the footnote to § 5. SSI is currently reviewing the relevant regulation, SSI FS 1991:5. Health physics in connection with work at the nuclear facilities is covered by SSI FS 1994:2, which is also referred to in the footnote to § 5.

In the case of these activities it must be possible, as for activities at nuclear facilities, to implement measures on a continuous basis in order to limit releases, including the measure of completely shutting down the activity.

2.4.3 PROTECTION OF HUMAN HEALTH FROM A CLOSED REPOSITORY - RISK CONCEPT AND LEVEL OF INDIVIDUAL PROTECTION

Unlike ongoing activities, future releases from a closed repository and the resulting damage which can arise are hypothetical, known as potential exposure [ICRP Publication 64]. This results in difficulties in using criteria which, like those for the ongoing activities, are based on "actual" doses to e.g. the critical group. These difficulties are due to the uncertainty of whether an outflow will occur and of the consequences of such an outflow. An analysis is always associated with uncertainties concerning whether and when a release occurs, the dispersion pathways that the released radionuclides have in the geosphere and in the biosphere as well as the geographical location of the exposed individuals in relation to the outflow zone and their dietary and living habits.

Due to the special uncertainties that exist in connection with potential exposure, SSI has chosen to specify the individual protection criteria (for humans) in the form of an annual risk of harmful effects as a result of ionising radiation. The use of the concept "risk" relates to other protection work and facilitates a coherent societal assessment of the dose commitment to individual members of the public.

The "risk" referred to here concerns a repository undisturbed by man. The issue of the possibility of different types of intrusion into the repository is discussed in Section 2.6 Intrusion.

The concept of "risk" is defined in these regulations as the probability of the harmful effects (fatal and non-fatal cancers as well as hereditary damage) as a result of an outflow from the repository, taking into account the probability of the individual receiving a dose as well as the probability of harmful effects arising as a result of the dose. SSI has used the ICRP's definition of detriment [ICRP 60] in the assessment of the harmful effects of radiation. The detriment is described in greater detail in § 2 as well as in Section 2.2.4 Harmful Effects.

A repository must be designed so that no further measures have to be implemented after closure to prevent or limit the outflow of radioactive substances from the repository. Institutional control and knowledge of the location of the repository in a remote future cannot be assumed. The requirement regarding sustainable development in the 1992 Declaration of Rio means that scope must also be left for the use of other energy sources in the future, which may be environmentally hazardous. If an energy source which is used in fifty years' time can restrict the scope of the accepted harmful effects of energy production for thousands of years, it follows that the source must be regulated by very stringent requirements. Therefore, the impact from the repository must be in balance with the time that the energy source is used. It can also be assumed that in a certain region, there are 10 repositories, each with an inventory corresponding to that which is currently expected in the case of the Swedish repository. In this case, hypothetical outflows from the various repositories could overlap with each other and result in a greater impact on the population of the region. Other forms of future energy production can also, in the same way, result in a greater impact.

In order to take into account the interaction between various future risk sources, of which the repository is one, SSI requires that the risk from the repository to individuals who are representative of an exposed group must be lower than the risk that applies to the critical group near nuclear facilities in operation. Thus, SSI has decided to specify, in these regulations, that the annual risk of harmful effects as a result of the repository must not exceed 10^{-6}, i.e. one in a million . With ICRP's probability coefficient for cancer and hereditary effects of 0.073 per sievert, this risk level corresponds to an annual expected dose of about 15μ Sv.

2.4.4 ASSUMPTIONS FOR CALCULATIONS

As discussed above, risk is the product of the probability of receiving a radiation dose and the harmful effects of the radiation dose. This can be described as

$$E(D) \times \gamma$$

where E(D) is the expectation value of annual dose, multiplied by the probability of harmful effects per unit dose, γ (assumed to be 0.073 per Sv).

In many cases it is not possible to calculate an "exact" risk, on the basis of this formula. Instead, the risk must be assessed from the risk picture which is obtained by weighing together consequences and probabilities for different event sequences. In this context, the concept of the risk scenario refers to calculated, or otherwise assessed, consequences and probabilities for a relevant selection of possible event sequences (scenarios). The consequences must be calculated or estimated so that they include uncertainties in the assumptions and data upon which the calculations or assessments are based. The chosen scenarios must in their entirety give a full picture of the risks attributable to the final repository.

The use of risk as a criterion does not mean that the dose calculation can be skipped over. All of the stages in the calculation must be reported. The risk measure used in the regulations can, as described above, be transformed into an expected dose, using the ICRP's factor of 0.073 per Sv.

The proponent's responsibility with respect to risk limitation concerns a larger group that obtains a dose from the repository. It must be ensured that representative individuals from this group are not exposed to risks greater than 10^{-6} per year. The group is not necessarily geographically segregated. Instead it comprises individuals who will receive the highest dose commitment from several future sources.

For releases in a remote future, calculations can only be based on "hypothetical" individuals. The hypothetical group cannot be replaced by an existing group of people whose living habits can be described and for whom both measurements and calculations can be carried out. When calculating a hypothetical dose in a remote future, it is reasonable to take into account sex and age distributions. However, beyond this, the concept of the group does not contribute anything to the line of reasoning besides the average value of the dose and risk, calculated with respect to age and sex, for a hypothetical individual.

The ICRP's Publication 43 proposes that, in certain cases (when the ratio between the average dose to the group and the dose limitation is less than one-tenth), the group must be considered to consist of individuals who receive doses within a factor of ten, i.e. with a factor of about three on both sides of the average dose. This means that the risk has the same range. SSI has decided instead to allow the hypothetical regional group to have a risk range which is ten times greater, i.e. a factor of 100.

If the proponent wishes to perform calculations with respect to an individual who is estimated to have a high dose commitment, it may be acceptable to perform the calculations for an individual who represents the higher level within the range, instead of for an individual who is representative of the commitment of the entire group. In this way, the representative individual, according to the intention of the regulations, can have a risk that is ten times lower. The representativeness of the assumed living and consumption patterns must also be investigated with respect to probability.

Doses higher than 1 mSv in a year, which cannot be ruled out for certain scenarios, e.g. for human intrusion into the repository, imply that the limit recommended by ICRP for protection of individuals of the public is exceeded. Such scenarios must be reported, and will be evaluated, separately.

2.4.5 SUMMARY OF ENVIRONMENTAL PROTECTION

- The limitation of risk has been established taking into account the fact that there shall be scope for future activities such as energy production.

- The limitation applies to a larger group of individuals who are expected to have a dispersion of a factor of one hundred between the lowest and highest risk, as a result of outflow from the repository.

- A final repository must be planned so that the dose to representative individuals in the most exposed group, as a result of outflow from the repository, is not expected to lead to risks in excess of 10^{-6}.

2.5 Environmental Protection (§§ 6 - 7)

2.5.1 GENERAL

§ 1 of the Radiation Protection Act states that the "aim of this act is to protect humans, animals and the environment from the harmful effects of radiation". This means that the purview of the act has been broadened, compared to before; Bill 1987/88:88 of the New Radiation Protection Act states that a new Radiation Protection Act must not "like the current act be limited to mainly providing protection for mankind. Effects on fauna and flora should also be included in the Act, as should protection of the environment in general." "Protection of the environment in general" has not been defined in the Radiation Protection Act. In SSI's opinion, in this context, it should be understood to comprise conditions for biological life in all of its forms and organisation levels, i.e. protection of the environment aims at the protection of organisms.

The opinion which has so far been upheld within radiation protection, on the basis of the ICRP's Publications 26 and 60, has been that organisms in the environment have been protected as long as the conditions for the protection of human beings have been fulfilled ("The Commission believes that the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk", ICRP 60 §16)

Since the ICRP and others formulated these assessments, the focus within the area of environmental protection in general has changed, largely as a result of the Earth Summit on the environment and development in Rio de Janeiro in 1992. The focus is now on concepts such as "biodiversity", "biological resources" and "sustainable use." So far, limited attention has been paid to these issues within radiation protection.

The Convention on Biodiversity [SÖ 1993:97] defines the concept of biodiversity as "the variability among living organisms of all sources, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems." Thus, the importance of all organisms contributing to the structure of the ecosystem is emphasised. Crops, cattle etc. are also included.

The importance of preserving biodiversity has been emphasised by the Government [Bill 1993/94:30]: "Action plans or measures for the preservation of biodiversity should be prepared by the Swedish Environmental Protection Agency (SNV) for follow-up of environmental targets and for an overall assessment of the need for work within the entire field as well as by the competent authority in each sector in the form of sector-specific concrete plans or programmes." SSI has participated in the review of the national environmental targets conducted by SNV on behalf of the Government prior to the 1998 environmental bill [Bill 1997/98:145].

The Rio Convention emphasises that the environment and nature must be seen as resources which local, national or international communities must be able to use in a sustainable manner, now and in the future. In other words, current usage must not jeopardise future generations' use of the resources. The biological resources are dependent on biodiversity, e.g. in the form of genetic material of potential value for further improvement in terms of productivity and quality. Biological resources are only used in certain contexts without intermediaries, i.e. where there is a considerable share of self-initiated conservation of resources. In most cases, the biological resources are exploited via a market. This means that the values of the market will be a part of the resource concept. There may be cases where the market value of the product is reduced due to contamination, even where the radiological significance of such contamination is insignificant. This aspect may have to be taken into consideration in descriptions of the consequences of waste management.

2.5.2 COMMENTS ON THE REGULATIONS

The aim of §§ 6 - 7 is to limit the effects of ionising radiation on organisms occurring in the environment, now and in the future, and to thereby allow for a sustainable use of biological resources.

This aim is presented in § 6 of the regulations, where it is stated that the final management of spent nuclear fuel or nuclear waste shall not, in radiological terms, be detrimental to biodiversity or the sustainable use of biological resources. However, it must be emphasised that biodiversity changes with time for natural reasons. Thus, the aim cannot be to “freeze” the current state of diversity.”

In § 7, it is stated that the description should include biological effects of ionising radiation. Protection cannot be ensured if only abiotic parameters are taken into account, e.g. different types of safety indications. In order to be able to evaluate whether the protection targets are being fulfilled, the biological effects must be described. This means that an estimate of the dose contribution to relevant organisms or groups of organisms must be made.

The description must apply to organisms in the relevant habitats (i.e. the relevant environment for special organisms or groups of organisms) and ecosystems concerned. Of special interest are organisms which are genetically distinctive and which are therefore of potential special importance for the ecological processes, biodiversity and biological resources. These include populations at the margin of the species' distribution area, isolated populations with limited gene transfer within the main area where the species is found, endemic species (species found only in a geographically isolated area) and species threatened with extinction (i.e. where the number of individuals is a specific genetic limitation). The concept of organisms worth protecting also refers to organisms which, from a biological, cultural or economic standpoint, require special treatment.

Furthermore in § 7, it is stated that the description must be based on available knowledge, i.e. existing documentation or documentation which can be prepared in connection with the siting. This means that a detailed analysis can only be carried out in the short term. For long time-scales after the closure of a repository, it is not possible to predict which genetically distinct organisms can occur. In such cases, an evaluation must be made in accordance with the general guidelines presented in §§ 10 - 12 of the regulations, see also Section 2.7 Time Periods.

In §§ 6 – 7, it is implicit that SSI does not, at present, consider it to be possible to provide, in the form of regulations, quantitative criteria for environmental protection. This means that the precautionary principle must be applied, in accordance with the Declaration of Rio. UNSCEAR has recently compiled information [UNSCEAR 1995] on the radiosensitivity of various organisms, based on data from experiments and observed effects in the natural environment. SSI intends to investigate whether evaluation criteria can be derived from existing documentation, based on an ecotoxicological approach.

2.5.3 SUMMARY OF ENVIRONMENTAL PROTECTIOIN

- Biodiversity and a sustainable use of biological resources must be protected from the harmful effects of radiation.
- Analyses and evaluations must be made of biological effects in the environment, and where possible, with particular attention to genetically distinctive organisms and organisms which are otherwise worth protecting.

2.6 Intrusion (§§ 8 – 9)

2.6.1 CONSIDERATIONS

An important premise in discussions concerning requirements connected to intrusion is the responsibility of society for its own conscious actions. Therefore, it is not necessary, in connection with an application, to investigate issues concerning intentional intrusion into a repository which is sanctioned by society. Below, intrusion refers to unintentional human actions, inside or in the immediate vicinity of the repository, which degrade the protective capability of the repository.

In the case of a repository, the consequences of intrusion must be described. The essential point is not to describe the chain of events that leads to the intrusion, but to study the ability of the repository to isolate and retain the radioactive substances after an intrusion, in accordance with §§ 8 - 9 of the regulations.

In cases where the proponent proposes interim storage for a long period prior to final disposal, the question of intrusion into the interim storage facility must also be studied. Intrusion into an interim facility is an unintentional breach of the safety regulations and cannot be compared with an error, e.g. in connection with tunnel drilling in a remote future. In the case of intrusion into an interim storage facility, both the event chain and the consequences of the intrusion are of interest. SSI would like to emphasise that interim storage for long periods of time cannot be accepted as a plan for a final solution.

Questions relating to intrusion will be handled by SSI separately from the discussion concerning the undisturbed repository. Therefore, the stipulations concerning the holistic approach and optimisation in § 4 and in Section 2.3.3 shall not apply to intrusion into a repository. Estimated probabilities concerning human intrusion in the future are so uncertain that SSI does not wish to override requirements on the safety of the undisturbed repository.

On the other hand, it may help to clarify the issue if separate studies of the probability of intrusion were carried out, e.g. in order to investigate possible countermeasures. Bearing in mind the responsibility borne by society for the preservation of information concerning the repository in various archives for a long time after closure, such studies, carried out under the auspices of the competent authorities and from the particular standpoint of the authorities, can also be relevant.

Measures may also be planned and implemented by the proponent to facilitate future access, e.g. for inspection, repair or retrieval. Also in this case, SSI requires that the impact of the measures on the protective capability should be described.

The activities carried out in connection with waste management must be documented. This applies, in particular, to information concerning a repository, its location, inventory and design etc. SSI has issued a special regulation [SSI FS 1997:1] concerning documentation and document retention. The documentation which is currently kept by authorities and licensees has been prepared for purposes other than that of facilitating the understanding of a reader from a remote future. Further instructions and requirements may be formulated when it is time for SSI to adopt a position concerning an application for the construction of a repository.

2.6.2 SUMMARY OF INTRUSION

- If measures are planned to make intrusion more difficult or to make access easier, the consequences with respect to the protective capability of the repository shall be reported.

- The consequences of intrusion must be evaluated on the basis of the repository's ability to isolate and retain the waste after intrusion.

2.7 Time Periods (§§ 10 – 12)

2.7.1 CONSIDERATIONS

Human health and the environment must be given adequate protection, even over very long time-scales. SSI shares the opinion that future doses should not be considered to be less harmful than doses to which man is currently exposed. The same applies to the protection of the environment.

The reasons why individual requirements are made regarding reporting for various time periods are that the hazard of the waste decreases with time and that it is difficult to perform reliable quantitative analyses of radiation protection for a remote future. The latter particularly applies to how the biosphere may be affected by the future development of society. Thus, a discussion must be conducted concerning the protective capability of the repository to protect human health and the environment from the harmful effects of ionising radiation (protective capability) for various time periods.

The absolutely most important period taking into account the hazard of the waste is the first thousand years after repository closure. For this period, SSI is of the opinion that reliable assessments of the repository's protective capability can be made on the basis of quantitative analyses of a scenario which includes the probable development of external phenomena (e.g. climatic changes) and realistic assumptions of the internal phenomena (e.g. the performance of the engineered barriers).

The choice of the thousand-year perspective also has a legal aspect. Requirements are normally made in society with respect to time periods which are shorter than one hundred years. However, there are also examples of hundred-year time-scales. Certain legal aspects in a long-term and historical perspective are examined in SSI-rapport 94-11. In SSI's opinion, a thousand years is a reasonable upper boundary which distinguishes time-periods which can be associated with existing judicial traditions from time-periods associated with an unknown future.

The proponent applying for permission for final management must also describe what can happen to a repository over a longer time-scale, i.e. in a future beyond the initial thousand years after closure. Some very slow sequences, such as the development of geological formations, are being subjected to scientific study for long time sequences. Other aspects or sub-systems of a repository can also be studied for periods which are considerably beyond the previously mentioned thousand-year perspective. Such studies do not mean that the entire protective capability of the repository can be predicted. However, they can provide valuable information without entailing the prediction of doses to living creatures.

In order to assess how the repository’s predictive capabilities change over these extended periods of time, a relevant selection of possible processes (scenarios) for the development of repository properties and the environment are described and analysed. A description is also provided which illustrates different possible processes for the development of the biosphere. The descriptions will provide a view of the repository’s capability to protect human health and the environment under different postulated conditions, i.e. they will provide a comprehensive description of repository robustness. These descriptions should be based on quantitative calculations, as far as possible.

According to § 10, the description must always include a case based on the current (at the time that the application is submitted) biosphere conditions. In this context, known trends must also be taken into consideration, such as land elevation, which is important e.g. in the case of the planned expansion of SFR. It is important to once again emphasise that this does not result in a prediction of actual doses or environmental consequences in a remote future (more than one thousand years). The capability of the repository to isolate and retain the waste can instead be evaluated using safety indicators. One example of a safety indicator is the hypothetical dose to human beings, calculated using a mathematical model for dispersion after a hypothetical outflow from a repository. In the case of a remote future, it cannot be assumed that the calculation models describe the biosphere conditions and living habits correctly. However, the calculated radiation dose can still be used as an indicator of the repository's capability to fulfil its purpose. A repository design which indicates a lower dose can thus be estimated to be better than another design which indicates a higher dose, without the dose having a specific, predictive value.

Uncertainties must always be described for the different time periods (§ 10). This refers to uncertainties in e.g. calculation models, input data and parameter values. The way in which and the extent to which the uncertainties affect the assessment of the repository's protective capability must always be described.

2.7.2 SUMMARY OF TIME PERIODS

- Estimates of the repository's protective capability (capability of protecting health and environment) must be described for two periods, i) on the order of magnitude of up to one thousand years into the future, ii) very long time-scales.

- For periods up to the first thousand years following closure, calculations must be made of risk. In the case of long time-scales, the assessment of the protective capability must be based on descriptions of possible sequences for the repository and its environment. Knowledge of sub-systems must be reported even if the biosphere and other conditions cannot be described with the same degree of reliability.

- The reporting for various time periods must include a case that is based on current biosphere conditions.

2.8 Exceptions (§ 13)

In general, the option of making an exception is provided for, if situations arise which could decisively change the assessment of the situation. This includes future, unanticipated events (e.g. of a technical or political nature) which affect safety assessment.

3 Consequences

The proposed regulations aim at providing adequate protection to health and the environment. However, the direct consequences of the regulations to health and the environment are difficult to estimate, since a reference value in the form of not adopting any measures at all, in the long run, is unrealistic. Neither is any value available to express the benefit against which the costs of final management can be balanced. However, the cost-related aspects are relevant in the comparison between different alternatives for final management, when differences and costs can be balanced against differences in protective capability.

The Act [1984:3] on Nuclear Activities stipulates (§ 10) that the holder of a licence to conduct nuclear activities is responsible for “in a safe manner, handling and disposing of nuclear waste or nuclear material generated by the activity which are not re-used”. The concept of “responsible for” means that the licensees is responsible for covering the expenses for the management of spent nuclear fuel etc. The Radiation Protection Act contains corresponding regulations. In § 13 it is stated that “anyone conducting or who has conducted activities involving radiation shall ensure that radioactive waste generated by the activity is handled and, when necessary, disposed of in a manner that is satisfactory from the standpoint of radiation protection.” The regulations which are currently proposed do not place any new obligations on the licensees. Instead, they clarify the requirements which must be fulfilled to ensure that final disposal can be carried out in a satisfactory manner from the standpoint of radiation protection.

The fee obligation is regulated in detail by the Act [1992:1537] on the Financing of Future Expenses for Spent Nuclear Fuel etc. Funds are continuously being accumulated in the Nuclear Waste Fund through the fee system that is regulated in the Act and these fees will continue to be paid into the Fund for an additional number of years. Every year, the licensees must submit a cost-estimate of future costs. Thus, there is time to adjust the fees over a period of several years, as a more precise estimate of the final expenses can be made.

4 References

85/337 and 97/11	Council Directive, on Environmental Impact Assessments.
96/29/EURATOM	Council Directive, laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation
Dnr 042/942/97	SSI's draft regulations on final management of spent nuclear fuel (in Swedish).
Dnr 8205/2707/95	SSI's review of SKB's research programme 1995 (in Swedish).
IAEA 1995	IAEA Safety Series No. 111 F, ”The Principles of Radioactive Waste Management”.
ICRP 26	ICRP Publication No. 26, ”Recommendations of the International Commission on Radiological Protection”.
ICRP 43	ICRP Publication No. 43, ”Principles of Monitoring for the radiation Protection of the Population”.
ICRP 46	ICRP Publication No. 46, Radiation Protection Principles for the Disposal of Solid Radioactive Waste
ICRP 60	ICRP Publication No. 60, ”Recommendations of ICRP”
Gov. Bill 1993/94:30:	Strategy for biological diversity (in Swedish)
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Gov. Bill 1997/98:45	The Environmental Code (in Swedish)
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SFS 1984:3	Act on Nuclear Activities
SFS 1984:14	Ordinance on Nuclear Activities
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SOU 1996:103	The Environmental Code – Committee Proposal
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SSI FS 1991:5	SSI Regulations on limitation of discharges from nuclear power plants.
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2000 :17 SKI:s och SSI:s gemensamma granskning av SKB:s Säkerhetsrapport 97 -Granskningsrapport-

2000:18 The Swedish Radiation Protection Institute´s Regulations Concerning the Final Management of Spent Nuclear Fuel and Nuclear Waste -with background and comments
Avfall och miljö

STATENS STRÅLSKYDDSINSTITUT, SSI, är en central tillsynsmyndighet med uppgift att skydda människor, djur och miljö mot skadlig verkan av strålning. SSI arbetar för en god avvägning mellan risk och nytta med strålning, och för att öka kunskaperna om strålning, så att individens risk begränsas.

SSI sätter gränser för stråldoser till allmänheten och till dem som arbetar med strålning, utfärdar föreskrifter och kontrollerar att de efterlevs, bland annat genom inspektioner. Myndigheten informerar, utbildar och ger råd för att öka kunskaperna om strålning. SSI bedriver också egen forskning och stöder forskning vid universitet och högskolor.

Myndigheten medverkar i det internationella strålskyddssamarbetet. Därigenom bidrar SSI till förbättringar av strålskyddet i främst Baltikum och Ryssland. SSI håller beredskap dygnet runt mot olyckor med strålning. En tidig varning om olyckor fås genom svenska och utländska mätstationer och genom internationella varnings- och informationssystem.

SSI har idag ca 120 anställda och är beläget i Stockholm.

THE SWEDISH RADIATION PROTECTION INSTITUTE (SSI) is a government authority with the task of protecting mankind and the living environment from the harmful effects of radiation. SSI ensures that the risks and benefits inherent to radiation and its use are compared and evaluated, and that knowledge regarding radiation continues to develop, so that the risk to individuals is minimised.

SSI decides the dose limits for the public and for workers exposed to radiation, and issues regulations that, through inspections, it ensures are being followed. SSI provides information, education, and advice, carries out research and administers external research projects.

SSI participates on a national and international level in the field of radiation protection. As a part of that participation, SSI contributes towards improvements in radiation protection standards in the former Soviet states.

SSI is responsible for co-ordinating activities in Sweden should an accident involving radiation occur. Its resources can be called upon at any time of the day or night. If an accident occurs, a special emergency preparedness organisation is activated. Early notification of emergencies is obtained from automatic alarm monitoring stations in Sweden and abroad, and through international and bilateral agreements on early warning and information.

SSI has 120 employees and is situated in Stockholm.

Statens strålskyddsinstitut
Swedish Radiation Protection Institute

Adress: Statens strålskyddsinstitut; S-171 16 Stockholm;
Besöksadress: Karolinska sjukhusets område, Hus Z 5.
Telefon: 08-729 71 00, Fax: 08-729 71 08
Address: Swedish Radiation Protection Institute;
SE-171 16 Stockholm; Sweden
Telephone: + 46 8-729 71 00, Fax: + 46 8-729 71 08
www.ssi.se