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National plan for achieving the objectives of the OSPAR strategy with regard to radioactive substances

Statens strålskyddsinstitut

Swedish Radiation Protection Authority

AVDELNING/ DIVISION: Avdelningen för Avfall och Miljö/Department of Waste Management and Environmental Protection.

TITLE/ TITEL: National plan for achieving the objectives of the OSPAR strategy with regard to radioactive substances

SUMMARY: This report describes the Swedish plans for implementation of the OSPAR strategy with regard to radioactive substances. Revised release regulations for nuclear facilities are the primary tool in the work for achieving the objectives of the OSPAR strategy. The limitation of releases of radioactive substances shall be based on optimisation of radiation protection (ALARA) and the use of best available technique (BAT). Technical improvements to reduce discharges from the nuclear facilities include changes of daily routines in the waste management. Plans for the future include the introduction of new purification techniques and modernisation of waste facilities.

The implementation of the new regulations, and in particular the introduction of BAT in terms of reference and target values for nuclear power reactors indicates the foreseen reductions of releases for the forthcoming five years. After that time, new reference and target values will be established. The regulations stipulate that monitoring of releases of radioactive substances shall be reported to the authorities. These reports will fulfil the demand for following-up of the progress of implementing the strategy. In particular, in yearly reports the progress towards reaching the target values will be monitored.

SAMMANFATTNING: OSPAR-konventionen för skyddet av den marina miljön i Nordostatlanten trädde i kraft 1998. Konventionen har ratificerats av 16 länder samt EU. Vid OSPAR:s kommissionsmöte i Sintra 1998, kom miljöministrarna överens om att utsläpp och läckage av radioaktiva ämnen successivt ska minska och att halterna av dessa ämnen i den marina miljön ska vara nära noll för artificiella radioaktiva ämnen år 2020, halter i miljön orsakade av historiska utsläpp undantagna. Som ett led i att uppnå strategins mål ska varje land redovisa en nationell plan för genomförande av strategin.

I denna rapport redovisas den svenska planen. Planen innehåller en redogörelse för SSI:s nya föreskrifter för begränsning av utsläpp från vissa kärntekniska anläggningar, en beskrivning av de förändringar som berörda kärntekniska anläggningar planerar för att minska utsläppen, en översiktlig tidplan för reducering av utsläpp samt hur genomförandet av planen kommer att övervakas av SSI.

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National plan for achieving the objectives of the OSPAR strategy with regard to radioactive substances

Submitted by Sweden

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Summary

1. This report describes the Swedish plans for implementation of the OSPAR strategy with regard to radioactive substances. It is foreseen that the plan will be updated and revised when necessary. The details of the national plan can be summarized as follows:

2. *Modifications of discharge authorisations.* Revised discharge regulations for nuclear facilities entered into force 1 January 2002. A main objective of the new regulations is to limit and decrease the releases of radioactive substances from the nuclear facilities. The limitation of releases of radioactive substances shall be based on optimisation of radiation protection (ALARA) and the use of best available technique (BAT). The regulations are the primary tool in the work for achieving the objectives of the OSPAR strategy. The discharge regulations for non-nuclear facilities are presently being revised.

3. *Technical improvements to reduce discharges*. Changes of daily routines in the waste management are presently used to reduce discharges from the nuclear facilities. Plans for the future include the introduction of new purification techniques and modernisation of waste facilities. Both in the short and the long-term view it is primarily the releases of activated corrosion products that will be reduced.

4. *Forecasts to the year 2020 including intermediate goals*. The implementation of the new regulations, and in particular the introduction of BAT in terms of reference[1] and target[2] values for nuclear power reactors indicates the foreseen reductions of releases for the forthcoming five years. After that time, new reference and target values will be established. This will enable the competent Swedish Authority (The Swedish Radiation Protection Authority) to effectively oversee that the reduction of discharges will meet the objectives of the Strategy by 2020.

5. The Swedish Parliament has established 15 environmental quality objectives. According to the environmental quality objective “a safe radiation environment”, the concentrations of radioactive substances in the environment emitted from all human activities will by the year 2010 be so low as not to represent a threat to human health or biological diversity. From each practice, the additional annual individual dose to members of the public will be lower than 10 microSv. For Swedish nuclear facilities, the dose to members of the public is at present below 10 microSv per year.

6. *Monitoring, and reporting on, progress towards the intermediate goals.* The regulations stipulate that monitoring of releases of radioactive substances shall be reported to the authorities. These reports will fulfil the demand for following-up of the progress of implementing the strategy. In particular, in yearly reports the progress towards reaching the target values will be monitored.

[1] The reference value shall show the present normal and optimised level of discharges from a nuclear power reactor

[2] The target value shall show the level to which the discharges can be reduced during a specified time.

Introduction

7. At the 1998 Ministerial and Commission meeting under the OSPAR Convention, the Contracting Parties agreed on an OSPAR Strategy for radioactive substances, also summarised in the Sintra Declaration. The objective of the Strategy is to prevent pollution of the maritime area from ionising radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background for naturally occurring radioactive substances and close to zero for artificial radioactive substances. Effects from historical discharges are to be excluded.

8. At the OSPAR Commission meeting in Copenhagen 2000, the Commission considered that it was a priority for Contracting Parties to present to the Commission by 1 June 2001, and at the latest by December 2002, details of their national plans for achieving the objective of the OSPAR Strategy with regard to Radioactive Substances. These national plans should include information on:

- Modifications of discharge authorisations;
- Technical improvements to reduce discharges;
- Forecasts to the year 2020, as precise as possible, of anthropogenic discharges and discharges of radioactive substances which may reach and affect the maritime area, according to sector/activity and according to the region of the maritime area affected or likely to be affected.

9. At the OSPAR Commission meeting in Valencia 2001, the Commission decided that the details of the national plans should be provided at the latest by 1 July 2002. The Commission also decided that the Radioactive Substances Committee will develop, by its meeting in 2003, for consideration by the 2003 Ministerial Meeting of the Commission:

- A statement of intermediate goals which are forecast to be achieved under each of the national plans between 2003 and 2020, and the dates by which they are expected to be achieved;
- Proposals for monitoring, and reporting on, progress towards those intermediate goals.

10. In May 2001, Sweden submitted to the Commission a draft report describing the preliminary plan for achieving the objective of the OSPAR strategy. The present report is an update of that draft report. The plan will be updated and revised when necessary. The plan considers discharges from both nuclear and non-nuclear facilities, but the emphasis is put on nuclear facilities.

Nuclear facilities

MODIFICATIONS OF DISCHARGE AUTHORISATIONS

Legislation and regulations – general background

11. The aim of the Swedish Radiation Protection Act (SFS 1988:220) is to protect humans and the environment against harmful effects of radiation. In adhering to this general goal, licensees have the full responsibility to take the measures and precautions required to prevent or counteract harm to humans and the environment. Furthermore, the licensee has to maintain properly the technical devices and the measuring and radiation protection equipment used. Accordingly, the operators of nuclear facilities have the responsibility for control and measurements of releases of radioactive substances. The Radiation Protection Ordinance (SFS 1988:293) states that the

Swedish Radiation Protection Authority (SSI) may issue regulations concerning the provisions in the Act, which is fairly general and the provisions are thus further specified by SSI`s regulations. In 1977, on the basis of the authorisation granted in the Ordinance, SSI issued the first general regulations concerning limitations of releases of radioactive substances from nuclear power plants. Minor revisions of the regulations have been made during the period of more than twenty years that the regulations were in use (SSI FS 1991:5). A major revision of the release regulations entered into force 1 January 2002 (SSI FS 2000:12).

New regulations – modifications of discharge authorisations

12. The new regulations (SSI FS 2000:12) concerning protection of human health and the environment from releases[3] of radioactive substances from certain nuclear facilities are valid for nuclear power reactors, research reactors, fuel fabrication facilities, interim storage of spent fuel, and waste disposal facilities during their operating phase (shallow land burials for low-level waste are excluded).

13. The main objective of the regulations is to limit and decrease the releases of radioactive substances from the nuclear facilities. The limitation of releases shall be based on optimisation of radiation protection (ALARA – As Low As Reasonably Achievable) and use of the best available technique (BAT).

BAT and ALARA

14. The concept of BAT shall be used as a complement to the ALARA-concept. In the regulations, BAT is defined as “the most effective measure available to limit the releases of radioactive substances and the harmful effects of the releases on human health and the environment which does not entail unreasonable costs”. There are similarities between ALARA and BAT but there are also differences making the two concepts complementary. ALARA focuses on individual doses and stems from risk estimates for stochastic effects proposed by the International Commission on Radiological Protection (ICRP). ALARA has proved to be an effective tool for managing risks to humans after low-dose exposures taking into account individual doses, the number of exposed individuals and the likelihood that the exposure will occur. When focusing on the protection of the environment[4] it is not clear that stochastic effects are the most critical when considering other organisms than humans. The precautionary principle, originating from the Rio-conference in 1992, suggests that in order to protect the environment, positive actions may be required before scientific proof of harm has been established. The focus is therefore more on methods that will reduce or eliminate the input of hazardous waste into the environment than determining the assimilative capacities. The precautionary principle implies that concepts like BAT should be applied. A feature of the precautionary principle is that it will enable both present and future generations to meet their sustainable needs by reducing the input of pollutants into the environment. At present, it seems that the precautionary approach using BAT is more efficient than ALARA in taking actions to avoid any possible negative effects on the environment in the future.

Reference values and target values

15. The BAT concept is applicable to all sources of radioactivity at a nuclear facility. However, in the regulations nuclear power reactors are specially emphasised by introducing so called *reference values* and *target values* for the releases of radioactive substances. The reference value shall show the present normal and optimised level of releases from each reactor. Taking the

[3] In this report ”releases” of radioactive substances are the total of ”emissions” to the air and ”discharges” to the marine environment.

[4] Several international organisations, for example ICRP, EU and IAEA, are presently involved in work concerning the protection of the environment. In particular, the EU-project FASSET (Framework for Assessment of Environmental Impact) is coordinated by the SSI.

BAT concept into consideration the facility shall also set up target values for each reactor. The target value shall show the level to which the releases can be reduced during a specified period of time. It is fundamental that the process for setting up reference and target values is based on the understanding of the BAT concept and on an open dialogue between operators and the SSI. This is also a process over many years, as changes and modifications of technical systems need long-term planning. The dialogue will result in a proposal for reference and target values formulated by the operators. This proposal will be scrutinized and approved by SSI. The first reference and target values are set for each reactor from 1 January 2002 and are valid for about five years. At that time new reference and target values will be established.

Dose constraints and critical groups

16. According to SSI's regulations (SSI FS 1998:4) the dose limit for members of the public is 1 mSv per year from all contributing artificial radiation sources. This limit is also in accordance with the EC Basic Safety Standards (BSS) and the International BSS. Taking into consideration that an individual may be affected by dose contributions from more than one facility or source, a dose constraint for a particular site is set to 0.1 mSv per year in the regulations. In these regulations, this constraint shall in effect be regarded as a limit for the doses resulting from the releases (emissions to the air and discharges to the marine environment). The facility has to show that the doses from releases are below 0.1 mSv per year to the most affected individual. To take into account that some of the radioactive substances will be present in the environment for a long time, it is important to compare the dose constraint of 0.1 mSv with the dose commitment from a yearly discharge rather than with the dose from the discharge. SSI has chosen to set the integration time to 50 years when calculating the dose commitment. This time period is supposed to be conservative enough taking the expected operational time for nuclear power reactors in Sweden into consideration.

17. To ensure that the public is sufficiently protected the most exposed individuals in the public are defined as the *critical group* as described in ICRP Publication 60. There are different methods for defining the critical group. One is to identify the critical exposure pathways for each radionuclide and then identify the exposed individuals. Another method is to define a hypothetical group of individuals where all exposure pathways are represented. It is the responsibility of the facility to perform the calculations, but SSI will scrutinize the assumptions. For most facilities it is enough to use a general, more conservative approach because the calculated doses is far below the dose constraint of 0.1 mSv. The choice of a hypothetical group will then be sufficient. If the calculated dose to the hypothetical group exceeds 0.01 mSv (1/10 of the dose constraint) a real (existing) group shall be used as well as more realistic assumptions. In doing that, the most affected area shall be defined, also taking into consideration future use of the land.

Revised dose calculations

18. As a consequence of the new regulations and of the requirements in the EU BSS to make more realistic dose estimates, the earlier dose calculations have been revised. They now also include the six age groups defined in the EC BSS.

TECHNICAL IMPROVEMENTS TO REDUCE DISCHARGES

19. The Ringhals nuclear power plant (NPP) is the only Swedish nuclear facility that discharges into the Convention waters. However, by tradition Sweden has also reported discharges from the Barsebäck NPP which discharges into waters close to the Convention area.

Ringhals nuclear power plant

20. Ringhals is a nuclear power plant with one boiling water reactor (BWR, unit 1) and three pressurised water reactors (PWR, units 2-4), auxiliary facilities for waste treatment, maintenance etc, and a shallow land repository for low-level radioactive waste resulting from the operation of the plant.

Short description of systems to reduce discharges

21. The wastewater to be discharged is purified by particle filtration or ion exchange filters. To reduce the processing efforts, the wastewater is segregated according to contents of activity and chemicals (e.g. detergents and particles in the floor drain). Water containing low levels of activity is discharged without any further treatment. The judgement, however, is based on dose to the critical group rather than on activity. Evaporation of wastewater is not used, since the evaporators installed have too low capacity to process the total amount of liquid. In the recycling of boron in the PWR- units, evaporation is used.

22. The efficiency of the discharge reducing systems may be quantified by comparing the activity discharged with the activity deposited on the clean-up demineralisers of the reactor systems and the spent fuel pools. For Co-58 this "discharge index" is in the range 10^{-3} to 10^{-4} for unit 1 (BWR) and for units 2-4 (PWR) in the range 10^{-2} to 10^{-3}. For Co-60, the ranges of the discharge index are 10^{-2} to 10^{-3} for all four units. On special occasions, for example, when large volumes of water have to be treated in a short period of time or when the filters do not readily take up the physical or chemical forms, the fraction discharged may be higher, i.e., the removal efficiency of the reducing systems is then lower.

23. All tritium produced in the plant is discharged to the environment, although not necessarily in the same year as it is produced.

Present work on improvements to reduce discharges

24. The operator is presently working on minor changes of daily routines in order to reduce discharges. These changes include gaining better knowledge about the systems for purification of wastewater and retention of discharges but also the introduction of new routines to optimise operation of the systems:

- Reduction of the amount of water used to achieve effective purification;
- More accurate follow-up and operation of purification filters for reaching maximum operating conditions;
- In certain cases, transfer of wastewater from one unit to another in order to optimise the use existing facilities.

25. Experiments with new types of purification techniques are also being pursued. In the year 2001, experiments with new membrane techniques were started. If these experiments are successful the technique might be qualified to become an option as BAT and brought into use when larger maintenance or replacement will be necessary in the existing systems. When considering new techniques, it is crucial that the waste management aspect is taken into account as any waste resulting from the new technique must meet the requirements for the disposal systems that are presently in use in Sweden.

26. On the basis of experience from fuel failures in 1992 - 1994, the operator has introduced more stringent regimes for preventing fuel failures, and for fuel replacement in the event of new fuel failures.

27. The main dose contribution to the critical group from the emissions and discharges from the Ringhals site has for many years originated from the emission of noble gases from the BWR (see table 1 in the Annex). Therefore, the operator has focussed on efforts to reduce the environmental impact by installing a recombiner in the delay system for noble gases. In order to further improve the delay of noble gases, the operator has also reduced the leakage of air into the turbine system. As the dose contribution from the discharges (figure 1 and tables 2-5 in the Annex) has been substantially lowered, it has been logical to give highest priority to reduction of the emissions of noble gases.

28. However, in parallel to reduction of emissions, the operator has also implemented modified procedures to reduce the discharges. In Unit 1, a project with the aim to identify each single contributing liquid waste stream has been performed. The second stage will soon be started, where significant contributions to volume or activity will be reduced either by modification of the equipment or by using modified operating procedures.

Future work on improvements to reduce discharges

29. The improvement of daily routines has been in progress for a couple of years and the result is decreasing discharges of radioactive substances. This will result in minor changes of the waste treatment system design and operations. Experiences gained will form a basis of know-how for future major changes in the systems.

30. An estimate of the time period needed for introducing new purification techniques would be ten years. This would mean that the effects in terms of discharge reductions would primarily be seen during the second decade of the century. This type of new technique, if feasible, is likely to give a significant reduction the discharges.

31. Both in the short-term and the long-term view it is primarily the discharges of activated corrosion products that will be reduced. Discharges of fission products are already small but will also be reduced by the measures mentioned. Discharges of tritium are already at a level that is dependent on the level of production in form of activation of the coolant or boric acid respectively (PWR). Discharges of tritium are not affected by the reduction of water volume.

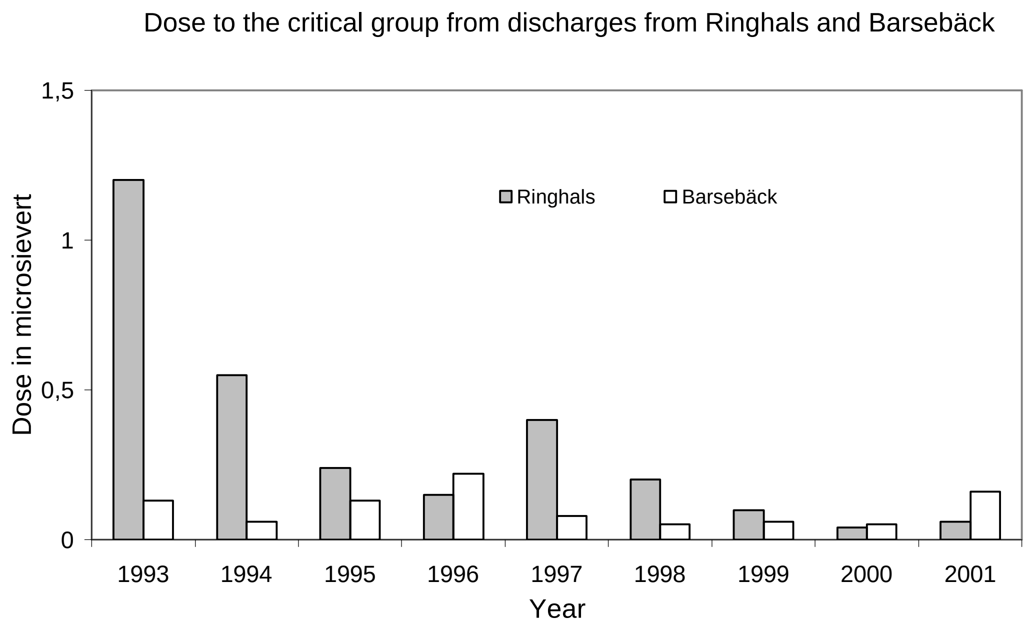

Figure 1

Barsebäck nuclear power plant

32. Barsebäck is a nuclear power plant with one boiling water reactor (Unit 2) in operation, and auxiliary facilities for waste treatment, maintenance etc. In accordance with governmental decision, the Barsebäck Unit 1 was closed down permanently on 30 November 1999.

Short description of systems to reduce discharges

33. Clean-up of wastewater is performed by using ion exchange filters in the reactor cleaning circuit, ion exchange filters for condensate cleaning, and mechanical and ion exchange filters for separation of particulates and ionogenic contaminants from the wastewater in the waste fa-

cility. An evaporation plant can be taken into use if a fuel failure should occur. The operator has adopted a fuel failure strategy. Systems for clean-up of air include recombiners and sand tanks for retention of noble gases in the process gases, and carbon filter beds for ventilation during operation. Measurement of filter and ion exchange masses during 1992 - 1998 gives an average value of 3.9 10^{12} Bq per year. The discharge value to the sea during 1992 - 1998 gives an average value of 7.2 10^{10} Bq per year (excluding C-14 and tritium). The efficiency is 98.2%.

34. The discharges have shown downward trends over the years. During the last eight years there was a transient peak in 1996 (see table 6 in the Annex). In that year, an intensive testing campaign took place, initiated by safety regulations. This resulted in large volumes of wastewater and elevated discharges of Co-58 and Co-60 during August 1996. The doses to the critical group from the discharges to water also show an increase during 1996 (see table 7 and figure 1).

Future work on improvements to reduce discharges

35. A future project concerning waste management is *inter alia* aimed at modernising the waste facility, and at improving the routines for handling the laundry.

36. In the policy concerning damaged fuel the new view is that there should be no tramp uranium on the core. Regarding handling of fuel, the routines are under revision.

37. The operator is evaluating the possibility to up-grade the evaporator and to use parts of the closed Unit 1 to the benefit of Unit 2 still in operation, for example using the sand tank for retardation of emissions.

FORECASTS TO THE YEAR 2020 INCLUDING INTERMEDIATE GOALS

38. The regulations (SSI FS 2000:12) concerning protection of human health and the environment from releases of radioactive substances from certain nuclear facilities entered into force 1 January 2002. A main objective of the new regulations is to limit and decrease the releases of radioactive substances. This limitation of releases of radioactive substances shall be based on optimisation of radiation protection and use of the BAT. This is a process that is constrained by the entailed costs. Future release limitations must also be seen in the light of the radiation doses incurred and doses potentially saved by various actions, as well as the total activity released to the environment. It is therefore not realistic to make a reliable forecast of the total reduction of discharges or intermediate for such reductions up to the year 2020.

Reference and Target values

39. The reference and target values for nuclear power reactors give information on planned reductions of releases for a specified period of time. Presently, reference and target values have been set for the four Ringhals reactors until 2006, and for the Barsebäck reactor until 2004. After that time new values will be established. Reference and target values will enable the Swedish Radiation Protection Authority to effectively oversee that the reduction of discharges will meet the objectives of the Strategy by 2020.

40. The planned reductions of releases from the Ringhals reactors are focussed on reducing emissions to air, i.e. the target values are lower than the reference values for specific radionuclides. In the case of discharges there are no differences between reference and target values for the time up to 2006. However, in spite of that, it is a judgement that the discharges may decrease as a consequence of on-going changes in the daily routines and the new technique presently tested. A forecast for the Ringhals NPP shows that over a ten-year period, and on certain assumptions, a reduction of discharges of radioactive substances in the order of ten may be possible. With the introduction of new technique currently explored, and if feasible, preliminary estimates show a further reduction of the discharges by an order of ten in another ten-year period.

41. For the Barsebäck reactor (unit 2) a reduction with a factor of two of the Co-60 releases, the reference nuclide and major contributor to dose, will be achieved during 2004.

Environmental goals

42. The Swedish Parliament has established 15 environmental quality objectives. One of these is "a safe radiation environment" with the general objective that "human health and biological diversity must be protected against the harmful effects of radiation in the environment." One interim target decided by the Parliament is: "By 2010 the concentrations of radioactive substances in the environment emitted from all human activities will be so low as not to represent a threat to human health or biological diversity. The additional annual individual dose to members of the public will be lower than 10 microSv from each practice." Presently, the individual doses to members of the public are below 10 microSv per year for both Ringhals and Barsebäck.

MONITORING, AND REPORTING ON, PROGRESS TOWARDS THE INTERMEDIATE GOALS

43. The baseline situation against which the progress in implementing the strategy should be measured consists of three classes of baseline reflecting discharges, concentrations and doses. The regulations stipulate that monitoring of releases of radioactive substances, the concentrations in the environment and the doses shall be reported to the authorities. These reports will fulfil the demand for following-up of the progress of implementing the strategy. In particular, in yearly reports the progress towards reaching the target values will be monitored.

44. Environmental monitoring around nuclear power plants is performed in a way that is relevant to assess long-term trends, to perform model verifications, and to ascertain compliance with environmental goals. The data show low environmental concentrations of key radioactive substances and do not reveal any significant increasing trends. Although there are no systems in place to assess impact on non-human biota in a general fashion, present knowledge indicates that the discharges from Ringhals and Barsebäck nuclear power plants cause no harm to the marine ecosystems.

Non-nuclear facilities

MODIFICATIONS OF DISCHARGE AUTHORISATIONS

45. The aim of the Radiation Protection Act (SFS 1988:220) is to protect man and the environment against harmful effects of radiation. The Radiation Protection Ordinance (SFS 1988:293) states that the Swedish Radiation Protection Authority may issue regulations concerning the provisions in the Act also for non-nuclear facilities. On the basis of the authorisation granted in the Ordinance, SSI has issued regulations (SSI FS 1983:7) on radioactive waste not associated with nuclear energy giving clearance levels and conditions on handling and disposal of this type of radioactive waste. These regulations are presently under revision.

Present discharges

46. There are around 300 different practices in Sweden possessing licenses from SSI to use unsealed radioactive substances in medicine, research and industry. About 70 of these practices are located in the Southwest of Sweden where the sewage is discharged into the OSPAR maritime area.

47. The total import to Sweden of radioactive substances is reported annually from the importing companies. Thus, SSI has the information on the total activity of each radionuclide used in the country each year. From the hospitals, the most frequent users of unsealed radioactive substances, SSI receive detailed annual reports on the diagnostic and therapeutic procedures (*in*

vivo) with data on numbers of patients as well as the activity of each radionuclide used per patient in each procedure. The hospitals are, however, not required to report the activity discharged.

48. SSI has made an overall estimation of annual use in the year 2000 of unsealed radionuclides and liquid waste production for hospitals, research institutions and pharmaceutical or biotechnical industries in Sweden. The results show that hospitals are by far the most frequent users of unsealed radioactive substances and the dominating radionuclides are I-131 and Tc-99m that are both short-lived. The contribution from other non-nuclear sectors was found to be negligible.

49. The annual amount of activity entering the Northeast Atlantic during 1999 has been estimated to be 4.0 10^{11} Bq per year I-131 and 1.5 10^{11} Bq per year Tc-99m. The major sources are the hospitals in Gothenburg, Halmstad, Malmö and Lund. All these are located close to the maritime area.

FORECASTS UP TO YEAR 2020

50. The regulations for non-nuclear facilities are under revision. It is too early to say how the revision will affect the discharge limits from e.g. hospitals, but it is not foreseen that any considerable changes will be introduced.

Annex: Tables

ANNUAL EFFECTIVE DOSES TO THE CRITICAL GROUP, RINGHALS NPP

Table 1. The average dose to individuals of the critical group resulting from emissions and discharges from the Ringhals nuclear power plant. Emissions do not include the contribution from C-14 (ca 7 microSv).

	Annual effective dose, microSv								
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Emissions	18	36	24	10	2	3.6	0.6	0.23	0.18
Discharges	1.2	0.55	0.24	0.15	0.4	0.2	0.097	0.04	0.06

ANNUAL LIQUID DISCHARGES, RINGHALS NPP

Table 2. Discharges in Bq from Ringhals Unit 1, BWR, 1993 –2001

Nuclide	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
H-3	5.03E+11	8.60E+11	8.32E+11	7.90E+11	4.89E+11	5.49E+11	9,86e+11	5,14E+11	6,73E+11
Co-58	2.45E+09	4.73E+09	4.35E+09	3.94E+09	1.13E+10	3.04E+09	4,25E+09	9,55E+08	8,80E+08
Co-60	4.18E+10	6.89E+10	3.79E+10	2.53E+10	1.08E+11	2.98E+10	1,42E+10	8,60E+09	1,69E+10
Zn-65	4.61E+08	1.24E+09	2.99E+08	1.48E+08	9.05E+08	8.87E+07	2,95E+07	1,65E+06	6,28E+06
Sr-90	2.50E+08	1.57E+08	9.94E+07	5.18E+07	5.92E+07	3.47E+07	2,48E+07	1,17E+07	2,39E+06
Zr/Nb-95	1.05E+09	3.14E+09	1.92E+08	2.02E+08	3.78E+08	1.72E+08	2,67E+09	1,21E+08	1,24E+08
Ru-106		1.75E+08	7.22E+07	3.55E+07	1.29E+08	3.05E+07	2,99E+07		
Ag-110m	1.17E+08	1.01E+08	1.05E+08	2.53E+08	4.76E+08	3.22E+08	2,41E+08	9,42E+07	1,34E+08
Sb-125	1.02E+08	8.06E+08	2.16E+08	1.53E+08	2.50E+09	1.37E+08	6,13E+08	8,46E+07	9,83E+07
Cs-134	2.26E+10	2.67E+10	2.75E+09	3.25E+08	4.21E+08	9.54E+08	1,48E+08	3,04E+07	5,29E+06
Cs-137	4.12E+10	4.06E+10	5.63E+09	1.73E+09	5.33E+09	1.02E+10	2,26E+09	4,21E+08	4,90E+08
Ce-144	6.22E+08	5.54E+08	8.27E+07	3.67E+06	3.23E+07		3,6E+07		
Other nuclides	7.67E+09	9.91E+10	1.79E+10	1.63E+10	2.39E+10	7.65E+09	4,92E+09	1,07E+09	1,47E+09
Total activity (excl tritium)	**1.18E+11**	**2.46E+11**	**6.96E+10**	**4.84E+10**	**1.53E+11**	**5.24E+10**	**2,94E+10**	**1,14E+10**	**2,01E+10**
Total alpha	**2.91E+07**	**1.83E+07**	**5.13E+06**	**3.43E+06**	**6.30E+06**	**1.10E+07**	**3,65E+06**	**6,90E+05**	**3,91E+05**

Table 3. Discharges in Bq from Ringhals Unit 2, 1993 - 2001

Nuclide	1993	1994	1995	1996	1997	1998	1999	2000	2001
H-3	6.45E+12	8.34E+12	4.47E+12	9.87E+12	7.13E+12	8.49E+12	1,41E+13	1,12E+13	1,05E+13
Co-58	6.79E+09	5.34E+09	4.52E+09	4.53E+09	2.27E+09	1.23E+10	1,20E+09	1,25E+09	3,78E+08
Co-60	8.97E+09	1.07E+10	4.61E+09	5.16E+09	2.01E+09	3.44E+09	6,94E+08	1,34E+09	4,63E+08
Zn-65	1.37E+08	1.85E+08	3.51E+07	5.90E+07	1.73E+07	4.11E+07	6,86E+06	1,10E+07	2,77E+06
Sr-90	1.47E+07	1.18E+07	1.26E+07	6.81E+06	3.75E+06	6.10E+06	4,01E+06	4,10E+06	8,45E+05
Zr/Nb-95	8.98E+08	1.25E+09	1.80E+08	1.05E+09	2.85E+08	7.08E+08	2,07E+08	1,44E+08	5,92E+07
Ru-106		1.88E+08	8.48E+07	3.54E+08	2.25E+08	3.35E+08	6,50E+07	1,52E+07	
Ag-110m	9.81E+08	5.60E+08	3.42E+08	1.44E+09	8.95E+08	2.74E+09	2,49E+08	6,54E+08	6,92E+08
Sb-125	1.01E+09	3.92E+08	3.19E+08	8.98E+08	1.27E+09	1.86E+08	1,77E+08	1,23E+09	9,12E+08
Cs-134	2.99E+07	8.15E+06	6.48E+08	9.19E+07	1.26E+07	1.66E+05			7,94E+06
Cs-137	1.24E+08	7.05E+07	9.72E+08	1.90E+08	3.91E+07	1.50E+07	9,84E+06	1,28E+07	3,79E+07
Ce-144	2.39E+07	1.64E+07	3.82E+05	8.34E+06		1.46E+06			2,77E+06
Other nuclides	7.36E+09	1.19E+10	2.11E+09	6.09E+09	1.31E+10	4.91E+09	2,08E+09	3,54E+09	9,33E+09
Total activity (excl tritium)	**2.63E+10**	**3.06E+10**	**1.38E+10**	**1.99E+10**	**2.01E+10**	**2.47E+10**	**4,69E+09**	**8,20E+09**	**1,19E+10**
Total alpha	**1.75E+07**	**1.29E+07**	**2.85E+06**	**9.11E+06**	**1.80E+06**	**3.60E+06**	**2,06E+07**	**1,30E+06**	**3,73E+05**

Table 4. Discharges in Bq from Ringhals Unit 3, 1993 - 2001

Nuclide	1993	1994	1995	1996	1997	1998	1999	2000	2001
H-3	2.01E+13	1.25E+13	6.32E+12	7.92E+12	8.78E+12	6.79E+12	1,13E+13	9,04E+12	8,93E+12
Co-58	2.78E+10	1.86E+10	2.49E+10	9.81E+09	1.07E+10	5.98E+09	1,82E+10	7,62E+09	1,77E+10
Co-60	7.01E+09	3.78E+09	6.18E+09	2.98E+09	3.47E+09	8.12E+08	1,37E+09	9,90E+08	1,55E+09
Zn-65	2.62E+07	1.53E+07	1.60E+08	2.58E+07	2.55E+07	8.42E+06	2,87E+07	1,77E+07	3,38E+07
Sr-90	1.20E+06	1.88E+06	4.56E+06	1.27E+06	1.78E+06	3.99E+06			
Zr/Nb-95	3.32E+09	6.83E+08	4.09E+09	5.75E+08	3.05E+08	2.55E+08	6,48E+08	4,15E+08	9,07E+08
Ru-106		1.26E+08	4.76E+08	3.53E+08	1.22E+07	3.51E+08	1,50E+08	1,64E+07	
Ag-110m	1.02E+09	9.90E+08	2.12E+09	1.36E+09	9.53E+08	2.47E+09	2,18E+09	4,19E+08	4,57E+08
Sb-125	3.88E+08	2.81E+08	6.29E+08	1.01E+09	2.23E+08	4.05E+08	9,35E+07	7,40E+07	1,40E+08
Cs-134	1.27E+09	3.24E+08	2.83E+08	4.60E+08	9.65E+07	2.93E+06	2,07E+07	1,73E+06	
Cs-137	1.25E+09	4.12E+08	3.35E+08	3.79E+08	1.13E+08	9.53E+06	1,86E+07	8,59E+06	3,55E+07
Ce-144	2.71E+07	4.32E+06	5.31E+07	4.76E+07	8.43E+06	9.50E+06	3,15E+06	1,86E+06	6,42E+06
Other nuclides	6.13E+09	4.75E+09	5.64E+09	2.98E+09	1.26E+09	1.08E+09	1,78E+09	1,32E+09	2,81E+09
Total activity (excl tritium)	**4.82E+10**	**3.00E+10**	**4.49E+10**	**2.00E+10**	**1.72E+10**	**1.14E+10**	**2,45E+10**	**1,09E+10**	**2,36E+10**
Total alpha	**7.86E+05**	**1.19E+06**	**2.78E+06**	**1.93E+06**	**6.20E+05**	**4.90E+05**	**7,43E+05**	**3,29E+05**	**6,01E+05**

Table 5. Discharges in Bq from Ringhals Unit 4, 1993 – 2001

Nuclide	1993	1994	1995	1996	1997	1998	1999	2000	2001
H-3	1.70E+13	1.37E+13	1.02E+13	6.85E+12	6.63E+12	1.03E+13	1,42E+13	5,67E+12	4,52E+12
Co-58	1.20E+10	2.80E+10	9.75E+09	4.82E+09	6.41E+09	2.48E+09	9,73E+09	3,17E+09	1,08E+10
Co-60	2.62E+09	3.10E+09	3.27E+09	1.87E+09	1.36E+09	1.08E+09	1,39E+09	7,94E+08	6,81E+08
Zn-65	1.43E+07	1.91E+07	3.82E+07	1.97E+07	1.03E+07	5.78E+06	4,79E+06	8,91E+06	6,26E+06
Sr-90	6.07E+05	6.59E+05	7.97E+05	5.65E+05	2.00E+06				2,01E+06
Zr/Nb-95	3.66E+08	1.26E+09	2.38E+09	3.12E+08	1.73E+08	1.28E+08	4,01E+08	3,44E+08	1,62E+08
Ru-106			1.41E+07	2.47E+07		1.10E+07	3,11E+07		
Ag-110m	8.94E+07	6.41E+07	2.71E+08	2.41E+08	3.52E+08	1.61E+08	1,30E+08	8,01E+07	3,99E+07
Sb-125	1.66E+08	2.81E+08	3.14E+08	3.28E+08	1.74E+08	3.59E+08	6,21E+07	1,49E+08	9,64E+07
Cs-134	9.13E+07	1.77E+07	2.44E+07	5.01E+06	2.92E+07	2.17E+07	3,59E+06		2,08E+07
Cs-137	1.28E+08	5.54E+07	6.00E+07	2.06E+07	3.22E+07	4.30E+07	1,77E+07	8,04E+06	3,16E+07
Ce-144	6.01E+06	8.99E+06	9.14E+06	1.08E+06	9.63E+05		1,47E+06	1,20E+06	4,86E+05
Other nuclides	1.23E+09	4.10E+09	6.25E+09	7.23E+08	1.03E+09	5.51E+08	8,85E+08	1,03E+09	6,88E+08
Total activity (excl tritium)	**1.67E+10**	**3.69E+10**	**2.24E+10**	**8.37E+09**	**9.57E+09**	**4.84E+09**	**1,27E+10**	**5,58E+09**	**1,25E+10**
Total alpha	**3.21E+05**	**2.61E+05**	**5.15E+05**	**2.53E+05**	**1.50E+05**	**6.10E+04**	**2,59E+05**	**2,57E+05**	**2,79E+05**

ANNUAL EFFECTIVE DOSES TO THE CRITICAL GROUP, BARSEBÄCK NPP

Table 6. The average dose to individuals of the critical group resulting from emissions and discharges from the Barsebäck nuclear power plant. Emissions do not include the contributions from C-14 (ca 0.5 microSv).

	Annual effective dose, microSv								
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Emissions	0.02	0.03	0.04	0.04	0.01	0.02	0.03	0.16	0.011
Discharges	0.13	0.06	0.13	0.22	0.08	0.05	0.06	0.05	0.16

ANNUAL LIQUID DISCHARGES, BARSEBÄCK NPP

Table 7. Discharges from the Barsebäck nuclear power plant, Units 1 and 2. Barsebäck Unit 1 was permanently closed on 30 November 1999

Nuclide	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
H-3	5.80E+11	5.30E+11	5.54E+11	1.10E+12	7.60E+11	4.90E+11	6,90E+11	4,00E+11	3,19E+11
Co-58	3.90E+09	4.60E+09	6.16E+09	6.50E+10	5.80E+09	3.70E+09	3,00E+09	1,90E+09	3,09E+09
Co-60	1.50E+10	1.20E+10	2.97E+10	5.20E+10	2.00E+10	9.20E+09	1,50E+10	1,80E+10	3,07E+10
Zn-65		8.90E+07	2.93E+08	4.20E+08	1.90E+08	1.70E+08	1,90E+08	2,50E+08	4,09E+08
Sr-90	4.50E+07	1.38E+06	7.93E+05	1.80E+06	8.80E+05	8.75E+05	1,50E+06	8,57E+05	1,59E+06
Zr/Nb-95	1.15E+08	1.52E+08	5.47E+08	3.70E+08	1.87E+08	5.40E+08	2,44E+08	7,80E+07	4,39E+08
Ru-106									
Ag-110m		1.70E+06	4.41E+07	8.40E+08	2.60E+07	9.50E+07	1,80E+08	1,10E+08	1,68E+08
Sb-125		1.20E+08	7.74E+08	3.50E+08	2.60E+08	4.20E+08	2,30E+07	7,40E+08	5,62E+08
Cs-134	4.80E+08	2.60E+08	3.12E+08	3.10E+07		1.90E+07		1,40E+08	1,12E+09
Cs-137	2.00E+09	1.50E+09	2.48E+09	7.40E+08	8.30E+08	1.00E+09	6,10E+08	1,20E+09	6,97E+09
Ce-144									
Other nuclides	4.59E+09	7.92E+09	1.75E+10	7.43E+10	3.10E+10	2.05E+10	7,17E+09	2,26E+09	5,24E+09
Total activity, excl tritium	**2.61E+10**	**2.66E+10**	**5.78E+10**	**1.94E+11**	**5.83E+10**	**3.56E+10**	**2,64E+10**	**2,47E+10**	**4,87E+10**
Total alpha	**8.59E+5**	**1.57E+5**	**3E+5**	**1.88E+05**	**9.20E+04**	**3.06E+04**	**8,61E+04**	**4,06E+04**	**5,41E+04**

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The Swedish parliament has appointed SSI to be in charge of the implementation of its environmental quality objective *Säker strålmiljö* ("A Safe Radiation Environment").

SSI sets radiation dose limits for the public and for workers exposed to radiation and regulates many other matters dealing with radiation. Compliance with the regulations is ensured through inspections.

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SSI has about 110 employees and is located in Stockholm.

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