R-01-03

Project SAFE

Low and intermediate level waste in SFR-1

Reference Waste Inventory

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June 2001

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Summary

The objective with this report is to describe all the waste and the waste package that is expected to be deposited in SFR-1 at the time of closure. This report is a part of the SAFE project (**S**afety **A**ssessment of **F**inal Repository for Radioactive Operational Wast**e**), i.e. the renewed safety assessment of SFR-1. The accounted waste inventory has been used as input to the release calculation that has been performed in the SAFE project.

The waste inventory is based on an estimated operational lifetime of the Swedish nuclear power plats of 40 years and that closure of the SFR repository will happen in 2030. In the report, data about geometries, weights, materials, chemicals and radionuclide are given. No chemotoxic material has been identified in the waste.

Th inventory is based on so called “waste types” and the waste types’ “reference waste package”. The reference waste package combined with a prognosis of the number of waste packages to the year 2030 gives the final waste inventory for SFR-1. All reference waste packages are thoroughly described in the appendices of this report. The reference waste packages are as far as possible based on actually experiences and measurements.

The radionuclide inventory is also based on actual measurements. The inventory is based on measurements of ^{60}Co and ^{137}Cs in waste packages and on measurements ^{239}Pu and ^{240}Pu in reactor water. Other nuclides in the inventory are calculated with correlation factors.

In the SAFE project’s prerequisites it was said that one realistic and one conservative (pessimistic) inventory should be produced. The conservative one should then be used for the release calculations. In this report one realistic and one conservative radionuclide inventory is presented. The conservative one adds up to 10^{16} Bq. Regarding materials there is only one inventory given since it is not certain what is a conservative assumption.

Sammanfattning

Syftet med denna rapport är att beskriva det avfall och de avfallskollin som förväntas finnas deponerade i SFR-1 vid förslutning. Denna rapport är en del i SAFE-projektet (**S**afety **A**ssessment of **F**inal Repository for Radioactive Operational Wast**e**), det vill säga den förnyade säkerhetsanalysen av SFR-1. Redovisat avfallsinventar har använts som indata till de konsekvensberäkningar som utförts i SAFE-projektet.

Avfallsinventariet bygger på att de svenska reaktorerna har en drifttid på 40 år och att förslutning av SFR sker 2030. I rapporten ges uppgifter om geometrier, vikter, materialsammansättning, kemikalier och radionuklider. Inget kemotoxiskt material har identifierats i avfallet.

Inventariet är baserat på så kallade avfallstyper och avfallstypens 'normalkolli' (Reference Waste Package). Normalkollin kombinerat med en prognos av antalet avfallskollin fram till 2030 ger det slutliga inventariet för SFR-1. Alla normalkollin beskrivs noggrant i rapportens bilagor. De normalkollin som redovisas är i så stor utsträckning som möjligt baserade på faktiska erfarenheter och mätningar.

Även radionuklidinnehållet i normalkollina är baserat på faktiska erfarenheter. Inventariet är uppbyggt på mätningar av ^{60}Co och ^{137}Cs på befintliga avfallskollin och på ^{239}Pu och ^{240}Pu mätningar på reaktorvatten. Baserat på dessa mätningar har resterande inventar tagits fram med hjälp av korrelationsfaktorer.

I SAFE-projektets förutsättningar angavs att ett realistiskt inventar och ett konservativt (pessimistiskt) inventar skulle tas fram. Det konservativa skulle sedan användas för konsekvensberäkningarna. Det finns ett realistiskt och ett konservativt radionuklid-inventar angivet. Det konservativa inventariet omfattar sammanlagt 10^{16} Bq. Däremot finns enbart ett materialinventar angivet då det inte är uppenbart vad som är ett konservativt antagande om de olika materialen.

Innehåll

1 General

1.1 Background

The SFR-1 repository has been in operation since 1988. In the final permit for operation the authorities demanded that the safety assessment of the repository be thoroughly updated at least each 10 year. A preliminary safety report was done in 1983; a final safety report was done in 1987. An update of the final report was published in 1991.

In 1997 a project named SAFE (**S**afety **A**ssessment of **F**inal Repository for Radioactive Operational Wast**e**) was initiated in order to make a complete update of the safety report and the safety assessment. This report is a part of the SAFE project. The report includes a detailed prognosis of the waste in SFR-1 including materials and radionuclide content.

Although the report includes very precise numbers one should keep in mind that this is only a prognosis, done with a specific purpose (to be an input to the calculations in the SAFE project). The assumptions made can sometimes be crude due to the uncertainties that inevitably lie in the future.

1.2 SFR-1

SFR-1 is situated in Forsmark in the northern part of Uppland, close to the Forsmark nuclear power plant. The storage vaults are located in the bedrock, approximately 60 m below the seabed, 1 km off the coast. The underground part of the repository is accessed through two tunnels.

SFR-1 is designed for final disposal of low and intermediate level radioactive waste from the Swedish nuclear power plants and the Central Interim Storage for Spent Nuclear Fuel (CLAB) and for similar waste from other industries, research and medical care.

In total the SFR-1 is intended for 90 000 m^3 of waste. In the previous safety assessment /SKB, 1993/ the total radioactivity in this waste was assumed to be 10^{16} Bq. Today (2001) the waste capacity in the existing parts of the facility is approximately 60 000 m^3 and approximately 27 500 m^3 of waste is disposed.

The repository is designed to isolate the waste from the biosphere in order to avoid harmful consequences to man and environment both under operation and after closure. This is accomplished by the emplacement in rock under the seabed and by the technical barriers surrounding the waste.

SFR-1 is divided into four types of rock vaults:

- The Silo.
- Rock Vault for Intermediate Level Waste (BMA).
- Rock Vaults for Concrete Tanks (BTF).
- Rock Vault for Low Level Waste (BLA).

The rock vaults are connected through a system of tunnels. The design of the first stage of SFR-1 is shown in Figure 1-1.

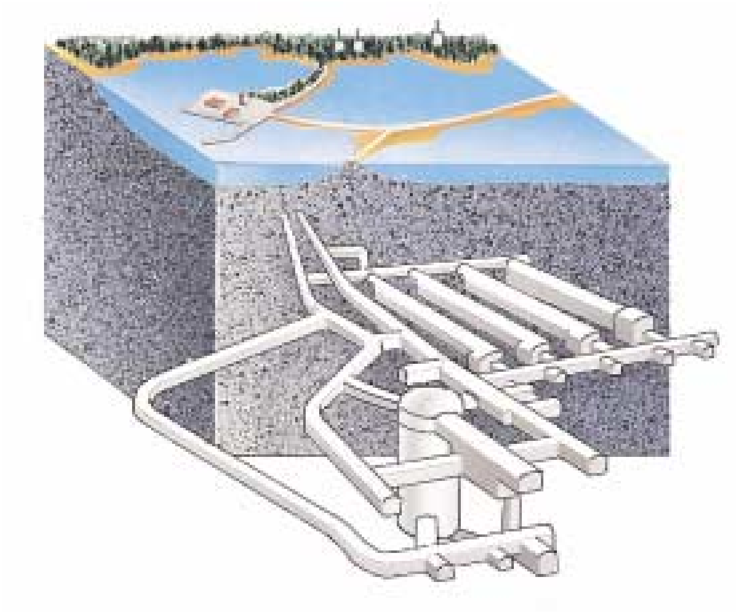

Figure 1-1. SFR-1.

1.2.1 The rock vault for low level waste (BLA)

The waste deposited in BLA is mainly low level scrap metal and refuses placed in standard steel containers. Some of the waste inside the containers is placed in steel drums and others in bales.

The rock vault is 160 m long and has a width of 15 m. Figure 1-2 shows BLA. There are no concrete structures in BLA except the floor.

The containers are placed two in a row and three full height containers in height. Most of the containers are half height and these are piled to a height of six. No backfill is planned.

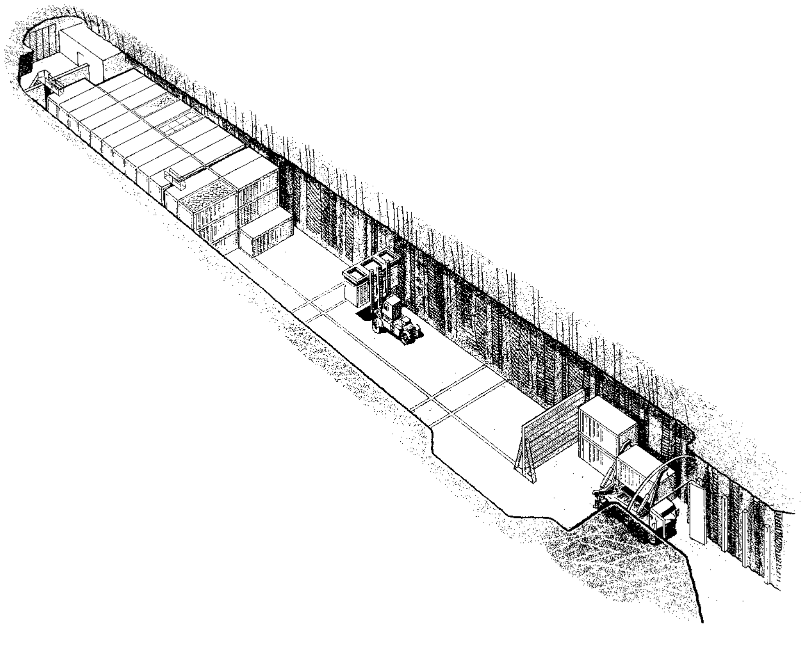

Figure 1-2. The BLA.

1.2.2 The rock vaults for concrete tanks (BTF)

In SFR-1 there are two rock vaults for concrete tanks, 1BTF and 2BTF. The waste placed in BTF is de-watered low-level ion exchange resin in concrete tanks. In addition, some drums with ashes are stored in 1BTF.

The rock vaults are 160 m long and width of 15 m. Figure 1-3 shows the principal picture of the vaults, Figure 1-4 shows a picture from 2BTF.

The concrete tanks, each with a volume of 10 m^3, are piled in two levels with four tanks in each row. A concrete radiation protection lid is placed on top of the pile. The space between the different tanks is backfilled with concrete and the space between the tanks and the rock wall will be filled with, for example, sand stabilised in cement.

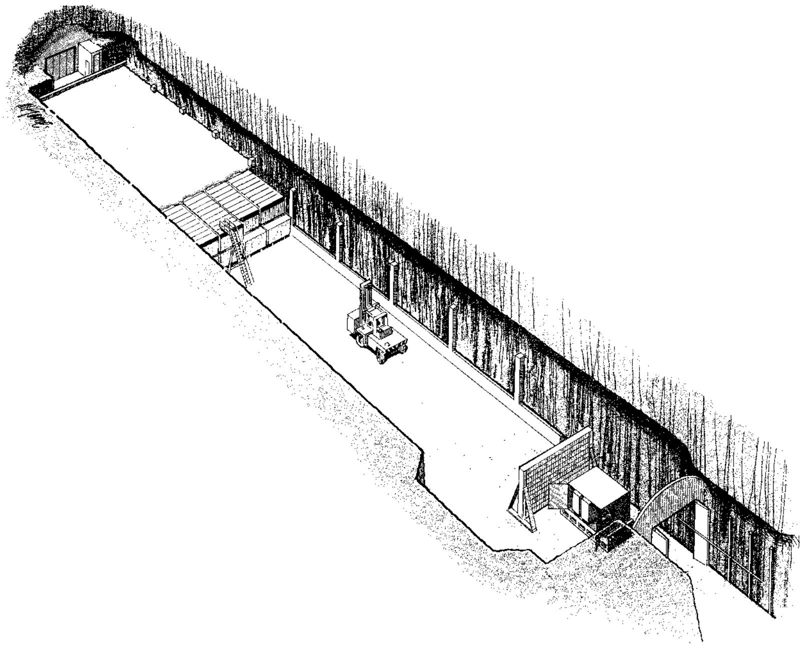

Figure 1-3. *1BTF and 2BTF.*

Figure 1-4. *Picture from 2BTF.*

1.2.3 The rock vault for intermediate level waste (BMA)

The radioactivity in the waste that is deposited in the BMA is mainly lower than in the waste in the Silo. The waste consists of ion exchange resins, scrap metal and trash in a concrete or bitumen matrix. The waste packages are of the same type as in the Silo, i.e. moulds and drums.

The rock vault is 160 m long and has width of 19,5 m. Figure 1-5 shows BMA. The concrete structure in the vault is divided into 15 compartments. The compartments are built like big boxes with concrete walls in between. The waste is piled on top of the concrete floor in a way that allows the concrete moulds to act as support for pre-fabricated concrete lids. The lids are put in position as soon as the compartments are filled. Finally a layer of concrete is casted on top of the lid. Figure 1-6 shows a view over the compartments.

Between the concrete structure and the rock wall there is a 2 m wide space. This space will be filled with sand. The space above the concrete structure could be left unfilled but could also be backfilled. Plugs will be placed in the two entrances to the vault when the repository is closed.

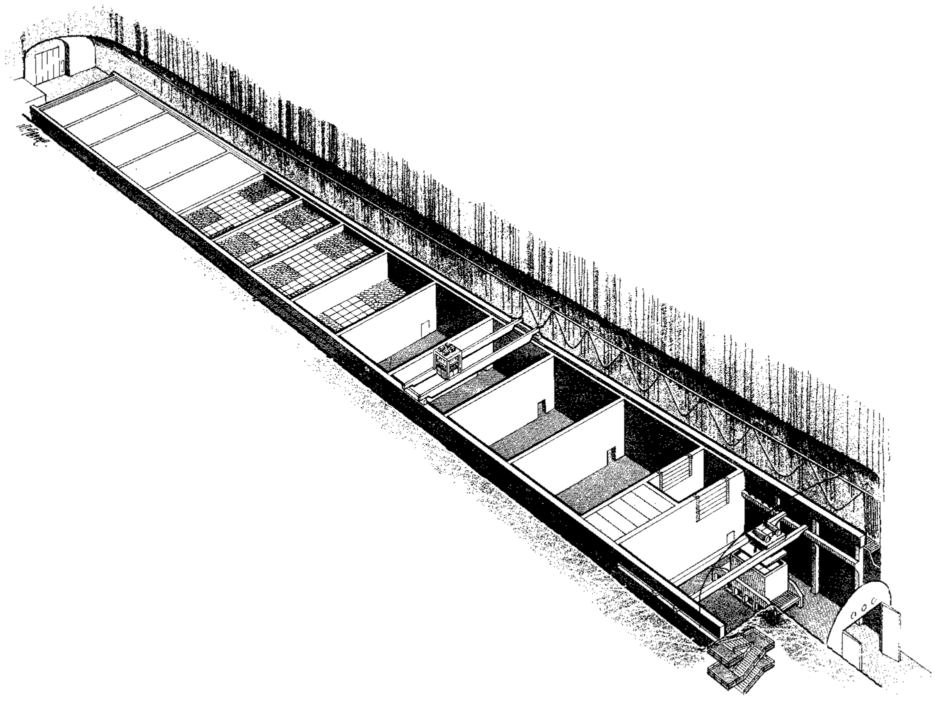

Figure 1-5. *The BMA.*

Figure 1-6. View over BMA.

1.2.4 The Silo

The main part of the radioactivity in the waste for SFR-1 is intended for disposal in the Silo. The waste is mainly composed of ion-exchange resin in a concrete or bitumen matrix.

The Silo consists of a concrete cylinder with the height of approximately 50 m and a diameter of approximately 30 m. Figure 1-7 shows the Silo.

The Silo is divided into vertical shafts with intervening concrete walls. The waste packages are placed in the shafts, normally in levels with four moulds or 16 drums. The voids between the waste packages are gradually backfilled with porous concrete.

The walls of the Silo are made of reinforced concrete with a thickness of 0,8 m. In between the Silo walls and the surrounding rock there is a bentonite backfill, on average 1,2 m thick. The 1 m thick concrete floor in the bottom of the Silo is placed on a layer of 90/10 sand/bentonite mixture. According to present plans the top of the Silo will be a 1 m thick concrete lid. The top of the lid will be covered with a thin layer of sand and then 1,5 m of sand/bentonite mixture (90/10). The remaining void above the sand/bentonite in the top will be filled with sand or gravel or sand stabilised in cement.

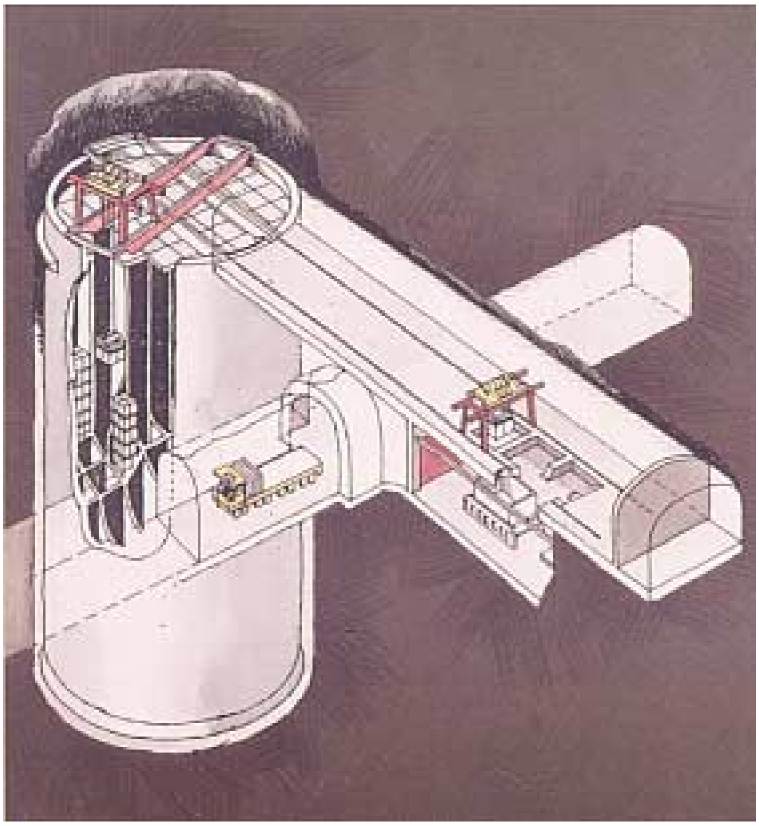

Figure 1-7. *The Silo including some adjacent tunnels.*

1.3 Aim of the study and general assumptions

The aim of this study is to present a waste inventory to be used as input to radionuclide release calculations and other kinds of calculation.

The inventory shall correspond to a completely filled repository; i.e. all present rock vaults should be used. The inventory is based on the assumption that the Swedish reactors should be in operation for 40 years, except Barsebäck 1 which was closed in 1999, and that future production of waste is produced with the same methods that is used today.

Waste in the form of large components or have some other feature that differentiates it from 'normal' waste is expected in SFR-1. In this study this waste is predicted to be deposited in BLA, 1BTF and BMA.

Furthermore, it is assumed that the majority of the Swedish power plants continue to use shallow land burial for their very low-level waste. Today Forsmark NPP, Oskarshamn NPP, Ringhals NPP and the Studsvik research site uses this method.

1.4 Structure of the report

This report is divided in one main part and seven appendices. The main part includes background, some common features for the waste and then a summary of all the waste, present and future, that is or will be deposited in the SFR-1 is presented.

The appendices are:

- Appendix A: A description of how the inventory regarding number of waste packages was calculated.
- Appendix B: A description of how the inventory regarding radionuclides was calculated.
- Appendix C: A thorough description of all waste types in the BLA rock cavern.
- Appendix D: A thorough description of all waste types in the BTF rock caverns.
- Appendix E: A thorough description of all waste types in the BMA rock cavern.
- Appendix F: A thorough description of all waste types in the Silo.

Appendix C–F includes geometry, materials, and radionuclide content for each waste type. Also, for each waste type a reference waste type is defined which is used in all kinds of calculations.

2 Waste packages in SFR-1 – general

2.1 The code system of waste in SFR – abbreviations

The first Swedish commercial nuclear power plant (Oskarshamn 1) has been in operation since the early 70's and consequently has produced waste since then. From the period before that, radioactive waste was produce in research and from the first test reactors. Most of that waste was dumped in the sea. The Swedish programme for final storage of the waste was not formed from the beginning, therefor has the different power plants used different forms of treatment and also different forms of geometries, although the waste has some common features. In order to bring some systematic classification into the waste treatment different waste types has been defined and a code system for these types has been developed. The system is very useful for data transferral between the power plants and the SFR facility.

The code system consists of one letter which denominates the producing plant, and two numbers giving information of what kind of raw waste, treatment method, geometry and in which part of the SFR the waste should be deposited in. A complementary number (given after a ':') could also be used to give information about some feature that differentiates this waste from others of the same kind.

For example the code R.01:9 means ion-exchange resins from the Ringhals NPP solidified in cement in a concrete package (mould) with the side 1,2 · 1,2 · 1,2 m. The waste is meant for disposal in the rock cavern for intermediate level waste (BMA). The ':9' means that is of an older type. In Table 2-1 and in Table 2-2 there are explanations of the different abbreviations.

Table 2-1. Abbreviations in the code system for the nuclear facilities in Sweden.

Aberration	Nuclear power plant
B	Barsebäck NPP
C	CLAB (central interim fuel storage)
F	Forsmark NPP
O	Oskarshamn NPP
R	Ringhals NPP
S	Studsvik Research Site

Regarding the complimentary number the meaning is defined for each type, e.g. for F:05:2 the ':2' means from Forsmark 2 but in B.05:2 the ':2' means that it is drums in bad condition placed in a steel box. The only complementary number generally defined is ':9' which means that it is of an older kind.

Table 2-2. Abbreviations in the code system for treatment etc.

Aberration	Disposal in	Raw waste	Geometry	Treatment
01	BMA	Ion-exchange resin	Concrete mould	Cement solidification
02	Silo	Ion-exchange resin	Concrete mould	Cement solidification
03	-			
04	Silo	Ion-exchange resin	Steel drum	Cement solidification
05	BMA	Ion-exchange resin	Steel drum	Bitumen stabilisation
06	Silo	Ion-exchange resin	Steel drum	Bitumen stabilisation
07	BTF	Ion-exchange resin	Concrete tank	De-watering
08	-	-	-	-
09	BMA	Sludge	Steel drum	Cement solidification
10	BMA	Sludge	Concrete mould	Cement solidification
11	Silo	Sludge	Concrete mould	Cement solidification
12	BLA	Scrap metal and refuse	ISO-container	-
13	BTF	Ashes	Steel drum	Cement stabilisation
14	BLA	Scrap metal and refuse	ISO-container	Cement stabilisation
15	BMA	Ion-exchange resin	Steel mould	Cement solidification
16	Silo	Ion-exchange resin	Steel mould	Cement solidification
17	BMA	Ion-exchange resin	Steel mould	Bitumen stabilisation
18	Silo	Ion-exchange resin	Steel mould	Bitumen stabilisation
19	BTF	Graphite	Steel box	-
20	BLA	Ion-exchange resins	ISO-container	Bitumen stabilised drums
21	BMA	Scrap metal and refuse	Steel drum	Cement stabilisation
22	Silo	Scrap metal and refuse	Steel drum	Cement stabilisation
23	BMA	Scrap metal and refuse	Mould*	Cement stabilisation
24	Silo	Scrap metal and refuse	Concrete mould	Cement stabilisation
99	All caverns	Odd waste	Differs	Differs

For each of the waste type there should be a 'waste type description'. This document includes descriptions of origin of the raw waste, the treatment process, interim storage at the site, transportation, handling in SFR and disposal in SFR. The document also includes the demands put on each waste package regarding general features like ID-number and chemical, physical, radiological and mechanistic features and how to achieve them. This document is made by the waste producers and then approved first by SKB and then by the Swedish authorities. Before the document is approved no disposal in the SFR is allowed. The 'Waste Type Descriptions' are included in the 'Final Safety Report' for SFR /SSR, 2001/.

2.2 Waste containers and matrices

As seen in the previous part, the waste packages in SFR are of many different kinds, but the containers and the waste matrices, i.e. treatment methods, are quite similar.

The containers are basically of six different kinds:

- Steel drums. Standard 200-litre drums. The measures differ a bit but the drums are approximately 90 cm high and have a diameter of 60 cm. In the BMA and the silo the drums are handled four by four put on a steel plate or in a steel box. Both types custom made for the system. In the BTF the drums are handled one by one.

- Concrete moulds. A concrete cube with the side 1,2 m. The walls have usually a thickness of 10 cm, but 25 cm and 35 cm could occur. The moulds are deposited in the BMA and in the Silo. Moulds with low doserate are used to build stabilisation walls in 1BTF.

- Steel moulds. Steel cubes with the same outer dimensions as the concrete mould but with just 5 or 6 mm thick walls. The steel moulds have room for more than 70 % more waste than the concrete ones but with considerable less radiation shielding properties. The steel moulds are used in the BMA and the Silo.

- Concrete tanks. These tanks have the length of 3,3 metres, width of 1,3 meters and height of 2.3 metres. The walls are 15 cm thick. The container has a de-watering system in the bottom of the tank. The tank is used in 1BTF and 2BTF.

- ISO-containers. Standard containers, usually with the dimensions 6,4 m · 2,4 m · 1,3 m but other dimensions can also be used. The containers can hold drums, boxes or bales. There can also be no inner package, just piled scrap metal. The containers are used in the BLA.

- Steel boxes. These boxes are primarily used inside the ISO-containers, but for one waste type (S.19 graphite waste) they are used as outer package. This type is planned to be disposed of in 1BTF.

- ‘Odd’ Waste. Large components as heat exchangers etc could be of interest to dispose off SFR-1. In the SAFE project they are assumed to be made of steel and concrete. The geometry is like a ISO-container, a concrete tank or a mould depending on which rock vault they are supposed to be placed.

The different treatment methods are:

- Cement solidification. Ion-exchange resins or sludge are mixed with concrete in drums or moulds.

- Cement stabilisation. Scrap metal and refuse are placed in moulds and cement is poured over it. Types 13, 14, 21 and 22 area bit different. The waste is placed in 100-litre drums, which is then put inside standard 200 litre drums. Concrete is the poured in-between the drums.

- Bitumen stabilisation. Ion-exchange resins are dried and mixed with bitumen and then poured into moulds or drums.

- De-watering. Wet ion-exchange resin is pumped into a concrete tank and water is removed by suction.

3 Description of waste in BLA

This chapter is a short summary of Appendix C.

3.1 Waste packages in BLA

The BLA is designed mainly to contain scrap metals and refuse. All waste in BLA is handled in ISO-containers. As stated in the previous chapter the containers can hold different smaller packages like drums, boxes and bales. One special type is type 20 (B.20 and F.20). These containers hold drums with bitumenised ion-exchange resins.

3.2 Amount of waste in BLA

The number of the different waste types that is used in the SAFE project calculations is presented in Table 3-1. How the numbers has been estimated is presented in appendix A.

Table 3-1. Number of different waste packages in BLA at the time of closure (2030).

Waste type	Number of packages
B.12	272
B.20	12
F.12	28
F.20	15
O.12	80
R.12	103
S.12	31
S.14	73
Odd packages	64

From the number of waste packages and the reference waste type one can derive the summarised amounts of different materials in the BLA, see Table 3-2.

Table 3-2. Summarised amounts of different materials in BLA.

Material	Weight (kg)	Area (m^2) *
Iron/Steel	$4,6 \cdot 10^6$	$2,6 \cdot 10^5$
Aluminium	$6,5 \cdot 10^4$	$9,5 \cdot 10^3$
Cellulose (wood, paper, cloth)	$4,3 \cdot 10^5$	
Other organic (plastics, rubber, cable)	$1,6 \cdot 10^6$	
Other inorganic (insulation etc)	$2,1 \cdot 10^5$	
Ion-exchange Resin	$9,2 \cdot 10^4$	
Bitumen	$1,2 \cdot 10^5$	

* 'Area' means the area exposed to ground water after closure of SFR-1.

3.3 Radionuclide inventory in BLA

The inventory of radionuclides that is used in the SAFE project calculations is presented in Table 3-3. How the amounts of different radionuclides have been calculated is presented in appendix B.

Table 3-3. Summarised amounts of different radionuclides in BLA at the time of closure (2030).

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
H-3	$6{,}6 \cdot 10^{8}$	Cs-137	$3{,}7 \cdot 10^{12}$
Be-10	$2{,}3 \cdot 10^{4}$	Pm-147	$1{,}9 \cdot 10^{10}$
C-14	$3{,}9 \cdot 10^{10}$	Sm-151	$1{,}9 \cdot 10^{10}$
Cl-36	$8{,}2 \cdot 10^{7}$	Eu-152	$1{,}1 \cdot 10^{8}$
Fe-55	$9{,}5 \cdot 10^{10}$	Eu-154	$7{,}6 \cdot 10^{10}$
Ni-59	$3{,}9 \cdot 10^{10}$	Eu-155	$1{,}3 \cdot 10^{10}$
Co-60	$1{,}0 \cdot 10^{12}$	Ho-166m	$1{,}5 \cdot 10^{8}$
Ni-63	$6{,}2 \cdot 10^{12}$	U-232	$6{,}1 \cdot 10^{4}$
Se-79	$3{,}3 \cdot 10^{7}$	U-234	$2{,}5 \cdot 10^{6}$
Sr-90	$3{,}6 \cdot 10^{11}$	U-235	$5{,}1 \cdot 10^{4}$
Mo-93	$1{,}9 \cdot 10^{8}$	U-236	$7{,}6 \cdot 10^{5}$
Nb-93m	$9{,}7 \cdot 10^{9}$	U-238	$1{,}0 \cdot 10^{6}$
Zr-93	$3{,}9 \cdot 10^{7}$	Np-237	$1{,}0 \cdot 10^{6}$
Nb-94	$3{,}9 \cdot 10^{8}$	Pu-238	$8{,}5 \cdot 10^{9}$
Tc-99	$4{,}1 \cdot 10^{10}$	Pu-239	$8{,}5 \cdot 10^{8}$
Ru-106	$1{,}4 \cdot 10^{5}$	Pu-240	$1{,}7 \cdot 10^{9}$
Pd-107	$8{,}2 \cdot 10^{6}$	Pu-241	$8{,}8 \cdot 10^{10}$
Ag-108m	$2{,}2 \cdot 10^{9}$	Pu-242	$7{,}6 \cdot 10^{6}$
Cd-113m	$1{,}0 \cdot 10^{9}$	Am-241	$2{,}5 \cdot 10^{9}$
Sb-125	$9{,}9 \cdot 10^{9}$	Am-242m	$2{,}3 \cdot 10^{7}$
Sn-126	$4{,}1 \cdot 10^{6}$	Am-243	$7{,}6 \cdot 10^{7}$
I-129	$2{,}5 \cdot 10^{6}$	Cm-243	$3{,}0 \cdot 10^{7}$
Ba-133	$5{,}1 \cdot 10^{7}$	Cm-244	$3{,}3 \cdot 10^{9}$
Cs-134	$6{,}3 \cdot 10^{9}$	Cm-245	$7{,}6 \cdot 10^{5}$
Cs-135	$4{,}1 \cdot 10^{7}$	Cm-246	$2{,}0 \cdot 10^{5}$
Total:			$1{,}2 \cdot 10^{13}$

4 Description of waste in BTF

This chapter is a short summary of Appendix D.

4.1 Waste packages in BTF

The BTF is designed mainly to contain de-watered ion-exchange resins, but solidified resins and ashes are present too. All waste in BTF is handled in concrete tanks, moulds or drums.

When the drums containing ashes is placed in the 1BTF-cavern some sort of stabilising walls are necessary. Concrete tanks are placed alongside the rock walls and drums are then piled lying down between them. When six rows of drums has been piled moulds are placed across the rock vault, see Figure 4-1 and Figure 4-2. Concrete is then poured over the drums in order to stabilise them.

Figure 4-1. *Inplacement of drums in 1BTF.*

4.2 Amount of waste in BTF

The number of the different waste types that is used in the SAFE project calculations is presented in Table 4-1. How the numbers has been estimated is presented in appendix A.

There are two rock caverns in SFR named BTF, i.e. 1BTF and 2BTF. There is a limited freedom to choose how to place the waste in the two caverns.

In order to perform detailed calculations some kind of estimated distribution of the waste packages has to be made. The main principles has been:

- Waste that actually been deposited has of course been distributed as they are placed with a small exception of some odd waste.
- 2BTF only contains concrete tanks with de-watered ion-exchange resins.

1BTF contains ashes, moulds with solidified waste and concrete tanks. All odd waste has been assumed to be placed in 1BTF.

Figure 4-2. *Wall of moulds across 1BTF.*

Table 4-1. Number of different waste packages in 1BTF and 2BTF at the time of closure (2030).

Waste type	Number of packages	
	1BTF	2BTF
B.07	103	255
C.01	38	
O.01	28	
O.07	83	545
R.01	119	
R.10	24	
R.23	7	
S.13	6479	
S.19	96	
Odd packages	415	

From the number of waste packages and the reference waste type one can derive the summarised amounts of different materials in the BTF, see Table 4-2 and Table 4-3.

Table 4-2. Summarised amounts of different materials in 1BTF.

Material	Weight (kg)	Area (m^2) *
Iron/Steel	$3{,}3 \cdot 10^6$	$1{,}3 \cdot 10^5$
Aluminium	$4{,}2 \cdot 10^4$	$2{,}3 \cdot 10^4$
Ashes	$4{,}1 \cdot 10^5$	
Ion-exchange resin	$2{,}5 \cdot 10^5$	
Other organic	$2{,}4 \cdot 10^4$	
Sludge	$4{,}7 \cdot 10^4$	
Graphite	$5{,}2 \cdot 10^4$	
Cement and concrete	$8{,}3 \cdot 10^6$	
Cellulose	$1{,}0 \cdot 10^2$	

* ‘Area’ means the area exposed to ground water after closure of SFR-1.

Table 4-3. Summarised amounts of different materials in 2BTF.

Material	Weight (kg)	Area (m^2) *
Iron/Steel	$5{,}2 \cdot 10^5$	$3{,}2 \cdot 10^4$
Ion-exchange resin	$9{,}0 \cdot 10^5$	
Other organic	$9{,}3 \cdot 10^4$	
Sludge	$3{,}4 \cdot 10^4$	
Cement and concrete	$8{,}3 \cdot 10^6$	

* ‘Area’ means the area exposed to ground water after closure of SFR-1.

4.3 Radionuclide inventory in BTF

The inventory of radionuclides that is used in the SAFE project calculations is presented in Table 4-4 and Table 4-5. How the amounts of different radionuclides have been calculated is presented in appendix B.

Table 4-4. Summarised amounts of different radionuclides in 1BTF at the time of closure (2030).

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
H-3	$3,3 \cdot 10^{9}$	Cs-137	$1,4 \cdot 10^{13}$
Be-10	$1,1 \cdot 10^{5}$	Pm-147	$8,7 \cdot 10^{10}$
C-14	$2,5 \cdot 10^{12}$	Sm-151	$6,9 \cdot 10^{10}$
Cl-36	$3,0 \cdot 10^{8}$	Eu-152	$4,4 \cdot 10^{11}$
Fe-55	$5,9 \cdot 10^{11}$	Eu-154	$2,8 \cdot 10^{11}$
Ni-59	$1,8 \cdot 10^{11}$	Eu-155	$4,9 \cdot 10^{10}$
Co-60	$5,4 \cdot 10^{12}$	Ho-166m	$7,2 \cdot 10^{8}$
Ni-63	$2,9 \cdot 10^{13}$	U-232	$8,1 \cdot 10^{4}$
Se-79	$1,2 \cdot 10^{8}$	U-234	$3,5 \cdot 10^{6}$
Sr-90	$1,3 \cdot 10^{12}$	U-235	$7,1 \cdot 10^{4}$
Zr-93	$1,8 \cdot 10^{8}$	U-236	$1,1 \cdot 10^{6}$
Mo-93	$9,1 \cdot 10^{8}$	U-238	$1,4 \cdot 10^{6}$
Nb-93m	$4,7 \cdot 10^{10}$	Np-237	$1,4 \cdot 10^{6}$
Nb-94	$1,8 \cdot 10^{9}$	Pu-238	$1,1 \cdot 10^{10}$
Tc-99	$1,5 \cdot 10^{11}$	Pu-239	$1,2 \cdot 10^{9}$
Ru-106	$1,5 \cdot 10^{6}$	Pu-240	$2,4 \cdot 10^{9}$
Pd-107	$3,0 \cdot 10^{7}$	Pu-241	$1,0 \cdot 10^{11}$
Ag-108m	$1,0 \cdot 10^{10}$	Pu-242	$1,1 \cdot 10^{7}$
Cd-113m	$3,6 \cdot 10^{9}$	Am-241	$3,4 \cdot 10^{9}$
Sb-125	$6,2 \cdot 10^{10}$	Am-242m	$3,1 \cdot 10^{7}$
Sn-126	$1,5 \cdot 10^{7}$	Cm-243	$3,8 \cdot 10^{7}$
I-129	$9,1 \cdot 10^{6}$	Am-243	$1,1 \cdot 10^{8}$
Ba-133	$2,5 \cdot 10^{8}$	Cm-244	$3,9 \cdot 10^{9}$
Cs-134	$3,3 \cdot 10^{10}$	Cm-245	$1,1 \cdot 10^{6}$
Cs-135	$1,5 \cdot 10^{8}$	Cm-246	$2,8 \cdot 10^{5}$
Total			$5,4 \cdot 10^{13}$

Table 4-5. Summarised amounts of different radionuclides in 2BTF at the time of closure (2030).

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
H-3	$5,3\cdot10^{9}$	Cs-137	$2,4\cdot10^{13}$
Be-10	$1,8\cdot10^{5}$	Pm-147	$1,6\cdot10^{11}$
C-14	$3,0\cdot10^{11}$	Sm-151	$1,2\cdot10^{11}$
Cl-36	$5,4\cdot10^{8}$	Eu-152	$7,1\cdot10^{8}$
Fe-55	$1,0\cdot10^{12}$	Eu-154	$4,8\cdot10^{11}$
Ni-59	$3,0\cdot10^{11}$	Eu-155	$8,9\cdot10^{10}$
Co-60	$9,1\cdot10^{12}$	Ho-166m	$1,2\cdot10^{9}$
Ni-63	$4,7\cdot10^{13}$	U-232	$6,3\cdot10^{4}$
Se-79	$2,2\cdot10^{8}$	U-234	$2,7\cdot10^{6}$
Sr-90	$2,3\cdot10^{12}$	U-235	$5,4\cdot10^{4}$
Zr-93	$3,0\cdot10^{8}$	U-236	$8,2\cdot10^{5}$
Mo-93	$1,5\cdot10^{9}$	U-238	$1,1\cdot10^{6}$
Nb-93m	$7,6\cdot10^{10}$	Np-237	$1,1\cdot10^{6}$
Nb-94	$3,0\cdot10^{9}$	Pu-238	$8,9\cdot10^{9}$
Tc-99	$2,7\cdot10^{11}$	Pu-239	$9,1\cdot10^{8}$
Ru-106	$2,8\cdot10^{6}$	Pu-240	$1,8\cdot10^{9}$
Pd-107	$5,4\cdot10^{7}$	Pu-241	$8,2\cdot10^{10}$
Ag-108m	$1,7\cdot10^{10}$	Pu-242	$8,2\cdot10^{6}$
Cd-113m	$6,4\cdot10^{9}$	Am-241	$2,6\cdot10^{9}$
Sb-125	$1,1\cdot10^{11}$	Am-242m	$2,4\cdot10^{7}$
Sn-126	$2,7\cdot10^{7}$	Cm-243	$3,0\cdot10^{7}$
I-129	$1,6\cdot10^{7}$	Am-243	$8,1\cdot10^{7}$
Ba-133	$4,1\cdot10^{8}$	Cm-244	$3,1\cdot10^{9}$
Cs-134	$6,0\cdot10^{10}$	Cm-245	$8,1\cdot10^{5}$
Cs-135	$2,7\cdot10^{8}$	Cm-246	$2,2\cdot10^{5}$
Total:			$8,5\cdot10^{13}$

5 Description of waste in BMA

This chapter is a short summary of Appendix E.

5.1 Waste packages in BMA

The BMA is designed to contain intermediate level waste which have a lower doserate or waste that of some kind of reason is not suitable to deposit in the Silo. The waste contains solidified (bitumen or cement) ion-exchange resins and stabilised scrap metal and refuses. All waste in BMA is handled in moulds or drums.

5.2 Amount of waste in BMA

The number of the different waste types that is used in the SAFE project calculations is presented in Table 5-1. How the numbers has been estimated is presented in appendix A.

Table 5-1. Number of different waste types in BMA at the time of closure (2030).

Waste type	Number of packages
B.05	4230
C.01	23
C.23	88
F.05	1718
F.15	11
F.17	879
F.23	324
O.01	715
O.23	696
R.01	1702
R.10	136
R.15	295
R.23	829
S.09	382
S.21	1493
S.23	61
Odd packages	238

From the number of waste packages and the reference waste type one can derive the summarised amounts of different materials in the BMA, see Table 5-2.

5.3 Radionuclide inventory in BMA

The inventory of radionuclides that is used in the SAFE project calculations is presented in Table 5-3. How the amounts of different radionuclides have been calculated is presented in appendix B.

Table 5-2. Summarised amounts of different materials in BMA.

Material	Weight (kg)	Area (m^2) *
Iron/Steel	$3,0\cdot10^{6}$	$1,6\cdot10^{5}$
Aluminium	$1,4\cdot10^{4}$	$2,0\cdot10^{3}$
Cellulose (wood, paper, cloth)	$1,1\cdot10^{5}$	
Other organic (plastic, rubber, cable)	$2,7\cdot10^{5}$	
Ion-exchange resin	$1,4\cdot10^{6}$	
Sludge	$2,5\cdot10^{5}$	
Evaporator bottoms	$1,1\cdot10^{5}$	
Bitumen	$1,5\cdot10^{6}$	
Cement and concrete	$1,2\cdot10^{7}$	

* 'Area' means the area exposed to ground water after closure of SFR-1.

Table 5-3. Summarised amounts of different radionuclides in BMA at the time of closure (2030).

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
H-3	$3,3\cdot10^{10}$	Cs-137	$1,4\cdot10^{14}$
Be-10	$1,3\cdot10^{6}$	Pm-147	$2,6\cdot10^{12}$
C-14	$2,1\cdot10^{12}$	Sm-151	$7,5\cdot10^{11}$
Cl-36	$3,4\cdot10^{9}$	Eu-152	$4,0\cdot10^{9}$
Fe-55	$1,9\cdot10^{13}$	Eu-154	$2,7\cdot10^{12}$
Ni-59	$2,1\cdot10^{12}$	Eu-155	$6,3\cdot10^{11}$
Co-60	$7,1\cdot10^{13}$	Ho-166m	$8,2\cdot10^{9}$
Ni-63	$3,2\cdot10^{14}$	U-232	$1,1\cdot10^{6}$
Se-79	$1,4\cdot10^{9}$	U-234	$4,5\cdot10^{7}$
Sr-90	$1,4\cdot10^{13}$	U-235	$8,9\cdot10^{5}$
Mo-93	$1,0\cdot10^{10}$	U-236	$1,3\cdot10^{7}$
Nb-93m	$4,9\cdot10^{11}$	U-238	$1,8\cdot10^{7}$
Zr-93	$2,1\cdot10^{9}$	Np-237	$1,8\cdot10^{7}$
Nb-94	$2,1\cdot10^{10}$	Pu-238	$1,5\cdot10^{11}$
Tc-99	$1,7\cdot10^{12}$	Pu-239	$1,5\cdot10^{10}$
Ru-106	$3,3\cdot10^{9}$	Pu-240	$3,0\cdot10^{10}$
Pd-107	$3,4\cdot10^{8}$	Pu-241	$1,6\cdot10^{12}$
Ag-108m	$1,2\cdot10^{11}$	Pu-242	$1,3\cdot10^{8}$
Cd-113m	$3,6\cdot10^{10}$	Am-241	$4,3\cdot10^{10}$
Sb-125	$1,9\cdot10^{12}$	Am-242m	$4,0\cdot10^{8}$
Sn-126	$1,7\cdot10^{8}$	Am-243	$1,3\cdot10^{9}$
I-129	$1,0\cdot10^{8}$	Cm-243	$5,3\cdot10^{8}$
Ba-133	$2,6\cdot10^{9}$	Cm-244	$5,9\cdot10^{10}$
Cs-134	$1,8\cdot10^{12}$	Cm-245	$1,3\cdot10^{7}$
Cs-135	$1,7\cdot10^{9}$	Cm-246	$3,6\cdot10^{6}$
Total:			$5,9\cdot10^{14}$

5.4 Inplacement of waste in BMA

The BMA cavern is the most complex regarding different waste, materials, placement of packages and so on. The cavern also contains a fair part (approximately 6 %) of the total inventory of radionuclides.

The SAFE project has come to the conclusion that detailed calculations have to be made on the release of radionuclides from the BMA. In order to do so some kind of distribution of the waste packages had to be made. The main principles, in falling order, has been:

- Waste that actually been deposited has of course been distributed as they are placed.
- Only one compartment containing burnable waste, i.e. bitumenised waste, is allowed to be open at certain time. When the compartment is filled a lid must be placed upon it.
- The compartments are filled in number order.
- Future waste has been placed in a running order, i.e. for each year, the annual production of each waste type is placed in the first available compartment.
- Odd waste has been placed in the last two small compartments and the last ‘big’ one (compartment 13).

Table 5-4 shows the distribution of the different waste types in the different compartments in the BMA.

Table 5-4. Distribution of waste in the different compartments in the BMA.

Waste type	package	matrix	Compartment 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
B.05	drum	bitumen		382	1438		2096	314										4230
C.01	mould	cement							2	1	15	5						23
C.23	mould	cement								17	11	6	14	6	34			88
F.05	drum	cement		1712				6										1718
F.15	mould	cement				8		3										11
F.17	mould	bitumen			144		28	348						359				879
F.23	mould	cement				64			12	41		18	72	27	90			324
O.01	mould	cement				76			262	29	190	158						715
O.23	mould	cement				36			36	189	136	59	105	60	75			696
R.01	mould	cement	576	148	145	143	144	144	144	146	88		4	6	14			1702
R.10	mould	cement								20	48	4	32	12	20			136
R.15	mould	cement				124				11		16	64	24	56			295
R.23	mould	cement				124			120	81	88	20	160	60	176			829
S.09	drum	cement											232	44	106			382
S.21	drum	cement										1152	240	28	73			1493
S.23	drum	cement								41		2	7	4	7			61
"odd"															58	90	90	238
Total			576	2242	1727	575	2268	815	576	576	576	1440	930	630	709	90	90	13820

6 Description of waste in the Silo

This chapter is a short summary of Appendix F.

6.1 Waste packages in the Silo

The Silo is designed to contain intermediate level waste. The waste contains solidified (bitumen or cement) ion-exchange resins and some small amount of stabilised scrap metals and refuse. All waste in the Silo is handled in moulds or drums.

6.2 Amount of waste in Silo

The number of the different waste types that is used in the SAFE project calculations is presented in Table 6-1. How the numbers has been estimated is presented in appendix A.

One should note that when the prognosis of waste was made it was concluded that only approximately 63 % of the silo were filled. Hence, the prognosticated number has been multiplied with a factor 100 % / 63 % = 1,59 to have a completely filled silo to make calculations on a fully used repository.

Table 6-1. Number of different waste types in the Silo at the time of closure (2030).

Waste type	Number of packages
B.06	6902
C.02	1438
C.24	150
F.18	938
O.02	2094
R.16	3733
R.02	705
S.11	96
S.22	430
S.24	2
S.04	134

From the number of waste packages and the reference waste type one can derive the summarised amounts of different materials in the Silo, see Table 6-2.

6.3 Radionuclide inventory in Silo

The inventory of radionuclides that is used in the SAFE project calculations is presented in Table 6-3. How the amounts of different radionuclides have been calculated is presented in appendix B.

Table 6-2. Summarised amounts of different materials in Silo.

Material	Weight (kg)	Area (m^2) *
Iron/Steel	$3{,}7\cdot10^6$	$1{,}8\cdot10^5$
Aluminium	$2{,}2\cdot10^3$	$3{,}0\cdot10^2$
Cellulose (wood, paper, cloth)	$8{,}9\cdot10^3$	
Other organics (plastic, rubber, cable)	$4{,}4\cdot10^4$	
Ion-exchange resins	$2{,}5\cdot10^6$	
Sludge	$3{,}2\cdot10^4$	
Bitumen	$1{,}9\cdot10^6$	
Cement and concrete	$2{,}1\cdot10^7$	

* 'Area' means the area exposed to ground water after closure of SFR-1.

Table 6-3. Summarised amounts of different radionuclides in Silo at the time of closure (2030).

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
H-3	$5{,}8\cdot10^{11}$	Cs-137	$2{,}5\cdot10^{15}$
Be-10	$1{,}3\cdot10^{7}$	Pm-147	$1{,}3\cdot10^{14}$
C-14	$2{,}1\cdot10^{13}$	Sm-151	$1{,}1\cdot10^{13}$
Cl-36	$4{,}7\cdot10^{10}$	Eu-152	$9{,}2\cdot10^{10}$
Fe-55	$6{,}3\cdot10^{14}$	Eu-154	$7{,}9\cdot10^{13}$
Ni-59	$2{,}1\cdot10^{13}$	Eu-155	$2{,}4\cdot10^{13}$
Co-60	$1{,}8\cdot10^{15}$	Ho-166m	$8{,}4\cdot10^{10}$
Ni-63	$3{,}6\cdot10^{15}$	U-232	$2{,}0\cdot10^{7}$
Se-79	$1{,}9\cdot10^{10}$	U-234	$8{,}4\cdot10^{8}$
Sr-90	$2{,}4\cdot10^{14}$	U-235	$1{,}7\cdot10^{7}$
Mo-93	$1{,}1\cdot10^{11}$	U-236	$2{,}5\cdot10^{8}$
Nb-93m	$7{,}6\cdot10^{12}$	U-238	$3{,}3\cdot10^{8}$
Zr-93	$2{,}1\cdot10^{10}$	Np-237	$3{,}3\cdot10^{8}$
Nb-94	$2{,}1\cdot10^{11}$	Pu-238	$2{,}8\cdot10^{12}$
Tc-99	$2{,}4\cdot10^{13}$	Pu-239	$2{,}8\cdot10^{11}$
Ru-106	$2{,}9\cdot10^{11}$	Pu-240	$5{,}6\cdot10^{11}$
Pd-107	$4{,}7\cdot10^{9}$	Pu-241	$3{,}1\cdot10^{13}$
Ag-108m	$1{,}2\cdot10^{12}$	Pu-242	$2{,}5\cdot10^{9}$
Cd-113m	$8{,}2\cdot10^{11}$	Am-241	$6{,}1\cdot10^{12}$
Sb-125	$6{,}4\cdot10^{13}$	Am-242m	$7{,}5\cdot10^{9}$
Sn-126	$2{,}4\cdot10^{9}$	Am-243	$2{,}5\cdot10^{10}$
I-129	$1{,}4\cdot10^{9}$	Cm-243	$1{,}0\cdot10^{10}$
Ba-133	$4{,}8\cdot10^{10}$	Cm-244	$1{,}1\cdot10^{12}$
Cs-134	$1{,}1\cdot10^{14}$	Cm-245	$2{,}5\cdot10^{8}$
Cs-135	$2{,}4\cdot10^{10}$	Cm-246	$6{,}7\cdot10^{7}$
Total:			$9{,}3\cdot10^{15}$

6.4 Inplacement of waste in Silo

The Silo contains the majority (approximately 92 %) of the total inventory of radionuclides.

The SAFE project has come to the conclusion that detailed calculations have to be made on the release of radionuclides from the Silo. In order to do so some kind of distribution of the waste packages had to be made. The main principles has been:

- Waste that actually been deposited has of course been distributed as they are placed.
- Bitumenised waste is placed in the centre of the silo.

7 Summary

This chapter summarises the waste amounts and the radionuclide inventory from chapter 3 to 6.

7.1 Amount of waste in SFR-1

The number of the different waste types that is used in the SAFE project calculations is presented in Table 7-1. How the numbers has been estimated is presented in appendix A.

Table 7-1. Number of different waste types in SFR-1 at the time of closure (2030).

Waste type	Rock Cavern	Number of waste packages
B.05	BMA	4230
B.06	Silo	6902
B.07	BTF	358
B.12	BLA	272
B.20	BLA	12
F.05	BMA	1718
F.12	BLA	28
F.15	BMA	11
F.17	BMA	879
F.18	Silo	938
F.20	BLA	15
F.23	BMA	324
O.01	BMA	743
O.02	Silo	2094
O.07	BTF	628
O.12	BLA	80
O.23	BMA	696
C.01	BMA	61
C.02	Silo	1438
C.23	BMA	88
C.24	Silo	150
R.01	BMA	1821
R.02	Silo	705
R.10	BMA	160
R.12	BLA	103
R.15	BMA	295
R.16	Silo	3733
R.23	BMA	836
S.04	Silo	134
S.09	BMA	382
S.11	Silo	96
S.12	BLA	31
S.13	BTF	6479
S.14	BLA	73
S.19	BTF	96
S.21	BMA	1493
S.22	Silo	430

Waste type	Rock Cavern	Number of waste packages
S.23	BMA	61
S.24	Silo	2
Odd BLA	BLA	64
Odd BTF	BTF	415
Odd BMA	BMA	238
Total		39312

7.2 Radionuclide inventory in SFR-1

The inventory of radionuclides that is used in the SAFE project calculations is presented in Table 7-2. How the amounts of different radionuclides have been calculated is presented in appendix B.

Table 7-2. Summarised amounts of different radionuclides in SFR-1 at the time of closure (2030).

Nuclide	Total (Bq)	Silo (Bq)	BTF (Bq)	BMA (Bq)	BLA (Bq)
H-3	$6,2\cdot10^{11}$	5,8·1011	$8,5\cdot10^{9}$	$3,3\cdot10^{10}$	$6,6\cdot10^{8}$
Be-10	$1,4\cdot10^{7}$	$1,3\cdot10^{7}$	$2,9\cdot10^{5}$	$1,3\cdot10^{6}$	$2,3\cdot10^{4}$
C-14	$2,6\cdot10^{13}$	$2,1\cdot10^{13}$	$2,8\cdot10^{12}$	$2,1\cdot10^{12}$	$3,9\cdot10^{10}$
Cl-36	$5,1\cdot10^{10}$	$4,7\cdot10^{10}$	$8,4\cdot10^{8}$	$3,4\cdot10^{9}$	$8,2\cdot10^{7}$
Fe-55	$6,5\cdot10^{14}$	$6,3\cdot10^{14}$	$1,6\cdot10^{12}$	$1,9\cdot10^{13}$	$9,5\cdot10^{10}$
Ni-59	$2,4\cdot10^{13}$	$2,1\cdot10^{13}$	$4,8\cdot10^{11}$	$2,1\cdot10^{12}$	$3,9\cdot10^{10}$
Co-60	$1,9\cdot10^{15}$	$1,8\cdot10^{15}$	$1,4\cdot10^{13}$	$7,1\cdot10^{13}$	$1,0\cdot10^{12}$
Ni-63	$4,0\cdot10^{15}$	$3,6\cdot10^{15}$	$7,6\cdot10^{13}$	$3,2\cdot10^{14}$	$6,2\cdot10^{12}$
Se-79	$2,1\cdot10^{10}$	$1,9\cdot10^{10}$	$3,4\cdot10^{8}$	$1,4\cdot10^{9}$	$3,3\cdot10^{7}$
Sr-90	$2,6\cdot10^{14}$	$2,4\cdot10^{14}$	$3,6\cdot10^{12}$	$1,4\cdot10^{13}$	$3,6\cdot10^{11}$
Mo-93	$1,2\cdot10^{11}$	$1,1\cdot10^{11}$	$2,4\cdot10^{9}$	$1,0\cdot10^{10}$	$1,9\cdot10^{8}$
Nb-93m	$8,2\cdot10^{12}$	$7,6\cdot10^{12}$	$1,2\cdot10^{11}$	$4,9\cdot10^{11}$	$9,7\cdot10^{9}$
Zr-93	$2,4\cdot10^{10}$	$2,1\cdot10^{10}$	$4,8\cdot10^{8}$	$2,1\cdot10^{9}$	$3,9\cdot10^{7}$
Nb-94	$2,4\cdot10^{11}$	$2,1\cdot10^{11}$	$4,8\cdot10^{9}$	$2,1\cdot10^{10}$	$3,9\cdot10^{8}$
Tc-99	$2,6\cdot10^{13}$	$2,4\cdot10^{13}$	$4,2\cdot10^{11}$	$1,7\cdot10^{12}$	$4,1\cdot10^{10}$
Ru-106	$2,9\cdot10^{11}$	$2,9\cdot10^{11}$	$4,5\cdot10^{6}$	$3,4\cdot10^{9}$	$1,5\cdot10^{5}$
Pd-107	$5,1\cdot10^{9}$	$4,7\cdot10^{9}$	$8,4\cdot10^{7}$	$3,4\cdot10^{8}$	$8,2\cdot10^{6}$
Ag-108m	$1,4\cdot10^{12}$	$1,2\cdot10^{12}$	$2,7\cdot10^{10}$	$1,2\cdot10^{11}$	$2,2\cdot10^{9}$
Cd-113m	$8,7\cdot10^{11}$	$8,2\cdot10^{11}$	$1,0\cdot10^{10}$	$3,6\cdot10^{10}$	$1,0\cdot10^{9}$
Sb-125	$6,6\cdot10^{13}$	$6,4\cdot10^{13}$	$1,7\cdot10^{11}$	$1,9\cdot10^{12}$	$9,9\cdot10^{9}$
Sn-126	$2,6\cdot10^{9}$	$2,4\cdot10^{9}$	$4,2\cdot10^{7}$	$1,7\cdot10^{8}$	$4,1\cdot10^{6}$
I-129	$1,5\cdot10^{9}$	$1,4\cdot10^{9}$	$2,5\cdot10^{7}$	$1,0\cdot10^{8}$	$2,5\cdot10^{6}$
Ba-133	$5,1\cdot10^{10}$	$4,8\cdot10^{10}$	$6,6\cdot10^{8}$	$2,6\cdot10^{9}$	$5,1\cdot10^{7}$
Cs-134	$1,1\cdot10^{14}$	$1,1\cdot10^{14}$	$9,4\cdot10^{10}$	$1,8\cdot10^{12}$	$6,3\cdot10^{9}$
Cs-135	$2,6\cdot10^{10}$	$2,4\cdot10^{10}$	$4,2\cdot10^{8}$	$1,7\cdot10^{9}$	$4,1\cdot10^{7}$
Cs-137	$2,7\cdot10^{15}$	$2,5\cdot10^{15}$	$3,7\cdot10^{13}$	$1,4\cdot10^{14}$	$3,7\cdot10^{12}$
Pm-147	$1,4\cdot10^{14}$	$1,3\cdot10^{14}$	$2,5\cdot10^{11}$	$2,6\cdot10^{12}$	$1,9\cdot10^{10}$
Sm-151	$1,2\cdot10^{13}$	$1,1\cdot10^{13}$	$1,9\cdot10^{11}$	$7,5\cdot10^{11}$	$1,9\cdot10^{10}$
Eu-152	$5,3\cdot10^{11}$	$9,2\cdot10^{10}$	$4,4\cdot10^{11}$	$4,0\cdot10^{9}$	$1,1\cdot10^{8}$
Eu-154	$8,2\cdot10^{13}$	$7,9\cdot10^{13}$	$7,6\cdot10^{11}$	$2,7\cdot10^{12}$	$7,6\cdot10^{10}$
Eu-155	$2,5\cdot10^{13}$	$2,4\cdot10^{13}$	$1,4\cdot10^{11}$	$6,3\cdot10^{11}$	$1,3\cdot10^{10}$
Ho-166m	$9,4\cdot10^{10}$	$8,4\cdot10^{10}$	$1,9\cdot10^{9}$	$8,2\cdot10^{9}$	$1,5\cdot10^{8}$
Pb-210	$9,2\cdot10^{0}$	$8,6\cdot10^{0}$	$5,6\cdot10^{-2}$	$4,51\cdot10^{-1}$	$2,5\cdot10^{-2}$

Nuclide	Total (Bq)	Silo (Bq)	BTF (Bq)	BMA (Bq)	BLA (Bq)
Ra-226	$1,8\cdot10^{2}$	$1,7\cdot10^{2}$	$1,2\cdot10^{0}$	$8,8\cdot10^{0}$	5,0E-01
Ac-227	$1,8\cdot10^{3}$	$1,7\cdot10^{3}$	$1,1\cdot10^{1}$	$8,9\cdot10^{1}$	$5,0\cdot10^{0}$
Th-229	$2,7\cdot10^{2}$	$2,5\cdot10^{2}$	$1,9\cdot10^{0}$	$1,3\cdot10^{1}$	7,6E-01
Th-230	$8,0\cdot10^{-4}$	$7,5\cdot10^{-4}$	$5,6\cdot10^{-2}$	$4,0\cdot10^{-3}$	$2,3\cdot10^{-2}$
Pa-231	$2,7\cdot10^{4}$	$2,5\cdot10^{4}$	$1,9\cdot10^{2}$	$1,3\cdot10^{3}$	$7,6\cdot10^{1}$
Th-232	$8,9\cdot10^{2}$	$8,4\cdot10^{2}$	$6,3\cdot10^{4}$	$4,5\cdot10^{3}$	$2,5\cdot10^{4}$
U-232	$2,1\cdot10^{7}$	$2,0\cdot10^{7}$	$1,4\cdot10^{5}$	$1,1\cdot10^{6}$	$6,1\cdot10^{4}$
U-233	$1,8\cdot10^{4}$	$1,7\cdot10^{4}$	$1,3\cdot10^{2}$	$8,9\cdot10^{2}$	$5,1\cdot10^{1}$
U-234	$8,9\cdot10^{8}$	$8,4\cdot10^{8}$	$6,3\cdot10^{6}$	$4,5\cdot10^{7}$	$2,5\cdot10^{6}$
U-235	$1,8\cdot10^{7}$	$1,7\cdot10^{7}$	$1,3\cdot10^{5}$	$8,9\cdot10^{5}$	$5,1\cdot10^{4}$
U-236	$2,7\cdot10^{8}$	$2,5\cdot10^{8}$	$1,9\cdot10^{6}$	$1,3\cdot10^{7}$	$7,6\cdot10^{5}$
Np-237	$3,6\cdot10^{8}$	$3,3\cdot10^{8}$	$2,5\cdot10^{6}$	$1,8\cdot10^{7}$	$1,0\cdot10^{6}$
Pu-238	$3,0\cdot10^{12}$	$2,8\cdot10^{12}$	$2,0\cdot10^{10}$	$1,5\cdot10^{11}$	$8,5\cdot10^{9}$
U-238	$3,6\cdot10^{8}$	$3,3\cdot10^{8}$	$2,5\cdot10^{6}$	$1,8\cdot10^{7}$	$1,0\cdot10^{6}$
Pu-239	$3,0\cdot10^{11}$	$2,8\cdot10^{11}$	$2,1\cdot10^{9}$	$1,5\cdot10^{10}$	$8,5\cdot10^{8}$
Pu-240	$5,9\cdot10^{11}$	$5,6\cdot10^{11}$	$4,2\cdot10^{9}$	$3,0\cdot10^{10}$	$1,7\cdot10^{9}$
Am-241	$6,1\cdot10^{12}$	$6,1\cdot10^{12}$	$6,0\cdot10^{9}$	$4,3\cdot10^{10}$	$2,5\cdot10^{9}$
Pu-241	$3,2\cdot10^{13}$	$3,1\cdot10^{13}$	$1,8\cdot10^{11}$	$1,6\cdot10^{12}$	$8,8\cdot10^{10}$
Am-242m	$8,0\cdot10^{9}$	$7,5\cdot10^{9}$	$5,5\cdot10^{7}$	$4,0\cdot10^{8}$	$2,3\cdot10^{7}$
Pu-242	$2,7\cdot10^{9}$	$2,5\cdot10^{9}$	$1,9\cdot10^{7}$	$1,3\cdot10^{8}$	$7,6\cdot10^{6}$
Am-243	$2,7\cdot10^{10}$	$2,5\cdot10^{10}$	$1,9\cdot10^{8}$	$1,3\cdot10^{9}$	$7,6\cdot10^{7}$
Cm-243	$1,1\cdot10^{10}$	$1,0\cdot10^{10}$	$6,8\cdot10^{7}$	$5,3\cdot10^{8}$	$3,0\cdot10^{7}$
Cm-244	$1,2\cdot10^{12}$	$1,1\cdot10^{12}$	$7,0\cdot10^{9}$	$5,9\cdot10^{10}$	$3,3\cdot10^{9}$
Pu-244	$6,2\cdot10^{2}$	$5,8\cdot10^{2}$	$4,4\cdot10^{0}$	$3,1\cdot10^{1}$	$1,8\cdot10^{0}$
Cm-245	$2,7\cdot10^{8}$	$2,5\cdot10^{8}$	$1,9\cdot10^{6}$	$1,3\cdot10^{7}$	$7,6\cdot10^{5}$
Cm-246	$7,1\cdot10^{7}$	$6,7\cdot10^{7}$	$5,0\cdot10^{5}$	$3,6\cdot10^{6}$	$2,0\cdot10^{5}$
Total	$1,0\cdot10^{16}$	$9,3\cdot10^{15}$	$1,4\cdot10^{14}$	$5,9\cdot10^{14}$	$1,2\cdot10^{13}$

7.3 Toxic material

No toxic material has been identified in SFR-1.

8 Uncertainties

Three major uncertainties have been identified at a general level. Uncertainties in different waste types etc are described in the text in appendices A–F.

The actual number of different waste packages is the first one. As all prognosis there is a major uncertainties in what lays in the future. Not only the number of packages is uncertain there could also be other waste types or changes in the described types that occur in the future.

The amount of materials is calculated with a simple model, a reference waste package times a prognosis of waste packages. This means that the uncertainties are multiplied. One should keep in mind that the most materials come from waste types that are relatively common and therefore are the uncertainties smaller. No uncertainty analysis has been performed since it has been judge that what is in future waste overshadows all other uncertainties. The future uncertainty can not be quantified.

The radionuclides are estimated with correlation factors. The factors themselves include quite large uncertainty, but also the method of correlation has weaknesses. In order to introduce some way to handle the uncertainties the SAFE project has used the conservative inventory in all analysis and calculations. For more discussion about correlation factors see appendix A and references therein.

9 References

This reference list only includes references from the main report. References in the appendices are listed after each appendix (appendices A–F).

SKB, 1993. Slutlig säkerhetsrapport för SFR-1 (in Swedish). Svensk Kärnbränslehantering AB, May 1993.

SSR, 2001. Slutlig säkerhetsrapport för SFR-1 (in Swedish). Svensk Kärnbränslehantering AB, June 2001.

Appendix A

Calculation of waste amounts

1 Method of calculation

1.1 Aim of calculations – restrictions

To know the waste amounts of waste or rather the number of waste packages is not important in it self when you performing a safety assessment for a repository for radioactive waste. However, the number of waste packages is a fundamental parameter if you are to calculate the total amount of materials, radionuclides and chemicals. The aim of the calculations of waste amounts is to get a realistic estimate of the amounts of radionuclides and materials and also their distribution in different parts of the SFR-1 repository.

There are always restrictions to a calculation, in this case it is of course the geometry of the repository. Also, as a starting point of the analysis we have assumed that the Swedish reactors have a life span of 40 years and that they during these 40 years produce waste that can and should be disposed of in SFR-1. Also we have assumed that the repository will be sealed in year 2030.

1.2 Available information sources

Radioactive waste has been produced in the Swedish nuclear power plants since the early 70's. In the research facility Studsvik and other places there were production of radioactive waste earlier than the 70's. The amounts from research to be disposed of in SFR-1 are small, if any, from the period before 1980. The SFR repository has been in operation since 1988. Hence, today there are an extensive experience regarding waste handling in Sweden. The sources to get information and data in this study are relatively few since the ones that are used are to be seen as thorough collections of data.

Information about waste that has already been disposed of in SFR has been taken from the operational database /TRIUMF, 2000/ in SFR. Complementary data regarding amounts of waste from Studsvik has been taken from /Chyssler, 2000/.

Future amounts of waste have been estimated based on /Johansson, 1999/.

1.3 Method of calculation

In order to systemise the vast amounts of different sorts of waste a system of waste types have been used in Sweden since a long time back. This system is described in the main report chapter 2.1.

The calculations of the number of waste packages can be separated in two categories, existing waste and future waste.

As said before data concerning existing waste is mainly taken from the operational database in SFR, TRIUMF. The number of existing waste packages in the inventory is the number of deposited packages 1 January 1999. No data from the nuclear power plants concerning waste packages stored at site has been used since it was judged that the error from this is negligible compared to the uncertainties in amounts of future waste.

Regarding future amounts of different waste types, data for annual production was taken from /Johansson, 1999/. These numbers have been multiplied with the number of remaining years of nuclear power plant operation.

The remaining years has been estimated from the approximation of 40 years of operation. Some extra operational time (1–2 years) has been included to allow to the delayed production of waste. Since it is almost impossible to back track the different waste streams to a single reactor, an average of end of waste production per site has been calculated. The remaining time (in years) is then calculated as “average year” minus “present year” (1999). In Table 1-1 are the assumed years of operation presented.

Three nuclear facilities differ from this calculation, Barsebäck 1, Studsvik and CLAB. Barsebäck 1 was closed in November 1999. To get a more accurate estimate of waste production, the average for Barsebäck is calculated as the mean of 40 years of operation of Barsebäck 2 and end of production in Barsebäck 1 in 2001. CLAB is going to be in operation until the last spent fuel is deposited in the deep repository which is much later than 2030, therefor it is assumed that CLAB produces waste until SFR-1 is closed in 2030. Studsvik has been estimated to produce waste until 2020. This estimate is very uncertain.

Table 1-1. Estimated end of operational waste production in the Swedish nuclear facilities.

Reactor	Start of operation[1]	Estimated end of operation[1] (reactors)	Estimated end of waste production	Average (per site) end of operation
Barsebäck 1	1 July 1975	30 November 1999	2001	
Barsebäck 2	1 July 1977	30 June 2017	2018	2010
Forsmark 1	10 December 1980	9 December 2020	2021	
Forsmark 2	7 July 1981	6 July 2021	2022	
Forsmark 3	22 August 1985	21 August 2025	2026	2023
Oskarshamn 1	6 February 1972	5 February 2012	2013	
Oskarshamn 2	15 December 1974	14 December 2014	2015	
Oskarshamn 3	15 August 1985	14 August 2025	2026	2018
Ringhals 1	1 January 1976	31 December 2015	2016	
Ringhals 2	1 May 1975	30 April 2015	2016	
Ringhals 3	9 September 1981	8 September 2021	2022	
Ringhals 4	21 November 1983	20 November 2023	2024	2020
CLAB			2030	2030
Studsvik			2020	2020

Note: this is an estimate of end of operation for nuclear facilities in Sweden. The purpose is to estimate waste amounts in SFR-1. Actual end of operation could differ significantly from this table.
[1] /SKB, 2000/.

Only waste types that are in production today or are in the process of being licensed has been included in the calculations. Possible changes in the production of the different waste types are ignored due to lack of data.

In SFR there are plans to dispose of waste that have odd geometry, chemical composition or some other feature that differ from the ordinary waste types. We call this waste “odd waste”. By definition these packages can not be described in some common geometry or other feature. Due to the method of calculation we have assumed that this waste has a geometry that is in accordance with the standard waste geometry in the different caverns in SFR. In BLA we have assumed ISO-container geometry, in BTF 10 m^3 tanks and in BMA as 1,73 m^3 moulds. No “odd” waste is planned in the Silo. The waste will not have this geometry in reality, therefore one should focus on the total volume rather than the number of packages.

A schematic picture of the calculation is shown in Figure 1-1. The last step of calculation including geometry in SFR is described in chapter 2.3.

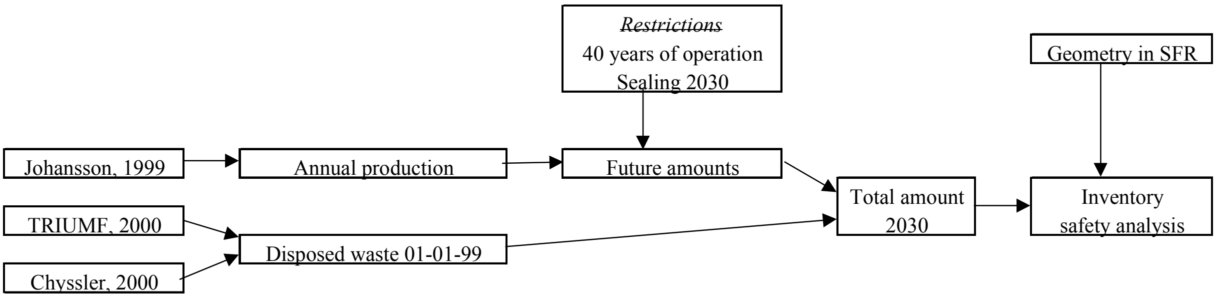

Figure 1-1. *Schematic structure of calculations.*

2 Waste amounts

2.1 Present amounts

At present, i.e. 1 January 1999, there are approximately 20 000 waste packages of different kinds disposed of in SFR-1. The data for the packages are presented in Table 2-1. The data is quantified in waste types according to the types presented in appendix C to appendix F.

Table 2-1. Number of waste packages disposed of in SFR-1 in 1 January 1999.

Waste type	Rock cavern in SFR	Waste packages 1 January 1999
B.05	BMA	4208
B.06	Silo	2684
B.07	BTF	193
B.12	BLA	188
B.20	BLA	12
F.05	BMA	1718
F.12	BLA	20
F.15	BMA	11
F.17	BMA	351
F.18	Silo	181
F.20	BLA	15
F.23	BMA	108
O.01	BMA	710
O.02	Silo	574
O.07	BTF	400
O.12	BLA	0
O.23	BMA	411
C.01	BMA	61
C.02	Silo	283
C.23	BMA	26
C.24	Silo	32
R.01	BMA	1779
R.02	Silo	359
R.10	BMA	76
R.12	BLA	35
R.15	BMA	127
R.16	Silo	664
R.23	BMA	416
S.04	Silo	0
S.09[1]	BMA	67
S.11[1]	Silo	60
S.12[1]	BLA	15
S.13	BTF	4589
S.14	BLA	22
S.19[1]	BTF	96
S.21[1]	BMA	1283
S.22[1]	Silo	270
S.23[1]	BMA	40
S.24[1]	Silo	1
Odd waste	-	excluded

[1] Produced but not disposed of in SFR.

2.2 Future amounts

Based on the principles for calculation of future amounts of waste (chapter 1.3) we estimate the coming number of packages to approximately 10 000. The data is presented in Table 2-2. The data is quantified in waste types according to the types presented in appendix C to appendix F.

Table 2-2. Future amounts of Waste in SFR-1.

Waste type	Rock Cavern	Annual production	operational years	Number of future packages
B.05	BMA	2	11	22
B.06	Silo	150	11	1650
B.07	BTF	15	11	165
B.12	BLA	12	11	132
B.20	BLA	0	11	0
F.05	BMA	0	24	0
F.12	BLA	1	24	12
F.15	BMA	0	24	0
F.17	BMA	22	24	528
F.18	Silo	17	24	408
F.20	BLA	0	24	0
F.23	BMA	9	24	216
O.01	BMA	0	19	0
O.02	Silo	39	19	741
O.07	BTF	12	19	228
O.12	BLA	5	19	95
O.23	BMA	15	19	285
C.01	BMA	0	31	0
C.02	Silo	20	31	620
C.23	BMA	2	31	62
C.24	Silo	2	31	62
R.01	BMA	2	21	42
R.02	Silo	4	21	84
R.10	BMA	4	21	84
R.12	BLA	4	21	84
R.15	BMA	8	21	168
R.16	Silo	80	21	1680
R.23	BMA	20	21	420
S.04	Silo	4	21	84
S.09	BMA	15	21	315
S.11	Silo	0	21	0
S.12	BLA	1	21	21
S.13	BTF	90	21	1890
S.14	BLA	3	21	63
S.19	BTF	0	21	0
S.21	BMA	10	21	210
S.22	Silo	0	21	0
S.23	BMA	1	21	21
S.24	Silo	0	21	0
Odd waste	-	Excluded	Excluded	Excluded

2.3 Total amount in 2030

If you add the present and future waste amounts you will find that the repository do not get filled to 100 %, see Table 2-3. In order not to put unnecessary restrictions on the operation of SFR we have assumed for the safety assessment that the repository will get totally filled with waste. This calculation must be done separately for each rock cavern.

Table 2-3. Percent filling in the SFR-1 according to calculations.

Silo	BTF	BMA	BLA	Totalt
63 %	75 %	97 %	105 %	82 %

In the Silo we have simply used a factor of 1,59 on the number of waste packages and rounded off to nearest integer. 1,59 is equal to (fraction of used volume)$^{-1}$.

In BMA and BTF all remaining volume has been used for “odd” waste.

In BLA the calculations show a filling percentage of 105 %. We reduced the number of waste packages to a filling percentage of 90 % and we have assumed that the remaining 10 % are used for “odd” waste. The motive of this approximation is that the waste amounts that will be disposed of in BLA are uncertain. The uncertainties are mainly because a fair amount of the future waste could be disposed of in shallow land repositories.

The numbers that are presented in Table 2-4 are the total amount of waste packages in 2030. These numbers are the foundation in the safety assessment for all calculations of materials, radionuclides etc that has its origin in the waste in SFR.

Table 2-4. Total number of waste packages in SFR-1 in 2030.

Waste type	Rock Cavern	Number of waste packages
B.05	BMA	4230
B.06	Silo	6902
B.07	BTF	358
B.12	BLA	272
B.20	BLA	12
F.05	BMA	1718
F.12	BLA	28
F.15	BMA	11
F.17	BMA	879
F.18	Silo	938
F.20	BLA	15
F.23	BMA	324
O.01	BMA	743
O.02	Silo	2094
O.07	BTF	628
O.12	BLA	80
O.23	BMA	696
C.01	BMA	61
C.02	Silo	1438
C.23	BMA	88
C.24	Silo	150
R.01	BMA	1821
R.02	Silo	705
R.10	BMA	160
R.12	BLA	103
R.15	BMA	295
R.16	Silo	3733
R.23	BMA	836
S.04	Silo	134
S.09	BMA	382
S.11	Silo	96
S.12	BLA	31
S.13	BTF	6479
S.14	BLA	73
S.19	BTF	96
S.21	BMA	1493
S.22	Silo	430
S.23	BMA	61
S.24	Silo	2
Odd BLA	BLA	64
Odd BTF	BTF	415
Odd BMA	BMA	238
Total		39312

3 Uncertainties

The identified uncertainties are:

- The annual production of waste varies from year to year. The numbers are originally based on experience and knowledge of the different waste producers. Over a period of time the uncertainties are smaller.
- New waste types will certainly be licensed during the time until 2030.
- The operational life of the reactors could vary a lot because of economical, political and/or technical issues.

In total the uncertainties are relatively large. But one has to remember the purpose of the calculations is to form a best estimate of waste amounts. Some kind of conservatism can be said to be included in the calculations due to the additional waste that has been assumed to fill the repository to 100 %.

4 References

Chyssler, 2000. Personal communication Jan Chyssler Studsvik RadWaste.

Johansson, 1999. Prognos över nyttjande av SFR-1 (in Swedish) SKB Drift PM 99/15.

SKB, 2000. Plan 2000 – Kostnader för kärnkraftens radioaktiva restprodukter (in Swedish) SKB report.

TRIUMF, 2000. Operational database for SFR, SKB [accessed 2000-07-01].

Appendix B

Calculation of radionuclide inventory

1 Method of calculation

1.1 Aim of calculations – restrictions

The primary issue in a safety assessment of a repository for radioactive waste is almost always to calculate the release of radionuclides to the environment. A nuclide specific estimate of the radionuclide content in the repository is then fundamental. This is also true for project SAFE and the safety assessment of SFR-1.

The most accurate method to estimate the radionuclides is almost always to make direct measurements on the waste. Unfortunately this is never feasible in reality to do for all waste, due to a number of reasons, e.g. the waste is not produced yet, the geometry, the shielding of activity (high detection limit), the measurements are not correct etc. The solution is to make some kind of estimate.

In the SAFE project we have been forced to make estimates since the facility still is in operation and waste are constantly being supplied to the repository. Also, there are no possibilities to make measurements on the waste packages other than on gamma emitting nuclides.

According to the license for the repository we are not allowed to deposit more than 10^{16} Bq in total by the time of sealing. One of the prerequisites of the SAFE project was that the allowed amount should not be changed. Another prerequisite was to make a realistic estimate of the nuclide inventory of SFR-1. The project has interpreted these prerequisites as there should be two inventories, one realistic based on the best available data in order to make better prognosis in the future and one conservative which should be the basis for the radionuclide release calculations. The conservative one should add up to 10^{16} Bq.

1.2 Available information sources

In the work estimating a radionuclide inventory we have aspired to use the best available data for this kind of waste. The sources we have used are

- /TRIUMF, 2000/, a database for waste that are deposited in SFR-1. The database includes detailed information for the approximately 25 000 deposited waste packages regarding gamma emitting nuclides. The data has been restricted to waste deposited before July 2000.

- Data concerning waste from /Studsvik, 2000/. In some cases some types of waste have not been produced and/or have not been deposited in SFR-1 yet. This is applicable for a few waste types from the Studsvik research site. In these cases measured data for gamma emitting nuclides from Studsvik's databases or their waste type descriptions been used.

- Correlation factors have been taken from SKB report "Low and Intermediate Level Waste in SFL 3-5: Reference Inventory" /Lindgren et al, 1998/.

- Half-lives for nuclides has been taken from /Firestone, 1998/.

- The data used for transuranic nuclides has been collected from the SKB database over transuranic elements in Swedish reactors. The database is used as foundation for the yearly accounts that is presented to SKI and SSI regarding transuranic activities in SFR-1 /TRU, 2000/.

Finally, the prognosis for future waste in SFR-1 is used. How the prognosis was made is described in appendix A in this report.

1.3 Method of calculation

1.3.1 Correlation factors

The nuclides that has been judged to exist in the waste and have such a long half-life that it is meaningful to perform release calculations on them are usually not directly measurable on the packages. The method we have found to be most effective is to make an estimate based on correlation factors. The "key-nuclides" we used are Co-60, Cs-137 and Pu-239/240.

Note that no exclusion is made dependent on the amount of the nuclide in this phase of the safety assessment. In the calculations of radionuclide release in the safety assessment some nuclides were judged as negligible.

The nuclides and the correlation factors are presented in Table 1-1.

Table 1-1. Calculated nuclides in SFR-1.

Mass number	Nuclide	Half-life [yr.]	Correlation nuclide	Correlation factor
3	H-3	12,33	Co-60	0,0001
10	Be-10	1600000	Co-60	$6 \cdot 10^{-10}$
14	C-14	5730	Co-60	0,001
36	Cl-36	301000	Cs-137	0,00001
55	Fe-55	2,73	Co-60	1
59	Ni-59	76000	Co-60	0,001
60	Co-60	5,27	Co-60	1
63	Ni-63	100,1	Co-60	0,2
79	Se-79	65000	Cs-137	0,000004
90	Sr-90	28,78	Cs-137	0,1
93	Mo-93	4000	Co-60	0,000005
93	Nb-93m	16,13	Co-60	0,001
93	Zr-93	1530000	Co-60	0,000001
94	Nb-94	20300	Co-60	0,00001
99	Tc-99	211000	Cs-137	0,005
106	Ru-106	1,02	Cs-137	0,005
107	Pd-107	6500000	Cs-137	0,000001
108	Ag-108m	418	Co-60	0,00006
113	Cd-113m	14,1	Cs-137	0,0006
125	Sb-125	2,7582	Co-60	0,1
126	Sn-126	100000	Cs-137	0,0000005
129	I-129	15700000	Cs-137	0,0000003
133	Ba-133	10,52	Co-60	0,00001
134	Cs-134	2,062	Cs-137	1
135	Cs-135	2300000	Cs-137	0,000005
137	Cs-137	30,17	Cs-137	1
147	Pm-147	2,6234	Cs-137	0,9

Mass number	**Nuclide**	**Half-life [yr.]**	**Correlation nuclide**	**Correlation factor**
151	Sm-151	90	Cs-137	0,003
152	Eu-152	13,542	Cs-137	0,00007
154	Eu-154	8,593	Cs-137	0,1
155	Eu-155	4,7611	Cs-137	0,07
166	Ho-166m	1200	Co-60	0,000004
210	Pb-210	22,3	Pu-239/240	$2\cdot10^{-11}$
226	Ra-226	1600	Pu-239/240	$2\cdot10^{-10}$
227	Ac-227	21,773	Pu-239/240	0,000000004
229	Th-229	7340	Pu-239/240	$3\cdot10^{-10}$
230	Th-230	$7{,}54\cdot10^{4}$	Pu-239/240	0,00000009
231	Pa-231	32760	Pu-239/240	0,00000003
232	Th-232	$1{,}41\cdot10^{10}$	Pu-239/240	$1\cdot10^{-13}$
232	U-232	68,9	Pu-239/240	0,00003
233	U-233	$1{,}59\cdot10^{5}$	Pu-239/240	0,00000002
234	U-234	$2{,}46\cdot10^{5}$	Pu-239/240	0,001
235	U-235	$7{,}04\cdot10^{8}$	Pu-239/240	0,00002
236	U-236	$2{,}34\cdot10^{7}$	Pu-239/240	0,0003
237	Np-237	$2{,}14\cdot10^{6}$	Pu-239/240	0,0004
238	Pu-238	87,7	Pu-239/240	4
238	U-238	$4{,}47\cdot10^{9}$	Pu-239/240	0,0004
241	Am-241	432,2	Pu-239/240	1
241	Pu-241	14,35	Pu-239/240	100
242	Am-242m	141	Pu-239/240	0,01
242	Pu-242	$3{,}73\cdot10^{5}$	Pu-239/240	0,003
243	Am-243	7370	Pu-239/240	0,03
243	Cm-243	29,1	Pu-239/240	0,02
244	Cm-244	18,1	Pu-239/240	3
244	Pu-244	$8{,}08\cdot10^{7}$	Pu-239/240	$7\cdot10^{-10}$
245	Cm-245	8500	Pu-239/240	0,0003
246	Cm-246	4730	Pu-239/240	0,00008

1.3.2 Calculation of nuclides correlated to Co-60 or Cs-137

The method of calculation has been as follows; in the waste databases that we used (see chapter 1.2), all activity data concerning measurements of Co-60 and Cs-137 has been collected for each of the different waste types. These data has then been recalculated to the time of production of each of the waste packages. An average value of each nuclide has then been made from these activities. The denominator in the operation has been the total number of each waste type rather than the number of activity data. This operation was performed in order to get a more representative average value.

The average values for these key nuclides at production are then the foundation for all calculations. Correlations are then made for all the nuclides in Table 1-1 that has Co-60 and Cs-137 as key nuclides. This nuclide list is then used as a reference waste package radionuclide inventory.

1.3.3 Calculation of nuclides correlated to Pu-239 and Pu-240

The reference waste package still lacks values for transuranic elements. For these nuclides the key nuclide is Pu-239 + Pu-240.

As database we have used the measurements that are made in the reactor water at the Swedish nuclear power plants according to a method used by SKB and accepted by the authorities. For each reactor plutonium has been measured in the reactor water and an average per year for the whole plant has been calculated. An amount of Pu in the scrap metal and refuse has also been calculated. These measurements are reported each year to the authorities. In our calculations we have used an average over the time period 1988–1999. The quality of data before 1988 has been judge to be too poor.

The data that is extractable from the database are on a plant specific base, not on a waste type base. To distribute the transuranic elements on each waste type we have used the distribution of Co-60 in the different waste types. One could argue that Cs-137 should be a better correlation to Pu since it's a fission product compared to the activation product Co-60, but experience shows that cobalt is a better key-nuclide, probably due to transport properties.

The chain of calculation is as follows:

1. The amount of Co-60 was taken from the reference waste package.
2. The number of waste packages, already existing and prognosticated was taken from the prognosis (appendix A), divided in already existing packages and estimated annual production.
3. The Co-60 activity was multiplied with the number of packages to calculate the total amount of Co-60 activity in each waste type.
4. The waste types were divided in types containing ion exchange resins and types containing scrap and refuse.
5. The percentage of Co-60 in each waste type, i.e. percentage regarding power plant and type of waste resins or refuse. This was done for both existing and prognosticated packages separately.

   E.g. For existing waste in Barsebäck: 100 % of all scrap and refuse are in type B.12. Then all Co-60 activity in scrap is in the B.12. The ion-exchange resins are divided in type B.05, B.06; B07 and B.20 with the percentages of 17,3 %, 80,2 %, 2,5 % and <0,1 % (=100 %) for Co-60.
6. The amount of Pu in resins and in refuse for each plant is extracted from the database and distributed between the different types according to the percentages.

   E.g. For existing waste in Barsebäck: Pu in scrap and refuse is $1,4 \cdot 10^4$ Bq, all of it is in B.12. Pu in resins are $7,1 \cdot 10^7$ Bq, of this amount $1,2 \cdot 10^7$ Bq (17,3 %) is in B.05, $5,7 \cdot 10^7$ Bq (80,2 %) is in B.06 and so on.
7. The other nuclides correlated to Pu-239/240 are then calculated with correlation factors.

Waste packages from Studsvik must be calculated in a different way since no analysis of reactor water is possible. Studsvik has a percentage of the nuclide inventory in SFR-1. Since Studsvik sort their packages to be disposed of in SFR primarily based on transuranic nuclides, the distribution among packages can be calculated from Co-60 activity and their allowed inventory, c.f. item 1–6 above. Correlations according to item 7 are performed in the same way.

Some exceptions exist;

- S.11; 50 m^3 of sludge and ion-exchange resins to be solidified, which has been thoroughly investigated regarding among other parameters transuranic activity. The measured Pu-activity has been used as “key-activity”
- S.19; boxes of graphite from a neutron reflector from the R1-research reactor. This material contains no transuranic material.
- S.24; one or two moulds containing smoke detectors. This waste contains only Am-241. The amount is estimated to $5 \cdot 10^{11}$ Bq.

1.3.4 Radioactive decay and summing up

In order to estimate the radionuclide inventory by the time of closure of the repository the different half-lives has to be regarded.

The waste packages can be divided into two kinds; already existing and future packages. For the ones that already exist, decay can easily be calculated since all necessary data is available (nuclide, half life ($t_{1/2}$), activity (A_0) at a specific time (T_0), and time of closure of the repository (T)). Decay according to the well know formula:

$$A\ (T) = A_0 \cdot e^{-\lambda \cdot (T-T_0)}\ ;\ \lambda = \ln 2\ /\ t_{1/2}$$

This formula is of course also used for waste packages still to be produced. The problem is just to specify T_0 since all other data is known. This is done simply by using the annual production rates specified in appendix A. Each year a batch is ‘produced’, which then is allowed to decay to the closure time.

1.3.5 Inventory at the time of closure

The numbers for each of the annual batches and the numbers for existing waste are then simply added. Note that each waste type has a ‘end-year’ after which no more batches are ‘produced’.

The result of these calculations is the realistic inventory. This adds up to approximately 10^{15} Bq. In order to create a conservative inventory a simple scaling factor is used. This factor is derived as the quota between the conservative total inventory for each repository cavern and the realistic total inventory for each cavern. The conservative total inventory for each cavern is known from the license, see Table 1-2.

Table 1-2. Allowed nuclide inventory according to the license for SFR-1.

Rock cavern	Activity (Bq)
Silo	$9{,}3\cdot10^{15}$
BTF	$1{,}4\cdot10^{14}$
BMA	$5{,}9\cdot10^{14}$
BLA	$1{,}2\cdot10^{13}$
Total	$1{,}0\cdot10^{16}$

1.3.6 ‘Odd’ waste

Some waste in SFR-1 is defined as ‘odd’ waste. This waste category represents different components that occur in small numbers, as large components like steam separators or reactor vessel lids.

Since the data for such waste are sparse it has been assumed that the relative activity of the packages are equal to the relative volume it takes, i.e. if the waste uses 10 % of the rock caverns available space, the activity is 10 % of the total activity in the cavern.

2 Reference package nuclide inventory

In this chapter the result of the reference waste packages is presented, see Table 2-1 to Table 2-6. In some cases data for the transuranic nuclides are missing, that is due to lack of data (all packages was produced before 1988 when transuranic data was of poor quality). Transuranic data exist for each summarised waste type, see Table 3-1 to Table 3-8.

Table 2-1. Reference waste packages from Barsebäck NPP.

Nuclide	B.05	B.06	B.07	B.12	B.20
Correlated to Co-60:					
Co-60	$8,7\cdot10^{9}$	$6,3\cdot10^{10}$	$2,8\cdot10^{10}$	$1,0\cdot10^{9}$	$2,6\cdot10^{6}$
Ag-108m	$5,2\cdot10^{5}$	$3,8\cdot10^{6}$	$1,7\cdot10^{6}$	$6,3\cdot10^{4}$	$1,6\cdot10^{2}$
Ba-133	$8,7\cdot10^{4}$	$6,3\cdot10^{5}$	$2,8\cdot10^{5}$	$1,0\cdot10^{4}$	$2,6\cdot10^{1}$
Be-10	$5,2\cdot10^{0}$	$3,8\cdot10^{1}$	$1,7\cdot10^{1}$	$6,3\cdot10^{-1}$	$1,6\cdot10^{-3}$
C-14	$8,7\cdot10^{6}$	$6,3\cdot10^{7}$	$2,8\cdot10^{7}$	$1,0\cdot10^{6}$	$2,6\cdot10^{3}$
Fe-55	$8,7\cdot10^{9}$	$6,3\cdot10^{10}$	$2,8\cdot10^{10}$	$1,0\cdot10^{9}$	$2,6\cdot10^{6}$
H-3	$8,7\cdot10^{5}$	$6,3\cdot10^{6}$	$2,8\cdot10^{6}$	$1,0\cdot10^{5}$	$2,6\cdot10^{2}$
Ho-166m	$3,5\cdot10^{4}$	$2,5\cdot10^{5}$	$1,1\cdot10^{5}$	$4,2\cdot10^{3}$	$1,1\cdot10^{1}$
Mo-93	$4,4\cdot10^{4}$	$3,2\cdot10^{5}$	$1,4\cdot10^{5}$	$5,2\cdot10^{3}$	$1,3\cdot10^{1}$
Nb-93m	$8,7\cdot10^{6}$	$6,3\cdot10^{7}$	$2,8\cdot10^{7}$	$1,0\cdot10^{6}$	$2,6\cdot10^{3}$
Nb-94	$8,7\cdot10^{4}$	$6,3\cdot10^{5}$	$2,8\cdot10^{5}$	$1,0\cdot10^{4}$	$2,6\cdot10^{1}$
Ni-59	$8,7\cdot10^{6}$	$6,3\cdot10^{7}$	$2,8\cdot10^{7}$	$1,0\cdot10^{6}$	$2,6\cdot10^{3}$
Ni-63	$1,7\cdot10^{9}$	$1,3\cdot10^{10}$	$5,5\cdot10^{9}$	$2,1\cdot10^{8}$	$5,3\cdot10^{5}$
Sb-125	$8,7\cdot10^{8}$	$6,3\cdot10^{9}$	$2,8\cdot10^{9}$	$1,0\cdot10^{8}$	$2,6\cdot10^{5}$
Zr-93	$8,7\cdot10^{3}$	$6,3\cdot10^{4}$	$2,8\cdot10^{4}$	$1,0\cdot10^{3}$	$2,6\cdot10^{0}$
Correlated to Cs-137:					
Cs-137	$7,2\cdot10^{8}$	$5,1\cdot10^{9}$	$1,7\cdot10^{9}$	$2,4\cdot10^{7}$	$4,9\cdot10^{3}$
Cd-113m	$4,3\cdot10^{5}$	$3,1\cdot10^{6}$	$1,0\cdot10^{6}$	$1,4\cdot10^{4}$	$3,0\cdot10^{0}$
Cl-36	$7,2\cdot10^{3}$	$5,1\cdot10^{4}$	$1,7\cdot10^{4}$	$2,4\cdot10^{2}$	$4,9\cdot10^{-2}$
Cs-134	$7,2\cdot10^{8}$	$5,1\cdot10^{9}$	$1,7\cdot10^{9}$	$2,4\cdot10^{7}$	$4,9\cdot10^{3}$
Cs-135	$3,6\cdot10^{3}$	$2,6\cdot10^{4}$	$8,6\cdot10^{3}$	$1,2\cdot10^{2}$	$2,5\cdot10^{-2}$
Eu-152	$5,0\cdot10^{4}$	$3,6\cdot10^{5}$	$1,2\cdot10^{5}$	$1,6\cdot10^{3}$	$3,4\cdot10^{-1}$
Eu-154	$7,2\cdot10^{7}$	$5,1\cdot10^{8}$	$1,7\cdot10^{8}$	$2,4\cdot10^{6}$	$4,9\cdot10^{2}$
Eu-155	$5,0\cdot10^{7}$	$3,6\cdot10^{8}$	$1,2\cdot10^{8}$	$1,6\cdot10^{6}$	$3,4\cdot10^{2}$
I-129	$2,2\cdot10^{2}$	$1,5\cdot10^{3}$	$5,2\cdot10^{2}$	$7,1\cdot10^{0}$	$1,5\cdot10^{-3}$
Pd-107	$7,2\cdot10^{2}$	$5,1\cdot10^{3}$	$1,7\cdot10^{3}$	$2,4\cdot10^{1}$	$4,9\cdot10^{-3}$
Pm-147	$6,5\cdot10^{8}$	$4,6\cdot10^{9}$	$1,5\cdot10^{9}$	$2,1\cdot10^{7}$	$4,4\cdot10^{3}$
Ru-106	$3,6\cdot10^{6}$	$2,6\cdot10^{7}$	$8,6\cdot10^{6}$	$1,2\cdot10^{5}$	$2,5\cdot10^{1}$
Se-79	$2,9\cdot10^{3}$	$2,0\cdot10^{4}$	$6,9\cdot10^{3}$	$9,4\cdot10^{1}$	$2,0\cdot10^{-2}$
Sm-151	$2,2\cdot10^{6}$	$1,5\cdot10^{7}$	$5,2\cdot10^{6}$	$7,1\cdot10^{4}$	$1,5\cdot10^{1}$
Sn-126	$3,6\cdot10^{2}$	$2,6\cdot10^{3}$	$8,6\cdot10^{2}$	$1,2\cdot10^{1}$	$2,5\cdot10^{-3}$
Sr-90	$7,2\cdot10^{7}$	$5,1\cdot10^{8}$	$1,7\cdot10^{8}$	$2,4\cdot10^{6}$	$4,9\cdot10^{2}$
Tc-99	$3,6\cdot10^{6}$	$2,6\cdot10^{7}$	$8,6\cdot10^{6}$	$1,2\cdot10^{5}$	$2,5\cdot10^{1}$

Table 2-1. Reference waste packages from Barsebäck NPP. (cont.)

Nuclide	B.05	B.06	B.07	B.12	B.20
Correlated to Pu-239 + Pu 240:					
Pu-239	$1,7\cdot10^{3}$	$1,3\cdot10^{4}$	$5,5\cdot10^{3}$	$2,5\cdot10^{1}$	
Pu-240	$3,5\cdot10^{3}$	$2,5\cdot10^{4}$	$1,1\cdot10^{4}$	$5,1\cdot10^{1}$	
Pb-210	$1,0\cdot10^{-7}$	$7,5\cdot10^{-7}$	$3,3\cdot10^{-7}$	$1,5\cdot10^{-9}$	
Ra-226	$1,0\cdot10^{-6}$	$7,5\cdot10^{-6}$	$3,3\cdot10^{-6}$	$1,5\cdot10^{-8}$	
Ac-227	$2,1\cdot10^{-5}$	$1,5\cdot10^{-4}$	$6,6\cdot10^{-5}$	$3,1\cdot10^{-7}$	
Th-229	$1,6\cdot10^{-6}$	$1,1\cdot10^{-5}$	$4,9\cdot10^{-6}$	$2,3\cdot10^{-8}$	
Th-230	$4,7\cdot10^{-4}$	$3,4\cdot10^{-3}$	$1,5\cdot10^{-3}$	$6,9\cdot10^{-6}$	
Th-232	$5,2\cdot10^{-10}$	$3,8\cdot10^{-9}$	$1,6\cdot10^{-9}$	$7,6\cdot10^{-12}$	
Pa-231	$1,6\cdot10^{-4}$	$1,1\cdot10^{-3}$	$4,9\cdot10^{-4}$	$2,3\cdot10^{-6}$	
U-232	$1,6\cdot10^{-1}$	$1,1\cdot10^{0}$	$4,9\cdot10^{-1}$	$2,3\cdot10^{-3}$	
U-233	$1,0\cdot10^{-4}$	$7,5\cdot10^{-4}$	$3,3\cdot10^{-4}$	$1,5\cdot10^{-6}$	
U-234	$5,2\cdot10^{0}$	$3,8\cdot10^{1}$	$1,6\cdot10^{1}$	$7,6\cdot10^{-2}$	
U-235	$1,0\cdot10^{-1}$	$7,5\cdot10^{-1}$	$3,3\cdot10^{-1}$	$1,5\cdot10^{-3}$	
U-236	$1,6\cdot10^{0}$	$1,1\cdot10^{1}$	$4,9\cdot10^{0}$	$2,3\cdot10^{-2}$	
U-238	$2,1\cdot10^{0}$	$1,5\cdot10^{1}$	$6,6\cdot10^{0}$	$3,1\cdot10^{-2}$	
Np-237	$2,1\cdot10^{0}$	$1,5\cdot10^{1}$	$6,6\cdot10^{0}$	$3,1\cdot10^{-2}$	
Pu-238	$2,1\cdot10^{4}$	$1,5\cdot10^{5}$	$6,6\cdot10^{4}$	$3,1\cdot10^{2}$	
Pu-241	$5,2\cdot10^{5}$	$3,8\cdot10^{6}$	$1,6\cdot10^{6}$	$7,6\cdot10^{3}$	
Pu-242	$1,6\cdot10^{1}$	$1,1\cdot10^{2}$	$4,9\cdot10^{1}$	$2,3\cdot10^{-1}$	
Am-241	$5,2\cdot10^{3}$	$3,8\cdot10^{4}$	$1,6\cdot10^{4}$	$7,6\cdot10^{1}$	
Am-242m	$5,2\cdot10^{1}$	$3,8\cdot10^{2}$	$1,6\cdot10^{2}$	$7,6\cdot10^{-1}$	
Am-243	$1,6\cdot10^{2}$	$1,1\cdot10^{3}$	$4,9\cdot10^{2}$	$2,3\cdot10^{0}$	
Cm-243	$1,0\cdot10^{2}$	$7,5\cdot10^{2}$	$3,3\cdot10^{2}$	$1,5\cdot10^{0}$	
Cm-244	$1,6\cdot10^{4}$	$1,1\cdot10^{5}$	$4,9\cdot10^{4}$	$2,3\cdot10^{2}$	
Cm-245	$1,6\cdot10^{0}$	$1,1\cdot10^{1}$	$4,9\cdot10^{0}$	$2,3\cdot10^{-2}$	
Cm-246	$4,2\cdot10^{-1}$	$3,0\cdot10^{0}$	$1,3\cdot10^{0}$	$6,1\cdot10^{-3}$	
Pu-244	$3,6\cdot10^{-6}$	$2,6\cdot10^{-5}$	$1,2\cdot10^{-5}$	$5,3\cdot10^{-8}$	
Total	$2,2\cdot10^{10}$	$1,6\cdot10^{11}$	$6,9\cdot10^{10}$	$2,5\cdot10^{9}$	$6,1\cdot10^{6}$

Table 2-2. Reference waste packages from Forsmark NPP.

Nuclide	F.12	F.20	F.05	F.15	F.17	F.23	F.18
Correlated to Co-60:							
Co-60	$1,5\cdot10^{10}$	$2,8\cdot10^{9}$	$4,0\cdot10^{9}$	$3,4\cdot10^{9}$	$9,2\cdot10^{10}$	$1,1\cdot10^{10}$	$8,2\cdot10^{11}$
Ag-108m	$9,0\cdot10^{5}$	$1,7\cdot10^{5}$	$2,4\cdot10^{5}$	$2,1\cdot10^{5}$	$5,5\cdot10^{6}$	$6,7\cdot10^{5}$	$4,9\cdot10^{7}$
Ba-133	$1,5\cdot10^{5}$	$2,8\cdot10^{4}$	$4,0\cdot10^{4}$	$3,4\cdot10^{4}$	$9,2\cdot10^{5}$	$1,1\cdot10^{5}$	$8,2\cdot10^{6}$
Be-10	$9,0\cdot10^{0}$	$1,7\cdot10^{0}$	$2,4\cdot10^{0}$	$2,1\cdot10^{0}$	$5,5\cdot10^{1}$	$6,7\cdot10^{0}$	$4,9\cdot10^{2}$
C-14	$1,5\cdot10^{7}$	$2,8\cdot10^{6}$	$4,0\cdot10^{6}$	$3,4\cdot10^{6}$	$9,2\cdot10^{7}$	$1,1\cdot10^{7}$	$8,2\cdot10^{8}$
Fe-55	$1,5\cdot10^{10}$	$2,8\cdot10^{9}$	$4,0\cdot10^{9}$	$3,4\cdot10^{9}$	$9,2\cdot10^{10}$	$1,1\cdot10^{10}$	$8,2\cdot10^{11}$
H-3	$1,5\cdot10^{6}$	$2,8\cdot10^{5}$	$4,0\cdot10^{5}$	$3,4\cdot10^{5}$	$9,2\cdot10^{6}$	$1,1\cdot10^{6}$	$8,2\cdot10^{7}$
Ho-166m	$6,0\cdot10^{4}$	$1,1\cdot10^{4}$	$1,6\cdot10^{4}$	$1,4\cdot10^{4}$	$3,7\cdot10^{5}$	$4,5\cdot10^{4}$	$3,3\cdot10^{6}$
Mo-93	$7,5\cdot10^{4}$	$1,4\cdot10^{4}$	$2,0\cdot10^{4}$	$1,7\cdot10^{4}$	$4,6\cdot10^{5}$	$5,6\cdot10^{4}$	$4,1\cdot10^{6}$
Nb-93m	$1,5\cdot10^{7}$	$2,8\cdot10^{6}$	$4,0\cdot10^{6}$	$3,4\cdot10^{6}$	$9,2\cdot10^{7}$	$1,1\cdot10^{7}$	$8,2\cdot10^{8}$
Nb-94	$1,5\cdot10^{5}$	$2,8\cdot10^{4}$	$4,0\cdot10^{4}$	$3,4\cdot10^{4}$	$9,2\cdot10^{5}$	$1,1\cdot10^{5}$	$8,2\cdot10^{6}$
Ni-59	$1,5\cdot10^{7}$	$2,8\cdot10^{6}$	$4,0\cdot10^{6}$	$3,4\cdot10^{6}$	$9,2\cdot10^{7}$	$1,1\cdot10^{7}$	$8,2\cdot10^{8}$
Ni-63	$3,0\cdot10^{9}$	$5,6\cdot10^{8}$	$7,9\cdot10^{8}$	$6,9\cdot10^{8}$	$1,8\cdot10^{10}$	$2,2\cdot10^{9}$	$1,6\cdot10^{11}$
Sb-125	$1,5\cdot10^{9}$	$2,8\cdot10^{8}$	$4,0\cdot10^{8}$	$3,4\cdot10^{8}$	$9,2\cdot10^{9}$	$1,1\cdot10^{9}$	$8,2\cdot10^{10}$
Zr-93	$1,5\cdot10^{4}$	$2,8\cdot10^{3}$	$4,0\cdot10^{3}$	$3,4\cdot10^{3}$	$9,2\cdot10^{4}$	$1,1\cdot10^{4}$	$8,2\cdot10^{5}$
Correlated to Cs-137:							
Cs-137	$1,7\cdot10^{8}$	$1,1\cdot10^{8}$	$4,4\cdot10^{7}$	$2,2\cdot10^{9}$	$1,7\cdot10^{10}$	$4,8\cdot10^{7}$	$8,6\cdot10^{10}$
Cd-113m	$9,9\cdot10^{4}$	$6,7\cdot10^{4}$	$2,6\cdot10^{4}$	$1,3\cdot10^{6}$	$1,0\cdot10^{7}$	$2,9\cdot10^{4}$	$5,2\cdot10^{7}$
Cl-36	$1,7\cdot10^{3}$	$1,1\cdot10^{3}$	$4,4\cdot10^{2}$	$2,2\cdot10^{4}$	$1,7\cdot10^{5}$	$4,8\cdot10^{2}$	$8,6\cdot10^{5}$
Cs-134	$1,7\cdot10^{8}$	$1,1\cdot10^{8}$	$4,4\cdot10^{7}$	$2,2\cdot10^{9}$	$1,7\cdot10^{10}$	$4,8\cdot10^{7}$	$8,6\cdot10^{10}$
Cs-135	$8,3\cdot10^{2}$	$5,6\cdot10^{2}$	$2,2\cdot10^{2}$	$1,1\cdot10^{4}$	$8,3\cdot10^{4}$	$2,4\cdot10^{2}$	$4,3\cdot10^{5}$
Eu-152	$1,2\cdot10^{4}$	$7,8\cdot10^{3}$	$3,1\cdot10^{3}$	$1,6\cdot10^{5}$	$1,2\cdot10^{6}$	$3,4\cdot10^{3}$	$6,0\cdot10^{6}$
Eu-154	$1,7\cdot10^{7}$	$1,1\cdot10^{7}$	$4,4\cdot10^{6}$	$2,2\cdot10^{8}$	$1,7\cdot10^{9}$	$4,8\cdot10^{6}$	$8,6\cdot10^{9}$
Eu-155	$1,2\cdot10^{7}$	$7,8\cdot10^{6}$	$3,1\cdot10^{6}$	$1,6\cdot10^{8}$	$1,2\cdot10^{9}$	$3,4\cdot10^{6}$	$6,0\cdot10^{9}$
I-129	$5,0\cdot10^{1}$	$3,4\cdot10^{1}$	$1,3\cdot10^{1}$	$6,7\cdot10^{2}$	$5,0\cdot10^{3}$	$1,4\cdot10^{1}$	$2,6\cdot10^{4}$
Pd-107	$1,7\cdot10^{2}$	$1,1\cdot10^{2}$	$4,4\cdot10^{1}$	$2,2\cdot10^{3}$	$1,7\cdot10^{4}$	$4,8\cdot10^{1}$	$8,6\cdot10^{4}$
Pm-147	$1,5\cdot10^{8}$	$1,0\cdot10^{8}$	$3,9\cdot10^{7}$	$2,0\cdot10^{9}$	$1,5\cdot10^{10}$	$4,3\cdot10^{7}$	$7,7\cdot10^{10}$
Ru-106	$8,3\cdot10^{5}$	$5,6\cdot10^{5}$	$2,2\cdot10^{5}$	$1,1\cdot10^{7}$	$8,3\cdot10^{7}$	$2,4\cdot10^{5}$	$4,3\cdot10^{8}$
Se-79	$6,6\cdot10^{2}$	$4,5\cdot10^{2}$	$1,7\cdot10^{2}$	$8,9\cdot10^{3}$	$6,6\cdot10^{4}$	$1,9\cdot10^{2}$	$3,4\cdot10^{5}$
Sm-151	$5,0\cdot10^{5}$	$3,4\cdot10^{5}$	$1,3\cdot10^{5}$	$6,7\cdot10^{6}$	$5,0\cdot10^{7}$	$1,4\cdot10^{5}$	$2,6\cdot10^{8}$
Sn-126	$8,3\cdot10^{1}$	$5,6\cdot10^{1}$	$2,2\cdot10^{1}$	$1,1\cdot10^{3}$	$8,3\cdot10^{3}$	$2,4\cdot10^{1}$	$4,3\cdot10^{4}$
Sr-90	$1,7\cdot10^{7}$	$1,1\cdot10^{7}$	$4,4\cdot10^{6}$	$2,2\cdot10^{8}$	$1,7\cdot10^{9}$	$4,8\cdot10^{6}$	$8,6\cdot10^{9}$
Tc-99	$8,3\cdot10^{5}$	$5,6\cdot10^{5}$	$2,2\cdot10^{5}$	$1,1\cdot10^{7}$	$8,3\cdot10^{7}$	$2,4\cdot10^{5}$	$4,3\cdot10^{8}$

Table 2-2. Reference waste packages from Forsmark NPP. (cont.)

Nuclide	F.12	F.20	F.05	F.15	F.17	F.23	F.18
Correlated to Pu-239 + Pu 240:							
Pu-239	$8,7 \cdot 10^{3}$				$2,0 \cdot 10^{5}$	$6,5 \cdot 10^{3}$	$1,8 \cdot 10^{6}$
Pu-240	$1,7 \cdot 10^{4}$				$4,0 \cdot 10^{5}$	$1,3 \cdot 10^{4}$	$3,6 \cdot 10^{6}$
Pb-210	$5,2 \cdot 10^{-7}$				$1,2 \cdot 10^{-5}$	$3,9 \cdot 10^{-7}$	$1,1 \cdot 10^{-4}$
Ra-226	$5,2 \cdot 10^{-6}$				$1,2 \cdot 10^{-4}$	$3,9 \cdot 10^{-6}$	$1,1 \cdot 10^{-3}$
Ac-227	$1,0 \cdot 10^{-4}$				$2,4 \cdot 10^{-3}$	$7,9 \cdot 10^{-5}$	$2,2 \cdot 10^{-2}$
Th-229	$7,9 \cdot 10^{-6}$				$1,8 \cdot 10^{-4}$	$5,9 \cdot 10^{-6}$	$1,6 \cdot 10^{-3}$
Th-230	$2,4 \cdot 10^{-3}$				$5,5 \cdot 10^{-2}$	$1,8 \cdot 10^{-3}$	$4,9 \cdot 10^{-1}$
Th-232	$2,6 \cdot 10^{-9}$				$6,1 \cdot 10^{-8}$	$2,0 \cdot 10^{-9}$	$5,4 \cdot 10^{-7}$
Pa-231	$7,9 \cdot 10^{-4}$				$1,8 \cdot 10^{-2}$	$5,9 \cdot 10^{-4}$	$1,6 \cdot 10^{-1}$
U-232	$7,9 \cdot 10^{-1}$				$1,8 \cdot 10^{1}$	$5,9 \cdot 10^{-1}$	$1,6 \cdot 10^{2}$
U-233	$5,2 \cdot 10^{-4}$				$1,2 \cdot 10^{-2}$	$3,9 \cdot 10^{-4}$	$1,1 \cdot 10^{-1}$
U-234	$2,6 \cdot 10^{1}$				$6,1 \cdot 10^{2}$	$2,0 \cdot 10^{1}$	$5,4 \cdot 10^{3}$
U-235	$5,2 \cdot 10^{-1}$				$1,2 \cdot 10^{1}$	$3,9 \cdot 10^{-1}$	$1,1 \cdot 10^{2}$
U-236	$7,9 \cdot 10^{0}$				$1,8 \cdot 10^{2}$	$5,9 \cdot 10^{0}$	$1,6 \cdot 10^{3}$
U-238	$1,0 \cdot 10^{1}$				$2,4 \cdot 10^{2}$	$7,9 \cdot 10^{0}$	$2,2 \cdot 10^{3}$
Np-237	$1,0 \cdot 10^{1}$				$2,4 \cdot 10^{2}$	$7,9 \cdot 10^{0}$	$2,2 \cdot 10^{3}$
Pu-238	$1,0 \cdot 10^{5}$				$2,4 \cdot 10^{6}$	$7,9 \cdot 10^{4}$	$2,2 \cdot 10^{7}$
Pu-241	$2,6 \cdot 10^{6}$				$6,1 \cdot 10^{7}$	$2,0 \cdot 10^{6}$	$5,4 \cdot 10^{8}$
Pu-242	$7,9 \cdot 10^{1}$				$1,8 \cdot 10^{3}$	$5,9 \cdot 10^{1}$	$1,6 \cdot 10^{4}$
Am-241	$2,6 \cdot 10^{4}$				$6,1 \cdot 10^{5}$	$2,0 \cdot 10^{4}$	$5,4 \cdot 10^{6}$
Am-242m	$2,6 \cdot 10^{2}$				$6,1 \cdot 10^{3}$	$2,0 \cdot 10^{2}$	$5,4 \cdot 10^{4}$
Am-243	$7,9 \cdot 10^{2}$				$1,8 \cdot 10^{4}$	$5,9 \cdot 10^{2}$	$1,6 \cdot 10^{5}$
Cm-243	$5,2 \cdot 10^{2}$				$1,2 \cdot 10^{4}$	$3,9 \cdot 10^{2}$	$1,1 \cdot 10^{5}$
Cm-244	$7,9 \cdot 10^{4}$				$1,8 \cdot 10^{6}$	$5,9 \cdot 10^{4}$	$1,6 \cdot 10^{7}$
Cm-245	$7,9 \cdot 10^{0}$				$1,8 \cdot 10^{2}$	$5,9 \cdot 10^{0}$	$1,6 \cdot 10^{3}$
Cm-246	$2,1 \cdot 10^{0}$				$4,8 \cdot 10^{1}$	$1,6 \cdot 10^{0}$	$4,3 \cdot 10^{2}$
Pu-244	$1,8 \cdot 10^{-5}$				$4,2 \cdot 10^{-4}$	$1,4 \cdot 10^{-5}$	$3,8 \cdot 10^{-3}$
Total	$3,5 \cdot 10^{10}$	$6,8 \cdot 10^{9}$	$9,3 \cdot 10^{9}$	$1,5 \cdot 10^{10}$	$2,6 \cdot 10^{11}$	$2,6 \cdot 10^{10}$	$2,2 \cdot 10^{12}$

Table 2-3. Reference waste packages from CLAB.

Nuclide	C.01	C.23	C.02	C.24
Correlated to Co-60:				
Co-60	$1,3\cdot10^{12}$	$1,8\cdot10^{11}$	$4,5\cdot10^{11}$	$1,5\cdot10^{11}$
Ag-108m	$8,1\cdot10^{7}$	$1,1\cdot10^{7}$	$2,7\cdot10^{7}$	$9,0\cdot10^{6}$
Ba-133	$1,3\cdot10^{7}$	$1,8\cdot10^{6}$	$4,5\cdot10^{6}$	$1,5\cdot10^{6}$
Be-10	$8,1\cdot10^{2}$	$1,1\cdot10^{2}$	$2,7\cdot10^{2}$	$9,0\cdot10^{1}$
C-14	$1,3\cdot10^{9}$	$1,8\cdot10^{8}$	$4,5\cdot10^{8}$	$1,5\cdot10^{8}$
Fe-55	$1,3\cdot10^{12}$	$1,8\cdot10^{11}$	$4,5\cdot10^{11}$	$1,5\cdot10^{11}$
H-3	$1,3\cdot10^{8}$	$1,8\cdot10^{7}$	$4,5\cdot10^{7}$	$1,5\cdot10^{7}$
Ho-166m	$5,4\cdot10^{6}$	$7,3\cdot10^{5}$	$1,8\cdot10^{6}$	$6,0\cdot10^{5}$
Mo-93	$6,7\cdot10^{6}$	$9,2\cdot10^{5}$	$2,2\cdot10^{6}$	$7,5\cdot10^{5}$
Nb-93m	$1,3\cdot10^{9}$	$1,8\cdot10^{8}$	$4,5\cdot10^{8}$	$1,5\cdot10^{8}$
Nb-94	$1,3\cdot10^{7}$	$1,8\cdot10^{6}$	$4,5\cdot10^{6}$	$1,5\cdot10^{6}$
Ni-59	$1,3\cdot10^{9}$	$1,8\cdot10^{8}$	$4,5\cdot10^{8}$	$1,5\cdot10^{8}$
Ni-63	$2,7\cdot10^{11}$	$3,7\cdot10^{10}$	$8,9\cdot10^{10}$	$3,0\cdot10^{10}$
Sb-125	$1,3\cdot10^{11}$	$1,8\cdot10^{10}$	$4,5\cdot10^{10}$	$1,5\cdot10^{10}$
Zr-93	$1,3\cdot10^{6}$	$1,8\cdot10^{5}$	$4,5\cdot10^{5}$	$1,5\cdot10^{5}$
Correlated to Cs-137:				
Cs-137	$3,8\cdot10^{11}$	$3,1\cdot10^{10}$	$1,3\cdot10^{11}$	$6,5\cdot10^{10}$
Cd-113m	$2,3\cdot10^{8}$	$1,9\cdot10^{7}$	$7,7\cdot10^{7}$	$3,9\cdot10^{7}$
Cl-36	$3,8\cdot10^{6}$	$3,1\cdot10^{5}$	$1,3\cdot10^{6}$	$6,5\cdot10^{5}$
Cs-134	$3,8\cdot10^{11}$	$3,1\cdot10^{10}$	$1,3\cdot10^{11}$	$6,5\cdot10^{10}$
Cs-135	$1,9\cdot10^{6}$	$1,6\cdot10^{5}$	$6,4\cdot10^{5}$	$3,3\cdot10^{5}$
Eu-152	$2,7\cdot10^{7}$	$2,2\cdot10^{6}$	$9,0\cdot10^{6}$	$4,6\cdot10^{6}$
Eu-154	$3,8\cdot10^{10}$	$3,1\cdot10^{9}$	$1,3\cdot10^{10}$	$6,5\cdot10^{9}$
Eu-155	$2,7\cdot10^{10}$	$2,2\cdot10^{9}$	$9,0\cdot10^{9}$	$4,6\cdot10^{9}$
I-129	$1,2\cdot10^{5}$	$9,4\cdot10^{3}$	$3,8\cdot10^{4}$	$2,0\cdot10^{4}$
Pd-107	$3,8\cdot10^{5}$	$3,1\cdot10^{4}$	$1,3\cdot10^{5}$	$6,5\cdot10^{4}$
Pm-147	$3,5\cdot10^{11}$	$2,8\cdot10^{10}$	$1,2\cdot10^{11}$	$5,9\cdot10^{10}$
Ru-106	$1,9\cdot10^{9}$	$1,6\cdot10^{8}$	$6,4\cdot10^{8}$	$3,3\cdot10^{8}$
Se-79	$1,5\cdot10^{6}$	$1,3\cdot10^{5}$	$5,1\cdot10^{5}$	$2,6\cdot10^{5}$
Sm-151	$1,2\cdot10^{9}$	$9,4\cdot10^{7}$	$3,8\cdot10^{8}$	$2,0\cdot10^{8}$
Sn-126	$1,9\cdot10^{5}$	$1,6\cdot10^{4}$	$6,4\cdot10^{4}$	$3,3\cdot10^{4}$
Sr-90	$3,8\cdot10^{10}$	$3,1\cdot10^{9}$	$1,3\cdot10^{10}$	$6,5\cdot10^{9}$
Tc-99	$1,9\cdot10^{9}$	$1,6\cdot10^{8}$	$6,4\cdot10^{8}$	$3,3\cdot10^{8}$

Table 2-3. Reference waste packages from CLAB. (cont.)

Nuclide	C.01	C.23	C.02	C.24
Correlated to Pu-239 + Pu 240:				
Pu-239		$3,7\cdot10^{3}$	$1,0\cdot10^{5}$	$3,0\cdot10^{3}$
Pu-240		$7,4\cdot10^{3}$	$2,0\cdot10^{5}$	$6,1\cdot10^{3}$
Pb-210		$2,2\cdot10^{-7}$	$6,0\cdot10^{-6}$	$1,8\cdot10^{-7}$
Ra-226		$2,2\cdot10^{-6}$	$6,0\cdot10^{-5}$	$1,8\cdot10^{-6}$
Ac-227		$4,5\cdot10^{-5}$	$1,2\cdot10^{-3}$	$3,6\cdot10^{-5}$
Th-229		$3,3\cdot10^{-6}$	$9,0\cdot10^{-5}$	$2,7\cdot10^{-6}$
Th-230		$1,0\cdot10^{-3}$	$2,7\cdot10^{-2}$	$8,2\cdot10^{-4}$
Th-232		$1,1\cdot10^{-9}$	$3,0\cdot10^{-8}$	$9,1\cdot10^{-10}$
Pa-231		$3,3\cdot10^{-4}$	$9,0\cdot10^{-3}$	$2,7\cdot10^{-4}$
U-232		$3,3\cdot10^{-1}$	$9,0\cdot10^{0}$	$2,7\cdot10^{-1}$
U-233		$2,2\cdot10^{-4}$	$6,0\cdot10^{-3}$	$1,8\cdot10^{-4}$
U-234		$1,1\cdot10^{1}$	$3,0\cdot10^{2}$	$9,1\cdot10^{0}$
U-235		$2,2\cdot10^{-1}$	$6,0\cdot10^{0}$	$1,8\cdot10^{-1}$
U-236		$3,3\cdot10^{0}$	$9,0\cdot10^{1}$	$2,7\cdot10^{0}$
U-238		$4,5\cdot10^{0}$	$1,2\cdot10^{2}$	$3,6\cdot10^{0}$
Np-237		$4,5\cdot10^{0}$	$1,2\cdot10^{2}$	$3,6\cdot10^{0}$
Pu-238		$4,5\cdot10^{4}$	$1,2\cdot10^{6}$	$3,6\cdot10^{4}$
Pu-241		$1,1\cdot10^{6}$	$3,0\cdot10^{7}$	$9,1\cdot10^{5}$
Pu-242		$3,3\cdot10^{1}$	$9,0\cdot10^{2}$	$2,7\cdot10^{1}$
Am-241		$1,1\cdot10^{4}$	$3,0\cdot10^{5}$	$9,1\cdot10^{3}$
Am-242m		$1,1\cdot10^{2}$	$3,0\cdot10^{3}$	$9,1\cdot10^{1}$
Am-243		$3,3\cdot10^{2}$	$9,0\cdot10^{3}$	$2,7\cdot10^{2}$
Cm-243		$2,2\cdot10^{2}$	$6,0\cdot10^{3}$	$1,8\cdot10^{2}$
Cm-244		$3,3\cdot10^{4}$	$9,0\cdot10^{5}$	$2,7\cdot10^{4}$
Cm-245		$3,3\cdot10^{0}$	$9,0\cdot10^{1}$	$2,7\cdot10^{0}$
Cm-246		$8,9\cdot10^{-1}$	$2,4\cdot10^{1}$	$7,3\cdot10^{-1}$
Pu-244		$7,8\cdot10^{-6}$	$2,1\cdot10^{-4}$	$6,4\cdot10^{-6}$
Total	$4,3\cdot10^{12}$	$5,2\cdot10^{11}$	$1,4\cdot10^{12}$	$5,5\cdot10^{11}$

Table 2-4. Reference waste packages from Oskarshamn NPP.

Nuclide	O.12	O.07	O.01	O.23	O.02
Correlated to Co-60:					
Co-60	$4,3\cdot10^{9}$	$5,0\cdot10^{10}$	$4,2\cdot10^{10}$	$9,4\cdot10^{9}$	$1,1\cdot10^{11}$
Ag-108m	$2,6\cdot10^{5}$	$3,0\cdot10^{6}$	$2,5\cdot10^{6}$	$5,6\cdot10^{5}$	$6,3\cdot10^{6}$
Ba-133	$4,3\cdot10^{4}$	$5,0\cdot10^{5}$	$4,2\cdot10^{5}$	$9,4\cdot10^{4}$	$1,1\cdot10^{6}$
Be-10	$2,6\cdot10^{0}$	$3,0\cdot10^{1}$	$2,5\cdot10^{1}$	$5,6\cdot10^{0}$	$6,3\cdot10^{1}$
C-14	$4,3\cdot10^{6}$	$5,0\cdot10^{7}$	$4,2\cdot10^{7}$	$9,4\cdot10^{6}$	$1,1\cdot10^{8}$
Fe-55	$4,3\cdot10^{9}$	$5,0\cdot10^{10}$	$4,2\cdot10^{10}$	$9,4\cdot10^{9}$	$1,1\cdot10^{11}$
H-3	$4,3\cdot10^{5}$	$5,0\cdot10^{6}$	$4,2\cdot10^{6}$	$9,4\cdot10^{5}$	$1,1\cdot10^{7}$
Ho-166m	$1,7\cdot10^{4}$	$2,0\cdot10^{5}$	$1,7\cdot10^{5}$	$3,8\cdot10^{4}$	$4,2\cdot10^{5}$
Mo-93	$2,1\cdot10^{4}$	$2,5\cdot10^{5}$	$2,1\cdot10^{5}$	$4,7\cdot10^{4}$	$5,3\cdot10^{5}$
Nb-93m	$4,3\cdot10^{6}$	$5,0\cdot10^{7}$	$4,2\cdot10^{7}$	$9,4\cdot10^{6}$	$1,1\cdot10^{8}$
Nb-94	$4,3\cdot10^{4}$	$5,0\cdot10^{5}$	$4,2\cdot10^{5}$	$9,4\cdot10^{4}$	$1,1\cdot10^{6}$
Ni-59	$4,3\cdot10^{6}$	$5,0\cdot10^{7}$	$4,2\cdot10^{7}$	$9,4\cdot10^{6}$	$1,1\cdot10^{8}$
Ni-63	$8,5\cdot10^{8}$	$1,0\cdot10^{10}$	$8,3\cdot10^{9}$	$1,9\cdot10^{9}$	$2,1\cdot10^{10}$
Sb-125	$4,3\cdot10^{8}$	$5,0\cdot10^{9}$	$4,2\cdot10^{9}$	$9,4\cdot10^{8}$	$1,1\cdot10^{10}$
Zr-93	$4,3\cdot10^{3}$	$5,0\cdot10^{4}$	$4,2\cdot10^{4}$	$9,4\cdot10^{3}$	$1,1\cdot10^{5}$
Correlated to Cs-137:					
Cs-137	$8,1\cdot10^{8}$	$1,1\cdot10^{10}$	$1,2\cdot10^{10}$	$1,6\cdot10^{9}$	$8,7\cdot10^{10}$
Cd-113m	$4,9\cdot10^{5}$	$6,4\cdot10^{6}$	$7,1\cdot10^{6}$	$9,6\cdot10^{5}$	$5,2\cdot10^{7}$
Cl-36	$8,1\cdot10^{3}$	$1,1\cdot10^{5}$	$1,2\cdot10^{5}$	$1,6\cdot10^{4}$	$8,7\cdot10^{5}$
Cs-134	$8,1\cdot10^{8}$	$1,1\cdot10^{10}$	$1,2\cdot10^{10}$	$1,6\cdot10^{9}$	$8,7\cdot10^{10}$
Cs-135	$4,0\cdot10^{3}$	$5,3\cdot10^{4}$	$6,0\cdot10^{4}$	$8,0\cdot10^{3}$	$4,4\cdot10^{5}$
Eu-152	$5,7\cdot10^{4}$	$7,5\cdot10^{5}$	$8,3\cdot10^{5}$	$1,1\cdot10^{5}$	$6,1\cdot10^{6}$
Eu-154	$8,1\cdot10^{7}$	$1,1\cdot10^{9}$	$1,2\cdot10^{9}$	$1,6\cdot10^{8}$	$8,7\cdot10^{9}$
Eu-155	$5,7\cdot10^{7}$	$7,5\cdot10^{8}$	$8,3\cdot10^{8}$	$1,1\cdot10^{8}$	$6,1\cdot10^{9}$
I-129	$2,4\cdot10^{2}$	$3,2\cdot10^{3}$	$3,6\cdot10^{3}$	$4,8\cdot10^{2}$	$2,6\cdot10^{4}$
Pd-107	$8,1\cdot10^{2}$	$1,1\cdot10^{4}$	$1,2\cdot10^{4}$	$1,6\cdot10^{3}$	$8,7\cdot10^{4}$
Pm-147	$7,3\cdot10^{8}$	$9,6\cdot10^{9}$	$1,1\cdot10^{10}$	$1,4\cdot10^{9}$	$7,9\cdot10^{10}$
Ru-106	$4,0\cdot10^{6}$	$5,3\cdot10^{7}$	$6,0\cdot10^{7}$	$8,0\cdot10^{6}$	$4,4\cdot10^{8}$
Se-79	$3,2\cdot10^{3}$	$4,3\cdot10^{4}$	$4,8\cdot10^{4}$	$6,4\cdot10^{3}$	$3,5\cdot10^{5}$
Sm-151	$2,4\cdot10^{6}$	$3,2\cdot10^{7}$	$3,6\cdot10^{7}$	$4,8\cdot10^{6}$	$2,6\cdot10^{8}$
Sn-126	$4,0\cdot10^{2}$	$5,3\cdot10^{3}$	$6,0\cdot10^{3}$	$8,0\cdot10^{2}$	$4,4\cdot10^{4}$
Sr-90	$8,1\cdot10^{7}$	$1,1\cdot10^{9}$	$1,2\cdot10^{9}$	$1,6\cdot10^{8}$	$8,7\cdot10^{9}$
Tc-99	$4,0\cdot10^{6}$	$5,3\cdot10^{7}$	$6,0\cdot10^{7}$	$8,0\cdot10^{6}$	$4,4\cdot10^{8}$

Table 2-4. Reference waste packages from Oskarshamn NPP. (cont.)

Nuclide	O.12	O.07	O.01	O.23	O.02
Correlated to Pu-239 + Pu 240:					
Pu-239	$1,1\cdot10^{4}$	$2,6\cdot10^{5}$		$2,5\cdot10^{4}$	$1,7\cdot10^{3}$
Pu-240	$2,3\cdot10^{4}$	$5,2\cdot10^{5}$		$5,0\cdot10^{4}$	$3,5\cdot10^{3}$
Pb-210	$6,8\cdot10^{-7}$	$1,5\cdot10^{-5}$		$1,5\cdot10^{-6}$	$1,0\cdot10^{-7}$
Ra-226	$6,8\cdot10^{-6}$	$1,5\cdot10^{-4}$		$1,5\cdot10^{-5}$	$1,0\cdot10^{-6}$
Ac-227	$1,4\cdot10^{-4}$	$3,1\cdot10^{-3}$		$3,0\cdot10^{-4}$	$2,1\cdot10^{-5}$
Th-229	$1,0\cdot10^{-5}$	$2,3\cdot10^{-4}$		$2,2\cdot10^{-5}$	$1,6\cdot10^{-6}$
Th-230	$3,1\cdot10^{-3}$	$7,0\cdot10^{-2}$		$6,7\cdot10^{-3}$	$4,7\cdot10^{-4}$
Th-232	$3,4\cdot10^{-9}$	$7,7\cdot10^{-8}$		$7,5\cdot10^{-9}$	$5,2\cdot10^{-10}$
Pa-231	$1,0\cdot10^{-3}$	$2,3\cdot10^{-2}$		$2,2\cdot10^{-3}$	$1,6\cdot10^{-4}$
U-232	$1,0\cdot10^{0}$	$2,3\cdot10^{1}$		$2,2\cdot10^{0}$	$1,6\cdot10^{-1}$
U-233	$6,8\cdot10^{-4}$	$1,5\cdot10^{-2}$		$1,5\cdot10^{-3}$	$1,0\cdot10^{-4}$
U-234	$3,4\cdot10^{1}$	$7,7\cdot10^{2}$		$7,5\cdot10^{1}$	$5,2\cdot10^{0}$
U-235	$6,8\cdot10^{-1}$	$1,5\cdot10^{1}$		$1,5\cdot10^{0}$	$1,0\cdot10^{-1}$
U-236	$1,0\cdot10^{1}$	$2,3\cdot10^{2}$		$2,2\cdot10^{1}$	$1,6\cdot10^{0}$
U-238	$1,4\cdot10^{1}$	$3,1\cdot10^{2}$		$3,0\cdot10^{1}$	$2,1\cdot10^{0}$
Np-237	$1,4\cdot10^{1}$	$3,1\cdot10^{2}$		$3,0\cdot10^{1}$	$2,1\cdot10^{0}$
Pu-238	$1,4\cdot10^{5}$	$3,1\cdot10^{6}$		$3,0\cdot10^{5}$	$2,1\cdot10^{4}$
Pu-241	$3,4\cdot10^{6}$	$7,7\cdot10^{7}$		$7,5\cdot10^{6}$	$5,2\cdot10^{5}$
Pu-242	$1,0\cdot10^{2}$	$2,3\cdot10^{3}$		$2,2\cdot10^{2}$	$1,6\cdot10^{1}$
Am-241	$3,4\cdot10^{4}$	$7,7\cdot10^{5}$		$7,5\cdot10^{4}$	$5,2\cdot10^{3}$
Am-242m	$3,4\cdot10^{2}$	$7,7\cdot10^{3}$		$7,5\cdot10^{2}$	$5,2\cdot10^{1}$
Am-243	$1,0\cdot10^{3}$	$2,3\cdot10^{4}$		$2,2\cdot10^{3}$	$1,6\cdot10^{2}$
Cm-243	$6,8\cdot10^{2}$	$1,5\cdot10^{4}$		$1,5\cdot10^{3}$	$1,0\cdot10^{2}$
Cm-244	$1,0\cdot10^{5}$	$2,3\cdot10^{6}$		$2,2\cdot10^{5}$	$1,6\cdot10^{4}$
Cm-245	$1,0\cdot10^{1}$	$2,3\cdot10^{2}$		$2,2\cdot10^{1}$	$1,6\cdot10^{0}$
Cm-246	$2,7\cdot10^{0}$	$6,2\cdot10^{1}$		$6,0\cdot10^{0}$	$4,2\cdot10^{-1}$
Pu-244	$2,4\cdot10^{-5}$	$5,4\cdot10^{-4}$		$5,2\cdot10^{-5}$	$3,6\cdot10^{-6}$
Total	$1,2\cdot10^{10}$	$1,5\cdot10^{11}$	$1,3\cdot10^{11}$	$2,7\cdot10^{10}$	$5,2\cdot10^{11}$

Table 2-5. Reference waste packages from Ringhals NPP.

Nuclide	R.12	R.01	R.10	R.15	R.23	R.02	R.16
Correlated to Co-60:							
Co-60	$1,3\cdot10^{10}$	$7,7\cdot10^{10}$	$2,7\cdot10^{10}$	$8,9\cdot10^{10}$	$2,6\cdot10^{10}$	$7,5\cdot10^{10}$	$2,2\cdot10^{11}$
Ag-108m	$7,8\cdot10^{5}$	$4,6\cdot10^{6}$	$1,6\cdot10^{6}$	$5,3\cdot10^{6}$	$1,6\cdot10^{6}$	$4,5\cdot10^{6}$	$1,3\cdot10^{7}$
Ba-133	$1,3\cdot10^{5}$	$7,7\cdot10^{5}$	$2,7\cdot10^{5}$	$8,9\cdot10^{5}$	$2,6\cdot10^{5}$	$7,5\cdot10^{5}$	$2,2\cdot10^{6}$
Be-10	$7,8\cdot10^{0}$	$4,6\cdot10^{1}$	$1,6\cdot10^{1}$	$5,3\cdot10^{1}$	$1,6\cdot10^{1}$	$4,5\cdot10^{1}$	$1,3\cdot10^{2}$
C-14	$1,3\cdot10^{7}$	$7,7\cdot10^{7}$	$2,7\cdot10^{7}$	$8,9\cdot10^{7}$	$2,6\cdot10^{7}$	$7,5\cdot10^{7}$	$2,2\cdot10^{8}$
Fe-55	$1,3\cdot10^{10}$	$7,7\cdot10^{10}$	$2,7\cdot10^{10}$	$8,9\cdot10^{10}$	$2,6\cdot10^{10}$	$7,5\cdot10^{10}$	$2,2\cdot10^{11}$
H-3	$1,3\cdot10^{6}$	$7,7\cdot10^{6}$	$2,7\cdot10^{6}$	$8,9\cdot10^{6}$	$2,6\cdot10^{6}$	$7,5\cdot10^{6}$	$2,2\cdot10^{7}$
Ho-166m	$5,2\cdot10^{4}$	$3,1\cdot10^{5}$	$1,1\cdot10^{5}$	$3,6\cdot10^{5}$	$1,0\cdot10^{5}$	$3,0\cdot10^{5}$	$8,8\cdot10^{5}$
Mo-93	$6,5\cdot10^{4}$	$3,9\cdot10^{5}$	$1,4\cdot10^{5}$	$4,5\cdot10^{5}$	$1,3\cdot10^{5}$	$3,7\cdot10^{5}$	$1,1\cdot10^{6}$
Nb-93m	$1,3\cdot10^{7}$	$7,7\cdot10^{7}$	$2,7\cdot10^{7}$	$8,9\cdot10^{7}$	$2,6\cdot10^{7}$	$7,5\cdot10^{7}$	$2,2\cdot10^{8}$
Nb-94	$1,3\cdot10^{5}$	$7,7\cdot10^{5}$	$2,7\cdot10^{5}$	$8,9\cdot10^{5}$	$2,6\cdot10^{5}$	$7,5\cdot10^{5}$	$2,2\cdot10^{6}$
Ni-59	$1,3\cdot10^{7}$	$7,7\cdot10^{7}$	$2,7\cdot10^{7}$	$8,9\cdot10^{7}$	$2,6\cdot10^{7}$	$7,5\cdot10^{7}$	$2,2\cdot10^{8}$
Ni-63	$2,6\cdot10^{9}$	$1,5\cdot10^{10}$	$5,5\cdot10^{9}$	$1,8\cdot10^{10}$	$5,2\cdot10^{9}$	$1,5\cdot10^{10}$	$4,4\cdot10^{10}$
Sb-125	$1,3\cdot10^{9}$	$7,7\cdot10^{9}$	$2,7\cdot10^{9}$	$8,9\cdot10^{9}$	$2,6\cdot10^{9}$	$7,5\cdot10^{9}$	$2,2\cdot10^{10}$
Zr-93	$1,3\cdot10^{4}$	$7,7\cdot10^{4}$	$2,7\cdot10^{4}$	$8,9\cdot10^{4}$	$2,6\cdot10^{4}$	$7,5\cdot10^{4}$	$2,2\cdot10^{5}$
Correlated to Cs-137:							
Cs-137	$4,8\cdot10^{9}$	$1,3\cdot10^{10}$	$2,3\cdot10^{8}$	$1,5\cdot10^{10}$	$6,1\cdot10^{8}$	$4,6\cdot10^{10}$	$3,4\cdot10^{10}$
Cd-113m	$2,9\cdot10^{6}$	$7,7\cdot10^{6}$	$1,4\cdot10^{5}$	$8,8\cdot10^{6}$	$3,6\cdot10^{5}$	$2,8\cdot10^{7}$	$2,0\cdot10^{7}$
Cl-36	$4,8\cdot10^{4}$	$1,3\cdot10^{5}$	$2,3\cdot10^{3}$	$1,5\cdot10^{5}$	$6,1\cdot10^{3}$	$4,6\cdot10^{5}$	$3,4\cdot10^{5}$
Cs-134	$4,8\cdot10^{9}$	$1,3\cdot10^{10}$	$2,3\cdot10^{8}$	$1,5\cdot10^{10}$	$6,1\cdot10^{8}$	$4,6\cdot10^{10}$	$3,4\cdot10^{10}$
Cs-135	$2,4\cdot10^{4}$	$6,4\cdot10^{4}$	$1,2\cdot10^{3}$	$7,4\cdot10^{4}$	$3,0\cdot10^{3}$	$2,3\cdot10^{5}$	$1,7\cdot10^{5}$
Eu-152	$3,4\cdot10^{5}$	$9,0\cdot10^{5}$	$1,6\cdot10^{4}$	$1,0\cdot10^{6}$	$4,2\cdot10^{4}$	$3,2\cdot10^{6}$	$2,4\cdot10^{6}$
Eu-154	$4,8\cdot10^{8}$	$1,3\cdot10^{9}$	$2,3\cdot10^{7}$	$1,5\cdot10^{9}$	$6,1\cdot10^{7}$	$4,6\cdot10^{9}$	$3,4\cdot10^{9}$
Eu-155	$3,4\cdot10^{8}$	$9,0\cdot10^{8}$	$1,6\cdot10^{7}$	$1,0\cdot10^{9}$	$4,2\cdot10^{7}$	$3,2\cdot10^{9}$	$2,4\cdot10^{9}$
I-129	$1,4\cdot10^{3}$	$3,8\cdot10^{3}$	$7,0\cdot10^{1}$	$4,4\cdot10^{3}$	$1,8\cdot10^{2}$	$1,4\cdot10^{4}$	$1,0\cdot10^{4}$
Pd-107	$4,8\cdot10^{3}$	$1,3\cdot10^{4}$	$2,3\cdot10^{2}$	$1,5\cdot10^{4}$	$6,1\cdot10^{2}$	$4,6\cdot10^{4}$	$3,4\cdot10^{4}$
Pm-147	$4,3\cdot10^{9}$	$1,2\cdot10^{10}$	$2,1\cdot10^{8}$	$1,3\cdot10^{10}$	$5,5\cdot10^{8}$	$4,2\cdot10^{10}$	$3,0\cdot10^{10}$
Ru-106	$2,4\cdot10^{7}$	$6,4\cdot10^{7}$	$1,2\cdot10^{6}$	$7,4\cdot10^{7}$	$3,0\cdot10^{6}$	$2,3\cdot10^{8}$	$1,7\cdot10^{8}$
Se-79	$1,9\cdot10^{4}$	$5,1\cdot10^{4}$	$9,3\cdot10^{2}$	$5,9\cdot10^{4}$	$2,4\cdot10^{3}$	$1,8\cdot10^{5}$	$1,3\cdot10^{5}$
Sm-151	$1,4\cdot10^{7}$	$3,8\cdot10^{7}$	$7,0\cdot10^{5}$	$4,4\cdot10^{7}$	$1,8\cdot10^{6}$	$1,4\cdot10^{8}$	$1,0\cdot10^{8}$
Sn-126	$2,4\cdot10^{3}$	$6,4\cdot10^{3}$	$1,2\cdot10^{2}$	$7,4\cdot10^{3}$	$3,0\cdot10^{2}$	$2,3\cdot10^{4}$	$1,7\cdot10^{4}$
Sr-90	$4,8\cdot10^{8}$	$1,3\cdot10^{9}$	$2,3\cdot10^{7}$	$1,5\cdot10^{9}$	$6,1\cdot10^{7}$	$4,6\cdot10^{9}$	$3,4\cdot10^{9}$
Tc-99	$2,4\cdot10^{7}$	$6,4\cdot10^{7}$	$1,2\cdot10^{6}$	$7,4\cdot10^{7}$	$3,0\cdot10^{6}$	$2,3\cdot10^{8}$	$1,7\cdot10^{8}$

Table 2-5. Reference waste packages from Ringhals NPP. (cont.)

Nuclide	R.12	R.01	R.10	R.15	R.23	R.02	R.16
Correlated to Pu-239 + Pu 240:							
Pu-239	$1,2\cdot10^{6}$	$4,1\cdot10^{6}$	$1,5\cdot10^{6}$	$4,7\cdot10^{6}$	$2,4\cdot10^{6}$	$4,0\cdot10^{6}$	$1,2\cdot10^{7}$
Pu-240	$2,4\cdot10^{6}$	$8,2\cdot10^{6}$	$2,9\cdot10^{6}$	$9,5\cdot10^{6}$	$4,8\cdot10^{6}$	$7,9\cdot10^{6}$	$2,3\cdot10^{7}$
Pb-210	$7,1\cdot10^{-5}$	$2,5\cdot10^{-4}$	$8,7\cdot10^{-5}$	$2,8\cdot10^{-4}$	$1,4\cdot10^{-4}$	$2,4\cdot10^{-4}$	$7,0\cdot10^{-4}$
Ra-226	$7,1\cdot10^{-4}$	$2,5\cdot10^{-3}$	$8,7\cdot10^{-4}$	$2,8\cdot10^{-3}$	$1,4\cdot10^{-3}$	$2,4\cdot10^{-3}$	$7,0\cdot10^{-3}$
Ac-227	$1,4\cdot10^{-2}$	$4,9\cdot10^{-2}$	$1,7\cdot10^{-2}$	$5,7\cdot10^{-2}$	$2,9\cdot10^{-2}$	$4,7\cdot10^{-2}$	$1,4\cdot10^{-1}$
Th-229	$1,1\cdot10^{-3}$	$3,7\cdot10^{-3}$	$1,3\cdot10^{-3}$	$4,3\cdot10^{-3}$	$2,1\cdot10^{-3}$	$3,6\cdot10^{-3}$	$1,0\cdot10^{-2}$
Th-230	$3,2\cdot10^{-1}$	$1,1\cdot10^{0}$	$3,9\cdot10^{-1}$	$1,3\cdot10^{0}$	$6,4\cdot10^{-1}$	$1,1\cdot10^{0}$	$3,1\cdot10^{0}$
Th-232	$3,6\cdot10^{-7}$	$1,2\cdot10^{-6}$	$4,4\cdot10^{-7}$	$1,4\cdot10^{-6}$	$7,1\cdot10^{-7}$	$1,2\cdot10^{-6}$	$3,5\cdot10^{-6}$
Pa-231	$1,1\cdot10^{-1}$	$3,7\cdot10^{-1}$	$1,3\cdot10^{-1}$	$4,3\cdot10^{-1}$	$2,1\cdot10^{-1}$	$3,6\cdot10^{-1}$	$1,0\cdot10^{0}$
U-232	$1,1\cdot10^{2}$	$3,7\cdot10^{2}$	$1,3\cdot10^{2}$	$4,3\cdot10^{2}$	$2,1\cdot10^{2}$	$3,6\cdot10^{2}$	$1,0\cdot10^{3}$
U-233	$7,1\cdot10^{-2}$	$2,5\cdot10^{-1}$	$8,7\cdot10^{-2}$	$2,8\cdot10^{-1}$	$1,4\cdot10^{-1}$	$2,4\cdot10^{-1}$	$7,0\cdot10^{-1}$
U-234	$3,6\cdot10^{3}$	$1,2\cdot10^{4}$	$4,4\cdot10^{3}$	$1,4\cdot10^{4}$	$7,1\cdot10^{3}$	$1,2\cdot10^{4}$	$3,5\cdot10^{4}$
U-235	$7,1\cdot10^{1}$	$2,5\cdot10^{2}$	$8,7\cdot10^{1}$	$2,8\cdot10^{2}$	$1,4\cdot10^{2}$	$2,4\cdot10^{2}$	$7,0\cdot10^{2}$
U-236	$1,1\cdot10^{3}$	$3,7\cdot10^{3}$	$1,3\cdot10^{3}$	$4,3\cdot10^{3}$	$2,1\cdot10^{3}$	$3,6\cdot10^{3}$	$1,0\cdot10^{4}$
U-238	$1,4\cdot10^{3}$	$4,9\cdot10^{3}$	$1,7\cdot10^{3}$	$5,7\cdot10^{3}$	$2,9\cdot10^{3}$	$4,7\cdot10^{3}$	$1,4\cdot10^{4}$
Np-237	$1,4\cdot10^{3}$	$4,9\cdot10^{3}$	$1,7\cdot10^{3}$	$5,7\cdot10^{3}$	$2,9\cdot10^{3}$	$4,7\cdot10^{3}$	$1,4\cdot10^{4}$
Pu-238	$1,4\cdot10^{7}$	$4,9\cdot10^{7}$	$1,7\cdot10^{7}$	$5,7\cdot10^{7}$	$2,9\cdot10^{7}$	$4,7\cdot10^{7}$	$1,4\cdot10^{8}$
Pu-241	$3,6\cdot10^{8}$	$1,2\cdot10^{9}$	$4,4\cdot10^{8}$	$1,4\cdot10^{9}$	$7,1\cdot10^{8}$	$1,2\cdot10^{9}$	$3,5\cdot10^{9}$
Pu-242	$1,1\cdot10^{4}$	$3,7\cdot10^{4}$	$1,3\cdot10^{4}$	$4,3\cdot10^{4}$	$2,1\cdot10^{4}$	$3,6\cdot10^{4}$	$1,0\cdot10^{5}$
Am-241	$3,6\cdot10^{6}$	$1,2\cdot10^{7}$	$4,4\cdot10^{6}$	$1,4\cdot10^{7}$	$7,1\cdot10^{6}$	$1,2\cdot10^{7}$	$3,5\cdot10^{7}$
Am-242m	$3,6\cdot10^{4}$	$1,2\cdot10^{5}$	$4,4\cdot10^{4}$	$1,4\cdot10^{5}$	$7,1\cdot10^{4}$	$1,2\cdot10^{5}$	$3,5\cdot10^{5}$
Am-243	$1,1\cdot10^{5}$	$3,7\cdot10^{5}$	$1,3\cdot10^{5}$	$4,3\cdot10^{5}$	$2,1\cdot10^{5}$	$3,6\cdot10^{5}$	$1,0\cdot10^{6}$
Cm-243	$7,1\cdot10^{4}$	$2,5\cdot10^{5}$	$8,7\cdot10^{4}$	$2,8\cdot10^{5}$	$1,4\cdot10^{5}$	$2,4\cdot10^{5}$	$7,0\cdot10^{5}$
Cm-244	$1,1\cdot10^{7}$	$3,7\cdot10^{7}$	$1,3\cdot10^{7}$	$4,3\cdot10^{7}$	$2,1\cdot10^{7}$	$3,6\cdot10^{7}$	$1,0\cdot10^{8}$
Cm-245	$1,1\cdot10^{3}$	$3,7\cdot10^{3}$	$1,3\cdot10^{3}$	$4,3\cdot10^{3}$	$2,1\cdot10^{3}$	$3,6\cdot10^{3}$	$1,0\cdot10^{4}$
Cm-246	$2,8\cdot10^{2}$	$9,8\cdot10^{2}$	$3,5\cdot10^{2}$	$1,1\cdot10^{3}$	$5,7\cdot10^{2}$	$9,5\cdot10^{2}$	$2,8\cdot10^{3}$
Pu-244	$2,5\cdot10^{-3}$	$8,6\cdot10^{-3}$	$3,1\cdot10^{-3}$	$9,9\cdot10^{-3}$	$5,0\cdot10^{-3}$	$8,3\cdot10^{-3}$	$2,4\cdot10^{-2}$
Total	$4,6\cdot10^{10}$	$2,2\cdot10^{11}$	$6,4\cdot10^{10}$	$2,5\cdot10^{11}$	$6,3\cdot10^{10}$	$3,2\cdot10^{11}$	$6,1\cdot10^{11}$

Table 2-6. Reference waste packages from Studsvik research site.

Nuclide	S.12	S.14	S.13	S.09	S.21	S.23	S.04	S.22	S.11
Correlated to Co-60:									
Co-60	$4,3\cdot10^{9}$	$2,1\cdot10^{9}$	$5,2\cdot10^{7}$	$1,1\cdot10^{8}$	$4,9\cdot10^{7}$	$1,7\cdot10^{10}$	$5,6\cdot10^{7}$	$7,2\cdot10^{7}$	$1,4\cdot10^{10}$
Ag-108m	$2,6\cdot10^{5}$	$1,3\cdot10^{5}$	$3,1\cdot10^{3}$	$6,6\cdot10^{3}$	$2,9\cdot10^{3}$	$1,0\cdot10^{6}$	$3,4\cdot10^{3}$	$4,3\cdot10^{3}$	$8,4\cdot10^{5}$
Ba-133	$4,3\cdot10^{4}$	$2,1\cdot10^{4}$	$5,2\cdot10^{2}$	$1,1\cdot10^{3}$	$4,9\cdot10^{2}$	$1,7\cdot10^{5}$	$5,6\cdot10^{2}$	$7,2\cdot10^{2}$	$1,4\cdot10^{5}$
Be-10	$2,6\cdot10^{0}$	$1,3\cdot10^{0}$	$3,1\cdot10^{-2}$	$6,6\cdot10^{-2}$	$2,9\cdot10^{-2}$	$1,0\cdot10^{1}$	$3,4\cdot10^{-2}$	$4,3\cdot10^{-2}$	$8,4\cdot10^{0}$
C-14	$4,3\cdot10^{6}$	$2,1\cdot10^{6}$	$5,2\cdot10^{4}$	$1,1\cdot10^{5}$	$4,9\cdot10^{4}$	$1,7\cdot10^{7}$	$5,6\cdot10^{4}$	$7,2\cdot10^{4}$	$1,4\cdot10^{7}$
Fe-55	$4,3\cdot10^{9}$	$2,1\cdot10^{9}$	$5,2\cdot10^{7}$	$1,1\cdot10^{8}$	$4,9\cdot10^{7}$	$1,7\cdot10^{10}$	$5,6\cdot10^{7}$	$7,2\cdot10^{7}$	$1,4\cdot10^{10}$
H-3	$4,3\cdot10^{5}$	$2,1\cdot10^{5}$	$5,2\cdot10^{3}$	$1,1\cdot10^{4}$	$4,9\cdot10^{3}$	$1,7\cdot10^{6}$	$5,6\cdot10^{3}$	$7,2\cdot10^{3}$	$1,4\cdot10^{6}$
Ho-166m	$1,7\cdot10^{4}$	$8,6\cdot10^{3}$	$2,1\cdot10^{2}$	$4,4\cdot10^{2}$	$2,0\cdot10^{2}$	$6,8\cdot10^{4}$	$2,3\cdot10^{2}$	$2,9\cdot10^{2}$	$5,6\cdot10^{4}$
Mo-93	$2,1\cdot10^{4}$	$1,1\cdot10^{4}$	$2,6\cdot10^{2}$	$5,5\cdot10^{2}$	$2,4\cdot10^{2}$	$8,5\cdot10^{4}$	$2,8\cdot10^{2}$	$3,6\cdot10^{2}$	$7,0\cdot10^{4}$
Nb-93m	$4,3\cdot10^{6}$	$2,1\cdot10^{6}$	$5,2\cdot10^{4}$	$1,1\cdot10^{5}$	$4,9\cdot10^{4}$	$1,7\cdot10^{7}$	$5,6\cdot10^{4}$	$7,2\cdot10^{4}$	$1,4\cdot10^{7}$
Nb-94	$4,3\cdot10^{4}$	$2,1\cdot10^{4}$	$5,2\cdot10^{2}$	$1,1\cdot10^{3}$	$4,9\cdot10^{2}$	$1,7\cdot10^{5}$	$5,6\cdot10^{2}$	$7,2\cdot10^{2}$	$1,4\cdot10^{5}$
Ni-59	$4,3\cdot10^{6}$	$2,1\cdot10^{6}$	$5,2\cdot10^{4}$	$1,1\cdot10^{5}$	$4,9\cdot10^{4}$	$1,7\cdot10^{7}$	$5,6\cdot10^{4}$	$7,2\cdot10^{4}$	$1,4\cdot10^{7}$
Ni-63	$8,5\cdot10^{8}$	$4,3\cdot10^{8}$	$1,0\cdot10^{7}$	$2,2\cdot10^{7}$	$9,8\cdot10^{6}$	$3,4\cdot10^{9}$	$1,1\cdot10^{7}$	$1,4\cdot10^{7}$	$2,8\cdot10^{9}$
Sb-125	$4,3\cdot10^{8}$	$2,1\cdot10^{8}$	$5,2\cdot10^{6}$	$1,1\cdot10^{7}$	$4,9\cdot10^{6}$	$1,7\cdot10^{9}$	$5,6\cdot10^{6}$	$7,2\cdot10^{6}$	$1,4\cdot10^{9}$
Zr-93	$4,3\cdot10^{3}$	$2,1\cdot10^{3}$	$5,2\cdot10^{1}$	$1,1\cdot10^{2}$	$4,9\cdot10^{1}$	$1,7\cdot10^{4}$	$5,6\cdot10^{1}$	$7,2\cdot10^{1}$	$1,4\cdot10^{4}$
Correlated to Cs-137:									
Cs-137	$8,1\cdot10^{8}$	$1,6\cdot10^{7}$	$3,7\cdot10^{6}$	$7,0\cdot10^{8}$	$7,7\cdot10^{6}$	$9,4\cdot10^{8}$	$2,1\cdot10^{7}$	$2,4\cdot10^{8}$	$1,4\cdot10^{11}$
Cd-113m	$4,9\cdot10^{5}$	$9,6\cdot10^{3}$	$2,2\cdot10^{3}$	$4,2\cdot10^{5}$	$4,6\cdot10^{3}$	$5,6\cdot10^{5}$	$1,3\cdot10^{4}$	$1,4\cdot10^{5}$	$8,5\cdot10^{7}$
Cl-36	$8,1\cdot10^{3}$	$1,6\cdot10^{2}$	$3,7\cdot10^{1}$	$7,0\cdot10^{3}$	$7,7\cdot10^{1}$	$9,4\cdot10^{3}$	$2,1\cdot10^{2}$	$2,4\cdot10^{3}$	$1,4\cdot10^{6}$
Cs-134	$8,1\cdot10^{8}$	$1,6\cdot10^{7}$	$3,7\cdot10^{6}$	$7,0\cdot10^{8}$	$7,7\cdot10^{6}$	$9,4\cdot10^{8}$	$2,1\cdot10^{7}$	$2,4\cdot10^{8}$	$1,4\cdot10^{11}$
Cs-135	$4,0\cdot10^{3}$	$8,0\cdot10^{1}$	$1,8\cdot10^{1}$	$3,5\cdot10^{3}$	$3,9\cdot10^{1}$	$4,7\cdot10^{3}$	$1,1\cdot10^{2}$	$1,2\cdot10^{3}$	$7,1\cdot10^{5}$
Eu-152	$5,7\cdot10^{4}$	$1,1\cdot10^{3}$	$2,6\cdot10^{2}$	$4,9\cdot10^{4}$	$5,4\cdot10^{2}$	$6,6\cdot10^{4}$	$1,5\cdot10^{3}$	$1,7\cdot10^{4}$	$9,9\cdot10^{6}$
Eu-154	$8,1\cdot10^{7}$	$1,6\cdot10^{6}$	$3,7\cdot10^{5}$	$7,0\cdot10^{7}$	$7,7\cdot10^{5}$	$9,4\cdot10^{7}$	$2,1\cdot10^{6}$	$2,4\cdot10^{7}$	$1,4\cdot10^{10}$
Eu-155	$5,7\cdot10^{7}$	$1,1\cdot10^{6}$	$2,6\cdot10^{5}$	$4,9\cdot10^{7}$	$5,4\cdot10^{5}$	$6,6\cdot10^{7}$	$1,5\cdot10^{6}$	$1,7\cdot10^{7}$	$9,9\cdot10^{9}$
I-129	$2,4\cdot10^{2}$	$4,8\cdot10^{0}$	$1,1\cdot10^{0}$	$2,1\cdot10^{2}$	$2,3\cdot10^{0}$	$2,8\cdot10^{2}$	$6,4\cdot10^{0}$	$7,2\cdot10^{1}$	$4,3\cdot10^{4}$
Pd-107	$8,1\cdot10^{2}$	$1,6\cdot10^{1}$	$3,7\cdot10^{0}$	$7,0\cdot10^{2}$	$7,7\cdot10^{0}$	$9,4\cdot10^{2}$	$2,1\cdot10^{1}$	$2,4\cdot10^{2}$	$1,4\cdot10^{5}$
Pm-147	$7,3\cdot10^{8}$	$1,4\cdot10^{7}$	$3,3\cdot10^{6}$	$6,3\cdot10^{8}$	$6,9\cdot10^{6}$	$8,4\cdot10^{8}$	$1,9\cdot10^{7}$	$2,2\cdot10^{8}$	$1,3\cdot10^{11}$
Ru-106	$4,0\cdot10^{6}$	$8,0\cdot10^{4}$	$1,8\cdot10^{4}$	$3,5\cdot10^{6}$	$3,9\cdot10^{4}$	$4,7\cdot10^{6}$	$1,1\cdot10^{5}$	$1,2\cdot10^{6}$	$7,1\cdot10^{8}$
Se-79	$3,2\cdot10^{3}$	$6,4\cdot10^{1}$	$1,5\cdot10^{1}$	$2,8\cdot10^{3}$	$3,1\cdot10^{1}$	$3,8\cdot10^{3}$	$8,6\cdot10^{1}$	$9,7\cdot10^{2}$	$5,7\cdot10^{5}$
Sm-151	$2,4\cdot10^{6}$	$4,8\cdot10^{4}$	$1,1\cdot10^{4}$	$2,1\cdot10^{6}$	$2,3\cdot10^{4}$	$2,8\cdot10^{6}$	$6,4\cdot10^{4}$	$7,2\cdot10^{5}$	$4,3\cdot10^{8}$
Sn-126	$4,0\cdot10^{2}$	$8,0\cdot10^{0}$	$1,8\cdot10^{0}$	$3,5\cdot10^{2}$	$3,9\cdot10^{0}$	$4,7\cdot10^{2}$	$1,1\cdot10^{1}$	$1,2\cdot10^{2}$	$7,1\cdot10^{4}$
Sr-90	$8,1\cdot10^{7}$	$1,6\cdot10^{6}$	$3,7\cdot10^{5}$	$7,0\cdot10^{7}$	$7,7\cdot10^{5}$	$9,4\cdot10^{7}$	$2,1\cdot10^{6}$	$2,4\cdot10^{7}$	$1,4\cdot10^{10}$
Tc-99	$4,0\cdot10^{6}$	$8,0\cdot10^{4}$	$1,8\cdot10^{4}$	$3,5\cdot10^{6}$	$3,9\cdot10^{4}$	$4,7\cdot10^{6}$	$1,1\cdot10^{5}$	$1,2\cdot10^{6}$	$7,1\cdot10^{8}$

Table 2-6. Reference waste packages from Studsvik research site. (cont.)

Nuclide	S.12	S.14	S.13	S.09	S.21	S.23	S.04	S.22	S.11
Correlated to Pu-239 + Pu 240:									
Pu-239	$2,0\cdot10^{5}$	$1,0\cdot10^{5}$	$9,3\cdot10^{3}$	$9,9\cdot10^{3}$	$4,4\cdot10^{3}$	$1,5\cdot10^{6}$	$7,4\cdot10^{6}$		
Pu-240	$4,1\cdot10^{5}$	$2,0\cdot10^{5}$	$1,9\cdot10^{4}$	$2,0\cdot10^{4}$	$8,8\cdot10^{3}$	$3,1\cdot10^{6}$	$1,5\cdot10^{7}$		
Pb-210	$1,2\cdot10^{-5}$	$6,1\cdot10^{-6}$	$5,6\cdot10^{-7}$	$5,9\cdot10^{-7}$	$2,6\cdot10^{-7}$	$9,2\cdot10^{-5}$	$4,4\cdot10^{-4}$		
Ra-226	$1,2\cdot10^{-4}$	$6,1\cdot10^{-5}$	$5,6\cdot10^{-6}$	$5,9\cdot10^{-6}$	$2,6\cdot10^{-6}$	$9,2\cdot10^{-4}$	$4,4\cdot10^{-3}$		
Ac-227	$2,4\cdot10^{-3}$	$1,2\cdot10^{-3}$	$1,1\cdot10^{-4}$	$1,2\cdot10^{-4}$	$5,3\cdot10^{-5}$	$1,8\cdot10^{-2}$	$8,9\cdot10^{-2}$		
Th-229	$1,8\cdot10^{-4}$	$9,2\cdot10^{-5}$	$8,3\cdot10^{-6}$	$8,9\cdot10^{-6}$	$3,9\cdot10^{-6}$	$1,4\cdot10^{-3}$	$6,6\cdot10^{-3}$		
Th-230	$5,5\cdot10^{-2}$	$2,8\cdot10^{-2}$	$2,5\cdot10^{-3}$	$2,7\cdot10^{-3}$	$1,2\cdot10^{-3}$	$4,1\cdot10^{-1}$	$2,0\cdot10^{0}$		
Th-232	$6,1\cdot10^{-8}$	$3,1\cdot10^{-8}$	$2,8\cdot10^{-9}$	$3,0\cdot10^{-9}$	$1,3\cdot10^{-9}$	$4,6\cdot10^{-7}$	$2,2\cdot10^{-6}$		
Pa-231	$1,8\cdot10^{-2}$	$9,2\cdot10^{-3}$	$8,3\cdot10^{-4}$	$8,9\cdot10^{-4}$	$3,9\cdot10^{-4}$	$1,4\cdot10^{-1}$	$6,6\cdot10^{-1}$		
U-232	$1,8\cdot10^{1}$	$9,2\cdot10^{0}$	$8,3\cdot10^{-1}$	$8,9\cdot10^{-1}$	$3,9\cdot10^{-1}$	$1,4\cdot10^{2}$	$6,6\cdot10^{2}$		
U-233	$1,2\cdot10^{-2}$	$6,1\cdot10^{-3}$	$5,6\cdot10^{-4}$	$5,9\cdot10^{-4}$	$2,6\cdot10^{-4}$	$9,2\cdot10^{-2}$	$4,4\cdot10^{-1}$		
U-234	$6,1\cdot10^{2}$	$3,1\cdot10^{2}$	$2,8\cdot10^{1}$	$3,0\cdot10^{1}$	$1,3\cdot10^{1}$	$4,6\cdot10^{3}$	$2,2\cdot10^{4}$		
U-235	$1,2\cdot10^{1}$	$6,1\cdot10^{0}$	$5,6\cdot10^{-1}$	$5,9\cdot10^{-1}$	$2,6\cdot10^{-1}$	$9,2\cdot10^{1}$	$4,4\cdot10^{2}$		
U-236	$1,8\cdot10^{2}$	$9,2\cdot10^{1}$	$8,3\cdot10^{0}$	$8,9\cdot10^{0}$	$3,9\cdot10^{0}$	$1,4\cdot10^{3}$	$6,6\cdot10^{3}$		
U-238	$2,4\cdot10^{2}$	$1,2\cdot10^{2}$	$1,1\cdot10^{1}$	$1,2\cdot10^{1}$	$5,3\cdot10^{0}$	$1,8\cdot10^{3}$	$8,9\cdot10^{3}$		
Np-237	$2,4\cdot10^{2}$	$1,2\cdot10^{2}$	$1,1\cdot10^{1}$	$1,2\cdot10^{1}$	$5,3\cdot10^{0}$	$1,8\cdot10^{3}$	$8,9\cdot10^{3}$		
Pu-238	$2,4\cdot10^{6}$	$1,2\cdot10^{6}$	$1,1\cdot10^{5}$	$1,2\cdot10^{5}$	$5,3\cdot10^{4}$	$1,8\cdot10^{7}$	$8,9\cdot10^{7}$		
Pu-241	$6,1\cdot10^{7}$	$3,1\cdot10^{7}$	$2,8\cdot10^{6}$	$3,0\cdot10^{6}$	$1,3\cdot10^{6}$	$4,6\cdot10^{8}$	$2,2\cdot10^{9}$		
Pu-242	$1,8\cdot10^{3}$	$9,2\cdot10^{2}$	$8,3\cdot10^{1}$	$8,9\cdot10^{1}$	$3,9\cdot10^{1}$	$1,4\cdot10^{4}$	$6,6\cdot10^{4}$		
Am-241	$6,1\cdot10^{5}$	$3,1\cdot10^{5}$	$2,8\cdot10^{4}$	$3,0\cdot10^{4}$	$1,3\cdot10^{4}$	$4,6\cdot10^{6}$	$2,2\cdot10^{7}$		
Am-242m	$6,1\cdot10^{3}$	$3,1\cdot10^{3}$	$2,8\cdot10^{2}$	$3,0\cdot10^{2}$	$1,3\cdot10^{2}$	$4,6\cdot10^{4}$	$2,2\cdot10^{5}$		
Am-243	$1,8\cdot10^{4}$	$9,2\cdot10^{3}$	$8,3\cdot10^{2}$	$8,9\cdot10^{2}$	$3,9\cdot10^{2}$	$1,4\cdot10^{5}$	$6,6\cdot10^{5}$		
Cm-243	$1,2\cdot10^{4}$	$6,1\cdot10^{3}$	$5,6\cdot10^{2}$	$5,9\cdot10^{2}$	$2,6\cdot10^{2}$	$9,2\cdot10^{4}$	$4,4\cdot10^{5}$		
Cm-244	$1,8\cdot10^{6}$	$9,2\cdot10^{5}$	$8,3\cdot10^{4}$	$8,9\cdot10^{4}$	$3,9\cdot10^{4}$	$1,4\cdot10^{7}$	$6,6\cdot10^{7}$		
Cm-245	$1,8\cdot10^{2}$	$9,2\cdot10^{1}$	$8,3\cdot10^{0}$	$8,9\cdot10^{0}$	$3,9\cdot10^{0}$	$1,4\cdot10^{3}$	$6,6\cdot10^{3}$		
Cm-246	$4,9\cdot10^{1}$	$2,5\cdot10^{1}$	$2,2\cdot10^{0}$	$2,4\cdot10^{0}$	$1,1\cdot10^{0}$	$3,7\cdot10^{2}$	$1,8\cdot10^{3}$		
Pu-244	$4,3\cdot10^{-4}$	$2,1\cdot10^{-4}$	$1,9\cdot10^{-5}$	$2,1\cdot10^{-5}$	$9,2\cdot10^{-6}$	$3,2\cdot10^{-3}$	$1,5\cdot10^{-2}$		
total	$1,2\cdot10^{10}$	$5,0\cdot10^{9}$	$1,3\cdot10^{8}$	$2,5\cdot10^{9}$	$1,4\cdot10^{8}$	$4,3\cdot10^{10}$	$2,6\cdot10^{9}$	$9,3\cdot10^{8}$	$4,8\cdot10^{11}$

3 Radioactive nuclide inventory, waste type level

This chapter summaries the radio nuclide inventories for each waste type at the 31 December 2030. Both realistic and conservative inventories are shown in Table 3-1 to Table 3-8.

Table 3-1. Realistic and conservative radionuclide inventory for Barsebäck NPP, waste type level.

Nuclide	**B.12**		**B.20**		**B.07**		**B.05**		**B.06**	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Co-60										
Co-60	$4,0\cdot10^{9}$	$3,2\cdot10^{10}$	$1,4\cdot10^{5}$	$1,1\cdot10^{6}$	$2,3\cdot10^{11}$	$2,0\cdot10^{12}$	$3,0\cdot10^{11}$	$1,4\cdot10^{12}$	$5,2\cdot10^{12}$	$5,5\cdot10^{13}$
Ag-108m	$1,5\cdot10^{7}$	$1,1\cdot10^{8}$	$1,8\cdot10^{3}$	$1,4\cdot10^{4}$	$5,7\cdot10^{8}$	$5,0\cdot10^{9}$	$2,1\cdot10^{9}$	$1,0\cdot10^{10}$	$1,2\cdot10^{10}$	$1,3\cdot10^{11}$
Ba-133	$3,0\cdot10^{5}$	$2,3\cdot10^{6}$	$2,1\cdot10^{1}$	$1,6\cdot10^{2}$	$1,4\cdot10^{7}$	$1,2\cdot10^{8}$	$3,3\cdot10^{7}$	$1,6\cdot10^{8}$	$3,1\cdot10^{8}$	$3,2\cdot10^{9}$
Be-10	$1,5\cdot10^{2}$	$1,2\cdot10^{3}$	$1,9\cdot10^{-2}$	$1,5\cdot10^{-1}$	$6,0\cdot10^{3}$	$5,2\cdot10^{4}$	$2,2\cdot10^{4}$	$1,1\cdot10^{5}$	$1,2\cdot10^{5}$	$1,3\cdot10^{6}$
C-14	$2,6\cdot10^{8}$	$2,0\cdot10^{9}$	$3,1\cdot10^{4}$	$2,5\cdot10^{5}$	$1,0\cdot10^{10}$	$8,7\cdot10^{10}$	$3,6\cdot10^{10}$	$1,8\cdot10^{11}$	$2,1\cdot10^{11}$	$2,2\cdot10^{12}$
Fe-55	$1,3\cdot10^{8}$	$9,9\cdot10^{8}$	$8,9\cdot10^{2}$	$7,0\cdot10^{3}$	$1,2\cdot10^{10}$	$1,0\cdot10^{11}$	$3,8\cdot10^{9}$	$1,8\cdot10^{10}$	$2,6\cdot10^{11}$	$2,8\cdot10^{12}$
H-3	$4,0\cdot10^{6}$	$3,2\cdot10^{7}$	$3,1\cdot10^{2}$	$2,4\cdot10^{3}$	$1,8\cdot10^{8}$	$1,6\cdot10^{9}$	$4,7\cdot10^{8}$	$2,2\cdot10^{9}$	$4,0\cdot10^{9}$	$4,2\cdot10^{10}$
Ho-166m	$1,0\cdot10^{6}$	$7,9\cdot10^{6}$	$1,2\cdot10^{2}$	$9,7\cdot10^{2}$	$3,9\cdot10^{7}$	$3,4\cdot10^{8}$	$1,4\cdot10^{8}$	$6,9\cdot10^{8}$	$8,2\cdot10^{8}$	$8,6\cdot10^{9}$
Mo-93	$1,3\cdot10^{6}$	$1,0\cdot10^{7}$	$1,6\cdot10^{2}$	$1,2\cdot10^{3}$	$5,0\cdot10^{7}$	$4,3\cdot10^{8}$	$1,8\cdot10^{8}$	$8,8\cdot10^{8}$	$1,0\cdot10^{9}$	$1,1\cdot10^{10}$
Nb-93m	$6,2\cdot10^{7}$	$4,9\cdot10^{8}$	$5,4\cdot10^{3}$	$4,2\cdot10^{4}$	$2,7\cdot10^{9}$	$2,3\cdot10^{10}$	$7,6\cdot10^{9}$	$3,7\cdot10^{10}$	$5,8\cdot10^{10}$	$6,2\cdot10^{11}$
Nb-94	$2,6\cdot10^{6}$	$2,0\cdot10^{7}$	$3,1\cdot10^{2}$	$2,5\cdot10^{3}$	$1,0\cdot10^{8}$	$8,7\cdot10^{8}$	$3,7\cdot10^{8}$	$1,8\cdot10^{9}$	$2,1\cdot10^{9}$	$2,2\cdot10^{10}$
Ni-59	$2,6\cdot10^{8}$	$2,0\cdot10^{9}$	$3,2\cdot10^{4}$	$2,5\cdot10^{5}$	$1,0\cdot10^{10}$	$8,7\cdot10^{10}$	$3,7\cdot10^{10}$	$1,8\cdot10^{11}$	$2,1\cdot10^{11}$	$2,2\cdot10^{12}$
Ni-63	$4,1\cdot10^{10}$	$3,2\cdot10^{11}$	$4,7\cdot10^{6}$	$3,7\cdot10^{7}$	$1,6\cdot10^{12}$	$1,4\cdot10^{13}$	$5,7\cdot10^{12}$	$2,7\cdot10^{13}$	$3,4\cdot10^{13}$	$3,6\cdot10^{14}$
Sb-125	$1,3\cdot10^{7}$	$1,1\cdot10^{8}$	$9,9\cdot10^{1}$	$7,8\cdot10^{2}$	$1,2\cdot10^{9}$	$1,1\cdot10^{10}$	$4,1\cdot10^{8}$	$2,0\cdot10^{9}$	$2,8\cdot10^{10}$	$2,9\cdot10^{11}$
Zr-93	$2,6\cdot10^{5}$	$2,0\cdot10^{6}$	$3,2\cdot10^{1}$	$2,5\cdot10^{2}$	$1,0\cdot10^{7}$	$8,7\cdot10^{7}$	$3,7\cdot10^{7}$	$1,8\cdot10^{8}$	$2,1\cdot10^{8}$	$2,2\cdot10^{9}$

Table 3-1. Realistic and conservative radionuclide inventory for Barsebäck NPP, waste type level. (cont.)

Nuclide	B.12		B.20		B.07		B.05		B.06	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Cs-137										
Cs-137	$2,7\cdot10^{9}$	$2,1\cdot10^{10}$	$2,3\cdot10^{4}$	$1,8\cdot10^{5}$	$3,0\cdot10^{11}$	$2,6\cdot10^{12}$	$1,3\cdot10^{12}$	$6,3\cdot10^{12}$	$8,4\cdot10^{12}$	$8,9\cdot10^{13}$
Cd-113m	$6,7\cdot10^{5}$	$5,3\cdot10^{6}$	$4,7\cdot10^{0}$	$3,7\cdot10^{1}$	$8,2\cdot10^{7}$	$7,1\cdot10^{8}$	$3,0\cdot10^{8}$	$1,5\cdot10^{9}$	$2,4\cdot10^{9}$	$2,5\cdot10^{10}$
Cl-36	$5,8\cdot10^{4}$	$4,6\cdot10^{5}$	$5,9\cdot10^{-1}$	$4,7\cdot10^{0}$	$6,2\cdot10^{6}$	$5,4\cdot10^{7}$	$3,0\cdot10^{7}$	$1,5\cdot10^{8}$	$1,7\cdot10^{8}$	$1,8\cdot10^{9}$
Cs-134	$3,0\cdot10^{5}$	$2,4\cdot10^{6}$	$5,6\cdot10^{-2}$	$4,4\cdot10^{-1}$	$1,1\cdot10^{8}$	$9,4\cdot10^{8}$	$2,0\cdot10^{7}$	$9,8\cdot10^{7}$	$3,2\cdot10^{9}$	$3,4\cdot10^{10}$
Cs-135	$2,9\cdot10^{4}$	$2,3\cdot10^{5}$	$3,0\cdot10^{-1}$	$2,3\cdot10^{0}$	$3,1\cdot10^{6}$	$2,7\cdot10^{7}$	$1,5\cdot10^{7}$	$7,3\cdot10^{7}$	$8,4\cdot10^{7}$	$8,9\cdot10^{8}$
Eu-152	$7,3\cdot10^{4}$	$5,8\cdot10^{5}$	$5,0\cdot10^{-1}$	$3,9\cdot10^{0}$	$9,0\cdot10^{6}$	$7,8\cdot10^{7}$	$3,3\cdot10^{7}$	$1,6\cdot10^{8}$	$2,6\cdot10^{8}$	$2,7\cdot10^{9}$
Eu-154	$4,1\cdot10^{7}$	$3,2\cdot10^{8}$	$2,1\cdot10^{2}$	$1,7\cdot10^{3}$	$5,5\cdot10^{9}$	$4,8\cdot10^{10}$	$1,6\cdot10^{10}$	$7,7\cdot10^{10}$	$1,6\cdot10^{11}$	$1,7\cdot10^{12}$
Eu-155	$4,0\cdot10^{6}$	$3,1\cdot10^{7}$	$1,0\cdot10^{1}$	$8,0\cdot10^{1}$	$6,8\cdot10^{8}$	$5,9\cdot10^{9}$	$1,1\cdot10^{9}$	$5,2\cdot10^{9}$	$2,0\cdot10^{10}$	$2,1\cdot10^{11}$
I-129	$1,7\cdot10^{3}$	$1,4\cdot10^{4}$	$1,8\cdot10^{-2}$	$1,4\cdot10^{-1}$	$1,9\cdot10^{5}$	$1,6\cdot10^{6}$	$9,1\cdot10^{5}$	$4,4\cdot10^{6}$	$5,0\cdot10^{6}$	$5,3\cdot10^{7}$
Pd-107	$5,8\cdot10^{3}$	$4,6\cdot10^{4}$	$5,9\cdot10^{-2}$	$4,7\cdot10^{-1}$	$6,2\cdot10^{5}$	$5,4\cdot10^{6}$	$3,0\cdot10^{6}$	$1,5\cdot10^{7}$	$1,7\cdot10^{7}$	$1,8\cdot10^{8}$
Pm-147	$1,8\cdot10^{6}$	$1,5\cdot10^{7}$	$9,8\cdot10^{-1}$	$7,7\cdot10^{0}$	$5,0\cdot10^{8}$	$4,3\cdot10^{9}$	$2,0\cdot10^{8}$	$9,9\cdot10^{8}$	$1,5\cdot10^{10}$	$1,6\cdot10^{11}$
Ru-106	$2,4\cdot10^{-1}$	$1,9\cdot10^{0}$	$2,0\cdot10^{-10}$	$1,6\cdot10^{-9}$	$3,3\cdot10^{2}$	$2,8\cdot10^{3}$	$1,9\cdot10^{1}$	$9,0\cdot10^{1}$	$9,8\cdot10^{3}$	$1,0\cdot10^{5}$
Se-79	$2,3\cdot10^{4}$	$1,8\cdot10^{5}$	$2,4\cdot10^{-1}$	$1,9\cdot10^{0}$	$2,5\cdot10^{6}$	$2,2\cdot10^{7}$	$1,2\cdot10^{7}$	$5,8\cdot10^{7}$	$6,7\cdot10^{7}$	$7,1\cdot10^{8}$
Sm-151	$1,3\cdot10^{7}$	$1,1\cdot10^{8}$	$1,3\cdot10^{2}$	$1,0\cdot10^{3}$	$1,5\cdot10^{9}$	$1,3\cdot10^{10}$	$6,9\cdot10^{9}$	$3,3\cdot10^{10}$	$4,0\cdot10^{10}$	$4,2\cdot10^{11}$
Sn-126	$2,9\cdot10^{3}$	$2,3\cdot10^{4}$	$3,0\cdot10^{-2}$	$2,3\cdot10^{-1}$	$3,1\cdot10^{5}$	$2,7\cdot10^{6}$	$1,5\cdot10^{6}$	$7,3\cdot10^{6}$	$8,4\cdot10^{6}$	$8,9\cdot10^{7}$
Sr-90	$2,6\cdot10^{8}$	$2,0\cdot10^{9}$	$2,2\cdot10^{3}$	$1,7\cdot10^{4}$	$2,9\cdot10^{10}$	$2,5\cdot10^{11}$	$1,3\cdot10^{11}$	$6,1\cdot10^{11}$	$8,1\cdot10^{11}$	$8,6\cdot10^{12}$
Tc-99	$2,9\cdot10^{7}$	$2,3\cdot10^{8}$	$3,0\cdot10^{2}$	$2,3\cdot10^{3}$	$3,1\cdot10^{9}$	$2,7\cdot10^{10}$	$1,5\cdot10^{10}$	$7,3\cdot10^{10}$	$8,4\cdot10^{10}$	$8,9\cdot10^{11}$

Table 3-1. Realistic and conservative radionuclide inventory for Barsebäck NPP, waste type level. (cont.)

Nuclide	B.12		B.20		B.07		B.05		B.06	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Pu-239 + Pu-240										
Pu-239	$6,9\cdot10^{3}$	$5,5\cdot10^{4}$	$3,5\cdot10^{0}$	$2,8\cdot10^{1}$	$1,5\cdot10^{6}$	$1,3\cdot10^{7}$	$4,1\cdot10^{6}$	$2,0\cdot10^{7}$	$4,0\cdot10^{7}$	$4,2\cdot10^{8}$
Pu-240	$1,4\cdot10^{4}$	$1,1\cdot10^{5}$	$7,1\cdot10^{0}$	$5,6\cdot10^{1}$	$3,0\cdot10^{6}$	$2,6\cdot10^{7}$	$8,3\cdot10^{6}$	$4,0\cdot10^{7}$	$7,9\cdot10^{7}$	$8,4\cdot10^{8}$
Pb-210	$1,7\cdot10^{-7}$	$1,3\cdot10^{-6}$	$8,2\cdot10^{-11}$	$6,5\cdot10^{-10}$	$3,9\cdot10^{-5}$	$3,4\cdot10^{-4}$	$9,7\cdot10^{-5}$	$4,7\cdot10^{-4}$	$1,0\cdot10^{-3}$	$1,1\cdot10^{-2}$
Ra-226	$4,1\cdot10^{-6}$	$3,2\cdot10^{-5}$	$2,1\cdot10^{-9}$	$1,7\cdot10^{-8}$	$8,9\cdot10^{-4}$	$7,7\cdot10^{-3}$	$2,5\cdot10^{-3}$	$1,2\cdot10^{-2}$	$2,4\cdot10^{-2}$	$2,5\cdot10^{-1}$
Ac-227	$3,3\cdot10^{-5}$	$2,6\cdot10^{-4}$	$1,6\cdot10^{-8}$	$1,3\cdot10^{-7}$	$7,7\cdot10^{-3}$	$6,6\cdot10^{-2}$	$1,9\cdot10^{-2}$	$9,1\cdot10^{-2}$	$2,0\cdot10^{-1}$	$2,1\cdot10^{0}$
Th-229	$6,2\cdot10^{-6}$	$4,9\cdot10^{-5}$	$3,2\cdot10^{-9}$	$2,5\cdot10^{-8}$	$1,4\cdot10^{-3}$	$1,2\cdot10^{-2}$	$3,7\cdot10^{-3}$	$1,8\cdot10^{-2}$	$3,6\cdot10^{-2}$	$3,8\cdot10^{-1}$
Th-230	$1,9\cdot10^{-3}$	$1,5\cdot10^{-2}$	$9,6\cdot10^{-7}$	$7,5\cdot10^{-6}$	$4,1\cdot10^{-1}$	$3,5\cdot10^{0}$	$1,1\cdot10^{0}$	$5,4\cdot10^{0}$	$1,1\cdot10^{1}$	$1,1\cdot10^{2}$
Th-232	$2,1\cdot10^{-9}$	$1,6\cdot10^{-8}$	$1,1\cdot10^{-12}$	$8,4\cdot10^{-12}$	$4,5\cdot10^{-7}$	$3,9\cdot10^{-6}$	$1,2\cdot10^{-6}$	$6,0\cdot10^{-6}$	$1,2\cdot10^{-5}$	$1,3\cdot10^{-4}$
Pa-231	$6,3\cdot10^{-4}$	$4,9\cdot10^{-3}$	$3,2\cdot10^{-7}$	$2,5\cdot10^{-6}$	$1,4\cdot10^{-1}$	$1,2\cdot10^{0}$	$3,7\cdot10^{-1}$	$1,8\cdot10^{0}$	$3,6\cdot10^{0}$	$3,8\cdot10^{1}$
U-232	$4,7\cdot10^{-1}$	$3,7\cdot10^{0}$	$2,3\cdot10^{-4}$	$1,8\cdot10^{-3}$	$1,0\cdot10^{2}$	$9,0\cdot10^{2}$	$2,7\cdot10^{2}$	$1,3\cdot10^{3}$	$2,7\cdot10^{3}$	$2,9\cdot10^{4}$
U-233	$4,2\cdot10^{-4}$	$3,3\cdot10^{-3}$	$2,1\cdot10^{-7}$	$1,7\cdot10^{-6}$	$9,0\cdot10^{-2}$	$7,8\cdot10^{-1}$	$2,5\cdot10^{-1}$	$1,2\cdot10^{0}$	$2,4\cdot10^{0}$	$2,5\cdot10^{1}$
U-234	$2,1\cdot10^{1}$	$1,6\cdot10^{2}$	$1,1\cdot10^{-2}$	$8,4\cdot10^{-2}$	$4,5\cdot10^{3}$	$3,9\cdot10^{4}$	$1,2\cdot10^{4}$	$6,0\cdot10^{4}$	$1,2\cdot10^{5}$	$1,3\cdot10^{6}$
U-235	$4,2\cdot10^{-1}$	$3,3\cdot10^{0}$	$2,1\cdot10^{-4}$	$1,7\cdot10^{-3}$	$9,0\cdot10^{1}$	$7,8\cdot10^{2}$	$2,5\cdot10^{2}$	$1,2\cdot10^{3}$	$2,4\cdot10^{3}$	$2,5\cdot10^{4}$
U-236	$6,3\cdot10^{0}$	$4,9\cdot10^{1}$	$3,2\cdot10^{-3}$	$2,5\cdot10^{-2}$	$1,4\cdot10^{3}$	$1,2\cdot10^{4}$	$3,7\cdot10^{3}$	$1,8\cdot10^{4}$	$3,6\cdot10^{4}$	$3,8\cdot10^{5}$
U-238	$8,3\cdot10^{0}$	$6,6\cdot10^{1}$	$4,2\cdot10^{-3}$	$3,3\cdot10^{-2}$	$1,8\cdot10^{3}$	$1,6\cdot10^{4}$	$5,0\cdot10^{3}$	$2,4\cdot10^{4}$	$4,8\cdot10^{4}$	$5,0\cdot10^{5}$
Np-237	$8,3\cdot10^{0}$	$6,6\cdot10^{1}$	$4,2\cdot10^{-3}$	$3,3\cdot10^{-2}$	$1,8\cdot10^{3}$	$1,6\cdot10^{4}$	$5,0\cdot10^{3}$	$2,4\cdot10^{4}$	$4,8\cdot10^{4}$	$5,0\cdot10^{5}$
Pu-238	$6,6\cdot10^{4}$	$5,2\cdot10^{5}$	$3,3\cdot10^{1}$	$2,6\cdot10^{2}$	$1,5\cdot10^{7}$	$1,3\cdot10^{8}$	$3,9\cdot10^{7}$	$1,9\cdot10^{8}$	$3,8\cdot10^{8}$	$4,1\cdot10^{9}$
Pu-241	$5,1\cdot10^{5}$	$4,0\cdot10^{6}$	$2,4\cdot10^{2}$	$1,9\cdot10^{3}$	$1,2\cdot10^{8}$	$1,1\cdot10^{9}$	$2,9\cdot10^{8}$	$1,4\cdot10^{9}$	$3,2\cdot10^{9}$	$3,4\cdot10^{10}$
Pu-242	$6,3\cdot10^{1}$	$4,9\cdot10^{2}$	$3,2\cdot10^{-2}$	$2,5\cdot10^{-1}$	$1,4\cdot10^{4}$	$1,2\cdot10^{5}$	$3,7\cdot10^{4}$	$1,8\cdot10^{5}$	$3,6\cdot10^{5}$	$3,8\cdot10^{6}$
Am-241	$2,0\cdot10^{4}$	$1,6\cdot10^{5}$	$1,0\cdot10^{1}$	$8,0\cdot10^{1}$	$4,3\cdot10^{6}$	$3,8\cdot10^{7}$	$1,2\cdot10^{7}$	$5,7\cdot10^{7}$	$1,1\cdot10^{8}$	$1,2\cdot10^{9}$
Am-242m	$1,8\cdot10^{2}$	$1,4\cdot10^{3}$	$9,1\cdot10^{-2}$	$7,2\cdot10^{-1}$	$4,0\cdot10^{4}$	$3,4\cdot10^{5}$	$1,1\cdot10^{5}$	$5,2\cdot10^{5}$	$1,0\cdot10^{6}$	$1,1\cdot10^{7}$
Am-243	$6,2\cdot10^{2}$	$4,9\cdot10^{3}$	$3,2\cdot10^{-1}$	$2,5\cdot10^{0}$	$1,4\cdot10^{5}$	$1,2\cdot10^{6}$	$3,7\cdot10^{5}$	$1,8\cdot10^{6}$	$3,6\cdot10^{6}$	$3,8\cdot10^{7}$
Cm-243	$2,1\cdot10^{2}$	$1,6\cdot10^{3}$	$1,0\cdot10^{-1}$	$8,1\cdot10^{-1}$	$4,7\cdot10^{4}$	$4,1\cdot10^{5}$	$1,2\cdot10^{5}$	$5,8\cdot10^{5}$	$1,2\cdot10^{6}$	$1,3\cdot10^{7}$
Cm-244	$2,0\cdot10^{4}$	$1,6\cdot10^{5}$	$9,9\cdot10^{0}$	$7,8\cdot10^{1}$	$4,8\cdot10^{6}$	$4,2\cdot10^{7}$	$1,2\cdot10^{7}$	$5,6\cdot10^{7}$	$1,3\cdot10^{8}$	$1,3\cdot10^{9}$
Cm-245	$6,2\cdot10^{0}$	$4,9\cdot10^{1}$	$3,2\cdot10^{-3}$	$2,5\cdot10^{-2}$	$1,4\cdot10^{3}$	$1,2\cdot10^{4}$	$3,7\cdot10^{3}$	$1,8\cdot10^{4}$	$3,6\cdot10^{4}$	$3,8\cdot10^{5}$
Cm-246	$1,7\cdot10^{0}$	$1,3\cdot10^{1}$	$8,5\cdot10^{-4}$	$6,7\cdot10^{-3}$	$3,6\cdot10^{2}$	$3,1\cdot10^{3}$	$9,9\cdot10^{2}$	$4,8\cdot10^{3}$	$9,5\cdot10^{3}$	$1,0\cdot10^{5}$
Pu-244	$1,5\cdot10^{-5}$	$1,2\cdot10^{-4}$	$7,4\cdot10^{-9}$	$5,9\cdot10^{-8}$	$3,2\cdot10^{-3}$	$2,7\cdot10^{-2}$	$8,7\cdot10^{-3}$	$4,2\cdot10^{-2}$	$8,4\cdot10^{-2}$	$8,8\cdot10^{-1}$

Table 3-2. Realistic and conservative radionuclide inventory for Forsmark NPP, waste type level.

Nuclide	F.12		F.20		F.05		F.15		F.17		F.23		F.18	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Co-60														
Co-60	$9,3\cdot10^{9}$	$7,3\cdot10^{10}$	$1,2\cdot10^{8}$	$9,2\cdot10^{8}$	$2,4\cdot10^{10}$	$1,1\cdot10^{11}$	$1,4\cdot10^{8}$	$6,7\cdot10^{8}$	$6,5\cdot10^{12}$	$3,1\cdot10^{13}$	$3,2\cdot10^{11}$	$1,6\cdot10^{12}$	$4,4\cdot10^{13}$	$4,7\cdot10^{14}$
Ag-108m	$2,4\cdot10^{7}$	$1,9\cdot10^{8}$	$2,3\cdot10^{6}$	$1,8\cdot10^{7}$	$4,9\cdot10^{8}$	$2,3\cdot10^{9}$	$2,1\cdot10^{6}$	$1,0\cdot10^{7}$	$4,6\cdot10^{9}$	$2,2\cdot10^{10}$	$2,1\cdot10^{8}$	$1,0\cdot10^{9}$	$2,5\cdot10^{10}$	$2,7\cdot10^{11}$
Ba-133	$5,2\cdot10^{5}$	$4,1\cdot10^{6}$	$2,2\cdot10^{4}$	$1,7\cdot10^{5}$	$4,5\cdot10^{6}$	$2,2\cdot10^{7}$	$2,3\cdot10^{4}$	$1,1\cdot10^{5}$	$1,8\cdot10^{8}$	$8,9\cdot10^{8}$	$8,9\cdot10^{6}$	$4,3\cdot10^{7}$	$1,2\cdot10^{9}$	$1,3\cdot10^{10}$
Be-10	$2,6\cdot10^{2}$	$2,0\cdot10^{3}$	$2,5\cdot10^{1}$	$2,0\cdot10^{2}$	$5,2\cdot10^{3}$	$2,5\cdot10^{4}$	$2,3\cdot10^{1}$	$1,1\cdot10^{2}$	$4,8\cdot10^{4}$	$2,3\cdot10^{5}$	$2,2\cdot10^{3}$	$1,0\cdot10^{4}$	$2,6\cdot10^{5}$	$2,8\cdot10^{6}$
C-14	$4,3\cdot10^{8}$	$3,4\cdot10^{9}$	$4,1\cdot10^{7}$	$3,3\cdot10^{8}$	$8,7\cdot10^{9}$	$4,2\cdot10^{10}$	$3,8\cdot10^{7}$	$1,8\cdot10^{8}$	$7,9\cdot10^{10}$	$3,8\cdot10^{11}$	$3,6\cdot10^{9}$	$1,7\cdot10^{10}$	$4,3\cdot10^{11}$	$4,6\cdot10^{12}$
Fe-55	$7,5\cdot10^{8}$	$5,9\cdot10^{9}$	$4,9\cdot10^{5}$	$3,8\cdot10^{6}$	$1,0\cdot10^{8}$	$4,8\cdot10^{8}$	$7,4\cdot10^{5}$	$3,6\cdot10^{6}$	$1,5\cdot10^{12}$	$7,4\cdot10^{12}$	$7,6\cdot10^{10}$	$3,7\cdot10^{11}$	$1,1\cdot10^{13}$	$1,1\cdot10^{14}$
H-3	$6,9\cdot10^{6}$	$5,4\cdot10^{7}$	$3,4\cdot10^{5}$	$2,7\cdot10^{6}$	$7,0\cdot10^{7}$	$3,4\cdot10^{8}$	$3,4\cdot10^{5}$	$1,7\cdot10^{6}$	$2,2\cdot10^{9}$	$1,1\cdot10^{10}$	$1,1\cdot10^{8}$	$5,1\cdot10^{8}$	$1,4\cdot10^{10}$	$1,5\cdot10^{11}$
Ho-166m	$1,7\cdot10^{6}$	$1,3\cdot10^{7}$	$1,6\cdot10^{5}$	$1,3\cdot10^{6}$	$3,4\cdot10^{7}$	$1,6\cdot10^{8}$	$1,5\cdot10^{5}$	$7,1\cdot10^{5}$	$3,1\cdot10^{8}$	$1,5\cdot10^{9}$	$1,4\cdot10^{7}$	$6,8\cdot10^{7}$	$1,7\cdot10^{9}$	$1,8\cdot10^{10}$
Mo-93	$2,1\cdot10^{6}$	$1,7\cdot10^{7}$	$2,1\cdot10^{5}$	$1,6\cdot10^{6}$	$4,3\cdot10^{7}$	$2,1\cdot10^{8}$	$1,9\cdot10^{5}$	$9,1\cdot10^{5}$	$3,9\cdot10^{8}$	$1,9\cdot10^{9}$	$1,8\cdot10^{7}$	$8,6\cdot10^{7}$	$2,2\cdot10^{9}$	$2,3\cdot10^{10}$
Nb-93m	$1,0\cdot10^{8}$	$8,2\cdot10^{8}$	$6,1\cdot10^{6}$	$4,8\cdot10^{7}$	$1,3\cdot10^{9}$	$6,1\cdot10^{9}$	$6,0\cdot10^{6}$	$2,9\cdot10^{7}$	$2,9\cdot10^{10}$	$1,4\cdot10^{11}$	$1,4\cdot10^{9}$	$6,6\cdot10^{9}$	$1,8\cdot10^{11}$	$1,9\cdot10^{12}$
Nb-94	$4,3\cdot10^{6}$	$3,4\cdot10^{7}$	$4,2\cdot10^{5}$	$3,3\cdot10^{6}$	$8,7\cdot10^{7}$	$4,2\cdot10^{8}$	$3,8\cdot10^{5}$	$1,8\cdot10^{6}$	$7,9\cdot10^{8}$	$3,8\cdot10^{9}$	$3,6\cdot10^{7}$	$1,7\cdot10^{8}$	$4,3\cdot10^{9}$	$4,6\cdot10^{10}$
Ni-59	$4,3\cdot10^{8}$	$3,4\cdot10^{9}$	$4,2\cdot10^{7}$	$3,3\cdot10^{8}$	$8,7\cdot10^{9}$	$4,2\cdot10^{10}$	$3,8\cdot10^{7}$	$1,8\cdot10^{8}$	$7,9\cdot10^{10}$	$3,8\cdot10^{11}$	$3,6\cdot10^{9}$	$1,7\cdot10^{10}$	$4,3\cdot10^{11}$	$4,6\cdot10^{12}$
Ni-63	$6,7\cdot10^{10}$	$5,3\cdot10^{11}$	$6,1\cdot10^{9}$	$4,8\cdot10^{10}$	$1,3\cdot10^{12}$	$6,2\cdot10^{12}$	$5,6\cdot10^{9}$	$2,7\cdot10^{10}$	$1,3\cdot10^{13}$	$6,4\cdot10^{13}$	$6,1\cdot10^{11}$	$2,9\cdot10^{12}$	$7,5\cdot10^{13}$	$7,9\cdot10^{14}$
Sb-125	$7,8\cdot10^{7}$	$6,2\cdot10^{8}$	$5,5\cdot10^{4}$	$4,3\cdot10^{5}$	$1,1\cdot10^{7}$	$5,4\cdot10^{7}$	$8,3\cdot10^{4}$	$4,0\cdot10^{5}$	$1,6\cdot10^{11}$	$7,6\cdot10^{11}$	$7,8\cdot10^{9}$	$3,8\cdot10^{10}$	$1,1\cdot10^{12}$	$1,1\cdot10^{13}$
Zr-93	$4,3\cdot10^{5}$	$3,4\cdot10^{6}$	$4,2\cdot10^{4}$	$3,3\cdot10^{5}$	$8,7\cdot10^{6}$	$4,2\cdot10^{7}$	$3,8\cdot10^{4}$	$1,8\cdot10^{5}$	$7,9\cdot10^{7}$	$3,8\cdot10^{8}$	$3,6\cdot10^{6}$	$1,7\cdot10^{7}$	$4,3\cdot10^{8}$	$4,6\cdot10^{9}$

Table 3-2. Realistic and conservative radionuclide inventory for Forsmark NPP, waste type level. (cont.)

Nuclide	F.12		F.20		F.05		F.15		F.17		F.23		F.18	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Cs-137														
Cs-137	$2,2\cdot10^{9}$	$1,7\cdot10^{10}$	$6,0\cdot10^{8}$	$4,7\cdot10^{9}$	$3,4\cdot10^{10}$	$1,7\cdot10^{11}$	$9,2\cdot10^{9}$	$4,4\cdot10^{10}$	$8,1\cdot10^{12}$	$3,9\cdot10^{13}$	$9,0\cdot10^{9}$	$4,3\cdot10^{10}$	$2,8\cdot10^{13}$	$2,9\cdot10^{14}$
Cd-113m	$5,6\cdot10^{5}$	$4,4\cdot10^{6}$	$1,1\cdot10^{5}$	$8,8\cdot10^{5}$	$6,4\cdot10^{6}$	$3,1\cdot10^{7}$	$1,8\cdot10^{6}$	$8,7\cdot10^{6}$	$2,8\cdot10^{9}$	$1,3\cdot10^{10}$	$3,1\cdot10^{6}$	$1,5\cdot10^{7}$	$1,0\cdot10^{10}$	$1,1\cdot10^{11}$
Cl-36	$4,7\cdot10^{4}$	$3,7\cdot10^{5}$	$1,7\cdot10^{4}$	$1,3\cdot10^{5}$	$9,6\cdot10^{5}$	$4,6\cdot10^{6}$	$2,5\cdot10^{5}$	$1,2\cdot10^{6}$	$1,4\cdot10^{8}$	$6,9\cdot10^{8}$	$1,5\cdot10^{5}$	$7,5\cdot10^{5}$	$4,5\cdot10^{8}$	$4,8\cdot10^{9}$
Cs-134	$1,9\cdot10^{6}$	$1,5\cdot10^{7}$	$5,0\cdot10^{2}$	$4,0\cdot10^{3}$	$3,1\cdot10^{4}$	$1,5\cdot10^{5}$	$1,4\cdot10^{4}$	$6,9\cdot10^{4}$	$1,2\cdot10^{11}$	$5,9\cdot10^{11}$	$1,4\cdot10^{8}$	$7,0\cdot10^{8}$	$4,9\cdot10^{11}$	$5,2\cdot10^{12}$
Cs-135	$2,4\cdot10^{4}$	$1,9\cdot10^{5}$	$8,4\cdot10^{3}$	$6,6\cdot10^{4}$	$4,8\cdot10^{5}$	$2,3\cdot10^{6}$	$1,2\cdot10^{5}$	$5,9\cdot10^{5}$	$7,2\cdot10^{7}$	$3,5\cdot10^{8}$	$7,7\cdot10^{4}$	$3,7\cdot10^{5}$	$2,3\cdot10^{8}$	$2,4\cdot10^{9}$
Eu-152	$6,1\cdot10^{4}$	$4,8\cdot10^{5}$	$1,2\cdot10^{4}$	$9,4\cdot10^{4}$	$6,8\cdot10^{5}$	$3,3\cdot10^{6}$	$1,9\cdot10^{5}$	$9,3\cdot10^{5}$	$3,1\cdot10^{8}$	$1,5\cdot10^{9}$	$3,5\cdot10^{5}$	$1,7\cdot10^{6}$	$1,1\cdot10^{9}$	$1,2\cdot10^{10}$
Eu-154	$3,7\cdot10^{7}$	$2,9\cdot10^{8}$	$4,6\cdot10^{6}$	$3,6\cdot10^{7}$	$2,6\cdot10^{8}$	$1,3\cdot10^{9}$	$7,9\cdot10^{7}$	$3,8\cdot10^{8}$	$2,6\cdot10^{11}$	$1,2\cdot10^{12}$	$3,0\cdot10^{8}$	$1,4\cdot10^{9}$	$9,8\cdot10^{11}$	$1,0\cdot10^{13}$
Eu-155	$5,1\cdot10^{6}$	$4,0\cdot10^{7}$	$1,8\cdot10^{5}$	$1,4\cdot10^{6}$	$1,0\cdot10^{7}$	$4,9\cdot10^{7}$	$3,4\cdot10^{6}$	$1,7\cdot10^{7}$	$6,8\cdot10^{10}$	$3,3\cdot10^{11}$	$8,0\cdot10^{7}$	$3,9\cdot10^{8}$	$2,7\cdot10^{11}$	$2,8\cdot10^{12}$
I-129	$1,4\cdot10^{3}$	$1,1\cdot10^{4}$	$5,0\cdot10^{2}$	$4,0\cdot10^{3}$	$2,9\cdot10^{4}$	$1,4\cdot10^{5}$	$7,4\cdot10^{3}$	$3,6\cdot10^{4}$	$4,3\cdot10^{6}$	$2,1\cdot10^{7}$	$4,6\cdot10^{3}$	$2,2\cdot10^{4}$	$1,4\cdot10^{7}$	$1,4\cdot10^{8}$
Pd-107	$4,7\cdot10^{3}$	$3,7\cdot10^{4}$	$1,7\cdot10^{3}$	$1,3\cdot10^{4}$	$9,6\cdot10^{4}$	$4,6\cdot10^{5}$	$2,5\cdot10^{4}$	$1,2\cdot10^{5}$	$1,4\cdot10^{7}$	$6,9\cdot10^{7}$	$1,5\cdot10^{4}$	$7,5\cdot10^{4}$	$4,5\cdot10^{7}$	$4,8\cdot10^{8}$
Pm-147	$6,1\cdot10^{6}$	$4,8\cdot10^{7}$	$1,1\cdot10^{4}$	$8,9\cdot10^{4}$	$6,8\cdot10^{5}$	$3,3\cdot10^{6}$	$2,8\cdot10^{5}$	$1,3\cdot10^{6}$	$2,2\cdot10^{11}$	$1,1\cdot10^{12}$	$2,6\cdot10^{8}$	$1,3\cdot10^{9}$	$8,9\cdot10^{11}$	$9,4\cdot10^{12}$
Ru-106	$3,1\cdot10^{1}$	$2,5\cdot10^{2}$	$5,5\cdot10^{-7}$	$4,3\cdot10^{-6}$	$4,1\cdot10^{-5}$	$2,0\cdot10^{-4}$	$3,1\cdot10^{-5}$	$1,5\cdot10^{-4}$	$3,2\cdot10^{7}$	$1,5\cdot10^{8}$	$3,8\cdot10^{4}$	$1,8\cdot10^{5}$	$1,3\cdot10^{8}$	$1,3\cdot10^{9}$
Se-79	$1,9\cdot10^{4}$	$1,5\cdot10^{5}$	$6,7\cdot10^{3}$	$5,3\cdot10^{4}$	$3,9\cdot10^{5}$	$1,9\cdot10^{6}$	$9,8\cdot10^{4}$	$4,7\cdot10^{5}$	$5,7\cdot10^{7}$	$2,8\cdot10^{8}$	$6,2\cdot10^{4}$	$3,0\cdot10^{5}$	$1,8\cdot10^{8}$	$1,9\cdot10^{9}$
Sm-151	$1,1\cdot10^{7}$	$8,5\cdot10^{7}$	$3,6\cdot10^{6}$	$2,8\cdot10^{7}$	$2,0\cdot10^{8}$	$9,9\cdot10^{8}$	$5,3\cdot10^{7}$	$2,6\cdot10^{8}$	$3,5\cdot10^{10}$	$1,7\cdot10^{11}$	$3,8\cdot10^{7}$	$1,9\cdot10^{8}$	$1,2\cdot10^{11}$	$1,2\cdot10^{12}$
Sn-126	$2,4\cdot10^{3}$	$1,9\cdot10^{4}$	$8,4\cdot10^{2}$	$6,6\cdot10^{3}$	$4,8\cdot10^{4}$	$2,3\cdot10^{5}$	$1,2\cdot10^{4}$	$5,9\cdot10^{4}$	$7,2\cdot10^{6}$	$3,5\cdot10^{7}$	$7,7\cdot10^{3}$	$3,7\cdot10^{4}$	$2,3\cdot10^{7}$	$2,4\cdot10^{8}$
Sr-90	$2,1\cdot10^{8}$	$1,6\cdot10^{9}$	$5,7\cdot10^{7}$	$4,5\cdot10^{8}$	$3,3\cdot10^{9}$	$1,6\cdot10^{10}$	$8,8\cdot10^{8}$	$4,2\cdot10^{9}$	$7,9\cdot10^{11}$	$3,8\cdot10^{12}$	$8,8\cdot10^{8}$	$4,2\cdot10^{9}$	$2,7\cdot10^{12}$	$2,9\cdot10^{13}$
Tc-99	$2,4\cdot10^{7}$	$1,9\cdot10^{8}$	$8,4\cdot10^{6}$	$6,6\cdot10^{7}$	$4,8\cdot10^{8}$	$2,3\cdot10^{9}$	$1,2\cdot10^{8}$	$5,9\cdot10^{8}$	$7,2\cdot10^{10}$	$3,5\cdot10^{11}$	$7,7\cdot10^{7}$	$3,7\cdot10^{8}$	$2,3\cdot10^{11}$	$2,4\cdot10^{12}$

Table 3-2. Realistic and conservative radionuclide inventory for Forsmark NPP, waste type level. (cont.)

Nuclide	F.12		F.20		F.05		F.15		F.17		F.23		F.18	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Pu-236 + Pu-240														
Pu-239	$2,1\cdot10^{5}$	$1,7\cdot10^{6}$	$8,5\cdot10^{4}$	$6,7\cdot10^{5}$	$8,6\cdot10^{5}$	$4,1\cdot10^{6}$	$7,8\cdot10^{4}$	$3,7\cdot10^{5}$	$1,7\cdot10^{8}$	$8,3\cdot10^{8}$	$2,0\cdot10^{6}$	$9,5\cdot10^{6}$	$1,0\cdot10^{9}$	$1,1\cdot10^{10}$
Pu-240	$4,2\cdot10^{5}$	$3,3\cdot10^{6}$	$1,7\cdot10^{5}$	$1,3\cdot10^{6}$	$1,7\cdot10^{6}$	$8,3\cdot10^{6}$	$1,5\cdot10^{5}$	$7,5\cdot10^{5}$	$3,4\cdot10^{8}$	$1,7\cdot10^{9}$	$3,9\cdot10^{6}$	$1,9\cdot10^{7}$	$2,1\cdot10^{9}$	$2,2\cdot10^{10}$
Pb-210	$5,4\cdot10^{-6}$	$4,2\cdot10^{-5}$	$2,0\cdot10^{-6}$	$1,6\cdot10^{-5}$	$2,0\cdot10^{-5}$	$9,6\cdot10^{-5}$	$1,8\cdot10^{-6}$	$8,7\cdot10^{-6}$	$5,2\cdot10^{-3}$	$2,5\cdot10^{-2}$	$6,2\cdot10^{-5}$	$3,0\cdot10^{-4}$	$3,3\cdot10^{-2}$	$3,4\cdot10^{-1}$
Ra-226	$1,3\cdot10^{-4}$	$9,9\cdot10^{-4}$	$5,1\cdot10^{-5}$	$4,0\cdot10^{-4}$	$5,1\cdot10^{-4}$	$2,5\cdot10^{-3}$	$4,6\cdot10^{-5}$	$2,2\cdot10^{-4}$	$1,0\cdot10^{-1}$	$5,0\cdot10^{-1}$	$1,2\cdot10^{-3}$	$5,6\cdot10^{-3}$	$6,2\cdot10^{-1}$	$6,6\cdot10^{0}$
Ac-227	$1,1\cdot10^{-3}$	$8,3\cdot10^{-3}$	$3,9\cdot10^{-4}$	$3,1\cdot10^{-3}$	$3,9\cdot10^{-3}$	$1,9\cdot10^{-2}$	$3,5\cdot10^{-4}$	$1,7\cdot10^{-3}$	$1,0\cdot10^{0}$	$5,0\cdot10^{0}$	$1,2\cdot10^{-2}$	$5,9\cdot10^{-2}$	$6,4\cdot10^{0}$	$6,8\cdot10^{1}$
Th-229	$1,9\cdot10^{-4}$	$1,5\cdot10^{-3}$	$7,7\cdot10^{-5}$	$6,0\cdot10^{-4}$	$7,7\cdot10^{-4}$	$3,7\cdot10^{-3}$	$7,0\cdot10^{-5}$	$3,4\cdot10^{-4}$	$1,6\cdot10^{-1}$	$7,5\cdot10^{-1}$	$1,8\cdot10^{-3}$	$8,5\cdot10^{-3}$	$9,4\cdot10^{-1}$	$9,9\cdot10^{0}$
Th-230	$5,7\cdot10^{-2}$	$4,5\cdot10^{-1}$	$2,3\cdot10^{-2}$	$1,8\cdot10^{-1}$	$2,3\cdot10^{-1}$	$1,1\cdot10^{0}$	$2,1\cdot10^{-2}$	$1,0\cdot10^{-1}$	$4,7\cdot10^{1}$	$2,2\cdot10^{2}$	$5,3\cdot10^{-1}$	$2,6\cdot10^{0}$	$2,8\cdot10^{2}$	$3,0\cdot10^{3}$
Th-232	$6,3\cdot10^{-8}$	$5,0\cdot10^{-7}$	$2,6\cdot10^{-8}$	$2,0\cdot10^{-7}$	$2,6\cdot10^{-7}$	$1,2\cdot10^{-6}$	$2,3\cdot10^{-8}$	$1,1\cdot10^{-7}$	$5,2\cdot10^{-5}$	$2,5\cdot10^{-4}$	$5,9\cdot10^{-7}$	$2,8\cdot10^{-6}$	$3,1\cdot10^{-4}$	$3,3\cdot10^{-3}$
Pa-231	$1,9\cdot10^{-2}$	$1,5\cdot10^{-1}$	$7,7\cdot10^{-3}$	$6,1\cdot10^{-2}$	$7,7\cdot10^{-2}$	$3,7\cdot10^{-1}$	$7,0\cdot10^{-3}$	$3,4\cdot10^{-2}$	$1,6\cdot10^{1}$	$7,5\cdot10^{1}$	$1,8\cdot10^{-1}$	$8,5\cdot10^{-1}$	$9,4\cdot10^{1}$	$9,9\cdot10^{2}$
U-232	$1,4\cdot10^{1}$	$1,1\cdot10^{2}$	$5,7\cdot10^{0}$	$4,5\cdot10^{1}$	$5,7\cdot10^{1}$	$2,7\cdot10^{2}$	$5,1\cdot10^{0}$	$2,5\cdot10^{1}$	$1,2\cdot10^{4}$	$6,0\cdot10^{4}$	$1,4\cdot10^{2}$	$6,9\cdot10^{2}$	$7,6\cdot10^{4}$	$8,0\cdot10^{5}$
U-233	$1,3\cdot10^{-2}$	$1,0\cdot10^{-1}$	$5,1\cdot10^{-3}$	$4,0\cdot10^{-2}$	$5,2\cdot10^{-2}$	$2,5\cdot10^{-1}$	$4,7\cdot10^{-3}$	$2,2\cdot10^{-2}$	$1,0\cdot10^{1}$	$5,0\cdot10^{1}$	$1,2\cdot10^{-1}$	$5,7\cdot10^{-1}$	$6,3\cdot10^{1}$	$6,6\cdot10^{2}$
U-234	$6,3\cdot10^{2}$	$5,0\cdot10^{3}$	$2,6\cdot10^{2}$	$2,0\cdot10^{3}$	$2,6\cdot10^{3}$	$1,2\cdot10^{4}$	$2,3\cdot10^{2}$	$1,1\cdot10^{3}$	$5,2\cdot10^{5}$	$2,5\cdot10^{6}$	$5,9\cdot10^{3}$	$2,8\cdot10^{4}$	$3,1\cdot10^{6}$	$3,3\cdot10^{7}$
U-235	$1,3\cdot10^{1}$	$1,0\cdot10^{2}$	$5,1\cdot10^{0}$	$4,0\cdot10^{1}$	$5,2\cdot10^{1}$	$2,5\cdot10^{2}$	$4,7\cdot10^{0}$	$2,2\cdot10^{1}$	$1,0\cdot10^{4}$	$5,0\cdot10^{4}$	$1,2\cdot10^{2}$	$5,7\cdot10^{2}$	$6,3\cdot10^{4}$	$6,6\cdot10^{5}$
U-236	$1,9\cdot10^{2}$	$1,5\cdot10^{3}$	$7,7\cdot10^{1}$	$6,1\cdot10^{2}$	$7,7\cdot10^{2}$	$3,7\cdot10^{3}$	$7,0\cdot10^{1}$	$3,4\cdot10^{2}$	$1,6\cdot10^{5}$	$7,5\cdot10^{5}$	$1,8\cdot10^{3}$	$8,5\cdot10^{3}$	$9,4\cdot10^{5}$	$9,9\cdot10^{6}$
U-238	$2,5\cdot10^{2}$	$2,0\cdot10^{3}$	$1,0\cdot10^{2}$	$8,1\cdot10^{2}$	$1,0\cdot10^{3}$	$5,0\cdot10^{3}$	$9,3\cdot10^{1}$	$4,5\cdot10^{2}$	$2,1\cdot10^{5}$	$1,0\cdot10^{6}$	$2,4\cdot10^{3}$	$1,1\cdot10^{4}$	$1,3\cdot10^{6}$	$1,3\cdot10^{7}$
Np-237	$2,5\cdot10^{2}$	$2,0\cdot10^{3}$	$1,0\cdot10^{2}$	$8,1\cdot10^{2}$	$1,0\cdot10^{3}$	$5,0\cdot10^{3}$	$9,3\cdot10^{1}$	$4,5\cdot10^{2}$	$2,1\cdot10^{5}$	$1,0\cdot10^{6}$	$2,4\cdot10^{3}$	$1,1\cdot10^{4}$	$1,3\cdot10^{6}$	$1,3\cdot10^{7}$
Pu-238	$2,0\cdot10^{6}$	$1,6\cdot10^{7}$	$8,1\cdot10^{5}$	$6,4\cdot10^{6}$	$8,1\cdot10^{6}$	$3,9\cdot10^{7}$	$7,3\cdot10^{5}$	$3,5\cdot10^{6}$	$1,7\cdot10^{9}$	$8,3\cdot10^{9}$	$2,0\cdot10^{7}$	$9,6\cdot10^{7}$	$1,1\cdot10^{10}$	$1,1\cdot10^{11}$
Pu-241	$1,7\cdot10^{7}$	$1,3\cdot10^{8}$	$5,9\cdot10^{6}$	$4,6\cdot10^{7}$	$5,9\cdot10^{7}$	$2,9\cdot10^{8}$	$5,3\cdot10^{6}$	$2,6\cdot10^{7}$	$1,8\cdot10^{10}$	$8,9\cdot10^{10}$	$2,2\cdot10^{8}$	$1,1\cdot10^{9}$	$1,2\cdot10^{11}$	$1,2\cdot10^{12}$
Pu-242	$1,9\cdot10^{3}$	$1,5\cdot10^{4}$	$7,7\cdot10^{2}$	$6,1\cdot10^{3}$	$7,7\cdot10^{3}$	$3,7\cdot10^{4}$	$7,0\cdot10^{2}$	$3,4\cdot10^{3}$	$1,6\cdot10^{6}$	$7,5\cdot10^{6}$	$1,8\cdot10^{4}$	$8,5\cdot10^{4}$	$9,4\cdot10^{6}$	$9,9\cdot10^{7}$
Am-241	$6,1\cdot10^{5}$	$4,8\cdot10^{6}$	$2,4\cdot10^{5}$	$1,9\cdot10^{6}$	$2,5\cdot10^{6}$	$1,2\cdot10^{7}$	$2,2\cdot10^{5}$	$1,1\cdot10^{6}$	$5,0\cdot10^{8}$	$2,4\cdot10^{9}$	$5,7\cdot10^{6}$	$2,7\cdot10^{7}$	$3,0\cdot10^{9}$	$3,2\cdot10^{10}$
Am-242m	$5,5\cdot10^{3}$	$4,4\cdot10^{4}$	$2,2\cdot10^{3}$	$1,7\cdot10^{4}$	$2,2\cdot10^{4}$	$1,1\cdot10^{5}$	$2,0\cdot10^{3}$	$9,7\cdot10^{3}$	$4,6\cdot10^{6}$	$2,2\cdot10^{7}$	$5,3\cdot10^{4}$	$2,6\cdot10^{5}$	$2,8\cdot10^{7}$	$3,0\cdot10^{8}$
Am-243	$1,9\cdot10^{4}$	$1,5\cdot10^{5}$	$7,7\cdot10^{3}$	$6,0\cdot10^{4}$	$7,7\cdot10^{4}$	$3,7\cdot10^{5}$	$7,0\cdot10^{3}$	$3,4\cdot10^{4}$	$1,6\cdot10^{7}$	$7,5\cdot10^{7}$	$1,8\cdot10^{5}$	$8,5\cdot10^{5}$	$9,4\cdot10^{7}$	$9,9\cdot10^{8}$
Cm-243	$6,6\cdot10^{3}$	$5,2\cdot10^{4}$	$2,5\cdot10^{3}$	$2,0\cdot10^{4}$	$2,5\cdot10^{4}$	$1,2\cdot10^{5}$	$2,3\cdot10^{3}$	$1,1\cdot10^{4}$	$6,1\cdot10^{6}$	$2,9\cdot10^{7}$	$7,1\cdot10^{4}$	$3,4\cdot10^{5}$	$3,8\cdot10^{7}$	$4,0\cdot10^{8}$
Cm-244	$6,7\cdot10^{5}$	$5,2\cdot10^{6}$	$2,4\cdot10^{5}$	$1,9\cdot10^{6}$	$2,4\cdot10^{6}$	$1,2\cdot10^{7}$	$2,2\cdot10^{5}$	$1,0\cdot10^{6}$	$6,7\cdot10^{8}$	$3,3\cdot10^{9}$	$8,0\cdot10^{6}$	$3,9\cdot10^{7}$	$4,2\cdot10^{9}$	$4,5\cdot10^{10}$
Cm-245	$1,9\cdot10^{2}$	$1,5\cdot10^{3}$	$7,7\cdot10^{1}$	$6,0\cdot10^{2}$	$7,7\cdot10^{2}$	$3,7\cdot10^{3}$	$7,0\cdot10^{1}$	$3,4\cdot10^{2}$	$1,6\cdot10^{5}$	$7,5\cdot10^{5}$	$1,8\cdot10^{3}$	$8,5\cdot10^{3}$	$9,4\cdot10^{5}$	$9,9\cdot10^{6}$
Cm-246	$5,0\cdot10^{1}$	$4,0\cdot10^{2}$	$2,0\cdot10^{1}$	$1,6\cdot10^{2}$	$2,1\cdot10^{2}$	$9,9\cdot10^{2}$	$1,9\cdot10^{1}$	$8,9\cdot10^{1}$	$4,1\cdot10^{4}$	$2,0\cdot10^{5}$	$4,7\cdot10^{2}$	$2,3\cdot10^{3}$	$2,5\cdot10^{5}$	$2,6\cdot10^{6}$
Pu-244	$4,4\cdot10^{-4}$	$3,5\cdot10^{-3}$	$1,8\cdot10^{-4}$	$1,4\cdot10^{-3}$	$1,8\cdot10^{-3}$	$8,7\cdot10^{-3}$	$1,6\cdot10^{-4}$	$7,9\cdot10^{-4}$	$3,6\cdot10^{-1}$	$1,8\cdot10^{0}$	$4,1\cdot10^{-3}$	$2,0\cdot10^{-2}$	$2,2\cdot10^{0}$	$2,3\cdot10^{1}$

Table 3-3. Realistic and conservative radionuclide inventory for CLAB, waste type level.

Nuclide	C.01		C.23		C.02		C.24	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Co-60								
Co-60	$8,1\cdot10^{10}$	$3,9\cdot10^{11}$	$2,9\cdot10^{12}$	$1,4\cdot10^{13}$	$7,1\cdot10^{13}$	$7,5\cdot10^{14}$	$4,8\cdot10^{12}$	$5,1\cdot10^{13}$
Ag-108m	$1,7\cdot10^{9}$	$8,3\cdot10^{9}$	$8,6\cdot10^{8}$	$4,2\cdot10^{9}$	$1,8\cdot10^{10}$	$1,9\cdot10^{11}$	$2,0\cdot10^{10}$	$2,1\cdot10^{11}$
Ba-133	$1,5\cdot10^{7}$	$7,4\cdot10^{7}$	$5,3\cdot10^{7}$	$2,5\cdot10^{8}$	$1,2\cdot10^{9}$	$1,3\cdot10^{10}$	$3,2\cdot10^{8}$	$3,3\cdot10^{9}$
Be-10	$1,9\cdot10^{4}$	$8,9\cdot10^{4}$	$8,9\cdot10^{3}$	$4,3\cdot10^{4}$	$1,8\cdot10^{5}$	$2,0\cdot10^{6}$	$2,1\cdot10^{5}$	$2,3\cdot10^{6}$
C-14	$3,1\cdot10^{10}$	$1,5\cdot10^{11}$	$1,5\cdot10^{10}$	$7,1\cdot10^{10}$	$3,1\cdot10^{11}$	$3,2\cdot10^{12}$	$3,6\cdot10^{11}$	$3,8\cdot10^{12}$
Fe-55	$3,6\cdot10^{8}$	$1,8\cdot10^{9}$	$1,6\cdot10^{12}$	$7,9\cdot10^{12}$	$4,0\cdot10^{13}$	$4,2\cdot10^{14}$	$1,4\cdot10^{12}$	$1,4\cdot10^{13}$
H-3	$2,4\cdot10^{8}$	$1,2\cdot10^{9}$	$5,9\cdot10^{8}$	$2,9\cdot10^{9}$	$1,4\cdot10^{10}$	$1,5\cdot10^{11}$	$4,4\cdot10^{9}$	$4,7\cdot10^{10}$
Ho-166m	$1,2\cdot10^{8}$	$5,8\cdot10^{8}$	$5,9\cdot10^{7}$	$2,8\cdot10^{8}$	$1,2\cdot10^{9}$	$1,3\cdot10^{10}$	$1,4\cdot10^{9}$	$1,5\cdot10^{10}$
Mo-93	$1,5\cdot10^{8}$	$7,4\cdot10^{8}$	$7,4\cdot10^{7}$	$3,6\cdot10^{8}$	$1,5\cdot10^{9}$	$1,6\cdot10^{10}$	$1,8\cdot10^{9}$	$1,9\cdot10^{10}$
Nb-93m	$4,3\cdot10^{9}$	$2,1\cdot10^{10}$	$7,1\cdot10^{9}$	$3,4\cdot10^{10}$	$1,6\cdot10^{11}$	$1,7\cdot10^{12}$	$7,1\cdot10^{10}$	$7,5\cdot10^{11}$
Nb-94	$3,1\cdot10^{8}$	$1,5\cdot10^{9}$	$1,5\cdot10^{8}$	$7,2\cdot10^{8}$	$3,1\cdot10^{9}$	$3,3\cdot10^{10}$	$3,6\cdot10^{9}$	$3,8\cdot10^{10}$
Ni-59	$3,1\cdot10^{10}$	$1,5\cdot10^{11}$	$1,5\cdot10^{10}$	$7,2\cdot10^{10}$	$3,1\cdot10^{11}$	$3,3\cdot10^{12}$	$3,6\cdot10^{11}$	$3,8\cdot10^{12}$
Ni-63	$4,5\cdot10^{12}$	$2,2\cdot10^{13}$	$2,6\cdot10^{12}$	$1,2\cdot10^{13}$	$5,5\cdot10^{13}$	$5,8\cdot10^{14}$	$5,5\cdot10^{13}$	$5,8\cdot10^{14}$
Sb-125	$4,1\cdot10^{7}$	$2,0\cdot10^{8}$	$1,7\cdot10^{11}$	$8,0\cdot10^{11}$	$4,0\cdot10^{12}$	$4,3\cdot10^{13}$	$1,4\cdot10^{11}$	$1,5\cdot10^{12}$
Zr-93	$3,1\cdot10^{7}$	$1,5\cdot10^{8}$	$1,5\cdot10^{7}$	$7,2\cdot10^{7}$	$3,1\cdot10^{8}$	$3,3\cdot10^{9}$	$3,6\cdot10^{8}$	$3,8\cdot10^{9}$

Table 3-3. Realistic and conservative radionuclide inventory for CLAB, waste type level. (cont.)

Nuclide	C.01		C.23		C.02		C.24	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Cs-137								
Cs-137	$2,8\cdot10^{12}$	$1,4\cdot10^{13}$	$1,6\cdot10^{12}$	$7,7\cdot10^{12}$	$6,0\cdot10^{13}$	$6,4\cdot10^{14}$	$2,2\cdot10^{13}$	$2,3\cdot10^{14}$
Cd-113m	$4,7\cdot10^{8}$	$2,3\cdot10^{9}$	$6,5\cdot10^{8}$	$3,1\cdot10^{9}$	$2,6\cdot10^{10}$	$2,7\cdot10^{11}$	$4,4\cdot10^{9}$	$4,6\cdot10^{10}$
Cl-36	$8,8\cdot10^{7}$	$4,3\cdot10^{8}$	$2,5\cdot10^{7}$	$1,2\cdot10^{8}$	$8,8\cdot10^{8}$	$9,3\cdot10^{9}$	$6,4\cdot10^{8}$	$6,7\cdot10^{9}$
Cs-134	$9,9\cdot10^{5}$	$4,8\cdot10^{6}$	$2,2\cdot10^{11}$	$1,1\cdot10^{12}$	$9,0\cdot10^{12}$	$9,5\cdot10^{13}$	$4,6\cdot10^{11}$	$4,8\cdot10^{12}$
Cs-135	$4,4\cdot10^{7}$	$2,1\cdot10^{8}$	$1,3\cdot10^{7}$	$6,1\cdot10^{7}$	$4,4\cdot10^{8}$	$4,7\cdot10^{9}$	$3,2\cdot10^{8}$	$3,4\cdot10^{9}$
Eu-152	$4,9\cdot10^{7}$	$2,4\cdot10^{8}$	$7,3\cdot10^{7}$	$3,5\cdot10^{8}$	$2,9\cdot10^{9}$	$3,1\cdot10^{10}$	$4,7\cdot10^{8}$	$5,0\cdot10^{9}$
Eu-154	$1,7\cdot10^{10}$	$8,0\cdot10^{10}$	$7,5\cdot10^{10}$	$3,6\cdot10^{11}$	$3,1\cdot10^{12}$	$3,2\cdot10^{13}$	$2,6\cdot10^{11}$	$2,8\cdot10^{12}$
Eu-155	$4,9\cdot10^{8}$	$2,4\cdot10^{9}$	$3,2\cdot10^{10}$	$1,5\cdot10^{11}$	$1,3\cdot10^{12}$	$1,4\cdot10^{13}$	$7,0\cdot10^{10}$	$7,4\cdot10^{11}$
I-129	$2,7\cdot10^{6}$	$1,3\cdot10^{7}$	$7,6\cdot10^{5}$	$3,7\cdot10^{6}$	$2,6\cdot10^{7}$	$2,8\cdot10^{8}$	$1,9\cdot10^{7}$	$2,0\cdot10^{8}$
Pd-107	$8,8\cdot10^{6}$	$4,3\cdot10^{7}$	$2,5\cdot10^{6}$	$1,2\cdot10^{7}$	$8,8\cdot10^{7}$	$9,3\cdot10^{8}$	$6,4\cdot10^{7}$	$6,7\cdot10^{8}$
Pm-147	$2,3\cdot10^{7}$	$1,1\cdot10^{8}$	$2,4\cdot10^{11}$	$1,2\cdot10^{12}$	$9,9\cdot10^{12}$	$1,1\cdot10^{14}$	$5,1\cdot10^{11}$	$5,4\cdot10^{12}$
Ru-106	$7,1\cdot10^{-3}$	$3,4\cdot10^{-2}$	$6,4\cdot10^{8}$	$3,1\cdot10^{9}$	$2,6\cdot10^{10}$	$2,7\cdot10^{11}$	$1,3\cdot10^{9}$	$1,4\cdot10^{10}$
Se-79	$3,5\cdot10^{7}$	$1,7\cdot10^{8}$	$1,0\cdot10^{7}$	$4,9\cdot10^{7}$	$3,5\cdot10^{8}$	$3,7\cdot10^{9}$	$2,5\cdot10^{8}$	$2,7\cdot10^{9}$
Sm-151	$1,8\cdot10^{10}$	$8,7\cdot10^{10}$	$6,4\cdot10^{9}$	$3,1\cdot10^{10}$	$2,3\cdot10^{11}$	$2,4\cdot10^{12}$	$1,3\cdot10^{11}$	$1,4\cdot10^{12}$
Sn-126	$4,4\cdot10^{6}$	$2,1\cdot10^{7}$	$1,3\cdot10^{6}$	$6,1\cdot10^{6}$	$4,4\cdot10^{7}$	$4,7\cdot10^{8}$	$3,2\cdot10^{7}$	$3,4\cdot10^{8}$
Sr-90	$2,7\cdot10^{11}$	$1,3\cdot10^{12}$	$1,6\cdot10^{11}$	$7,6\cdot10^{11}$	$5,9\cdot10^{12}$	$6,3\cdot10^{13}$	$2,1\cdot10^{12}$	$2,2\cdot10^{13}$
Tc-99	$4,4\cdot10^{10}$	$2,1\cdot10^{11}$	$1,3\cdot10^{10}$	$6,1\cdot10^{10}$	$4,4\cdot10^{11}$	$4,7\cdot10^{12}$	$3,2\cdot10^{11}$	$3,4\cdot10^{12}$

Table 3-3. Realistic and conservative radionuclide inventory for CLAB, waste type level. (cont.)

Nuclide	**C.01**		**C.23**		**C.02**		**C.24**	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Pu-236 + Pu-240								
Pu-239	$9,4\cdot10^{6}$	$4,5\cdot10^{7}$	$3,0\cdot10^{5}$	$1,5\cdot10^{6}$	$7,6\cdot10^{7}$	$8,1\cdot10^{8}$	$2,6\cdot10^{5}$	$2,8\cdot10^{6}$
Pu-240	$1,9\cdot10^{7}$	$9,0\cdot10^{7}$	$6,1\cdot10^{5}$	$2,9\cdot10^{6}$	$1,5\cdot10^{8}$	$1,6\cdot10^{9}$	$5,2\cdot10^{5}$	$5,5\cdot10^{6}$
Pb-210	$2,2\cdot10^{-4}$	$1,1\cdot10^{-3}$	$1,1\cdot10^{-5}$	$5,2\cdot10^{-5}$	$2,8\cdot10^{-3}$	$2,9\cdot10^{-2}$	$9,1\cdot10^{-6}$	$9,6\cdot10^{-5}$
Ra-226	$5,6\cdot10^{-3}$	$2,7\cdot10^{-2}$	$1,8\cdot10^{-4}$	$8,8\cdot10^{-4}$	$4,5\cdot10^{-2}$	$4,8\cdot10^{-1}$	$1,6\cdot10^{-4}$	$1,7\cdot10^{-3}$
Ac-227	$4,3\cdot10^{-2}$	$2,1\cdot10^{-1}$	$2,1\cdot10^{-3}$	$1,0\cdot10^{-2}$	$5,5\cdot10^{-1}$	$5,8\cdot10^{0}$	$1,8\cdot10^{-3}$	$1,9\cdot10^{-2}$
Th-229	$8,4\cdot10^{-3}$	$4,1\cdot10^{-2}$	$2,7\cdot10^{-4}$	$1,3\cdot10^{-3}$	$6,9\cdot10^{-2}$	$7,3\cdot10^{-1}$	$2,4\cdot10^{-4}$	$2,5\cdot10^{-3}$
Th-230	$2,5\cdot10^{0}$	$1,2\cdot10^{1}$	$8,2\cdot10^{-2}$	$4,0\cdot10^{-1}$	$2,1\cdot10^{1}$	$2,2\cdot10^{2}$	$7,1\cdot10^{-2}$	$7,5\cdot10^{-1}$
Th-232	$2,8\cdot10^{-6}$	$1,4\cdot10^{-5}$	$9,1\cdot10^{-8}$	$4,4\cdot10^{-7}$	$2,3\cdot10^{-5}$	$2,4\cdot10^{-4}$	$7,9\cdot10^{-8}$	$8,3\cdot10^{-7}$
Pa-231	$8,4\cdot10^{-1}$	$4,1\cdot10^{0}$	$2,7\cdot10^{-2}$	$1,3\cdot10^{-1}$	$6,9\cdot10^{0}$	$7,3\cdot10^{1}$	$2,4\cdot10^{-2}$	$2,5\cdot10^{-1}$
U-232	$6,2\cdot10^{2}$	$3,0\cdot10^{3}$	$2,3\cdot10^{1}$	$1,1\cdot10^{2}$	$5,8\cdot10^{3}$	$6,1\cdot10^{4}$	$2,0\cdot10^{1}$	$2,1\cdot10^{2}$
U-233	$5,6\cdot10^{-1}$	$2,7\cdot10^{0}$	$1,8\cdot10^{-2}$	$8,8\cdot10^{-2}$	$4,6\cdot10^{0}$	$4,8\cdot10^{1}$	$1,6\cdot10^{-2}$	$1,7\cdot10^{-1}$
U-234	$2,8\cdot10^{4}$	$1,4\cdot10^{5}$	$9,1\cdot10^{2}$	$4,4\cdot10^{3}$	$2,3\cdot10^{5}$	$2,4\cdot10^{6}$	$7,9\cdot10^{2}$	$8,3\cdot10^{3}$
U-235	$5,6\cdot10^{2}$	$2,7\cdot10^{3}$	$1,8\cdot10^{1}$	$8,8\cdot10^{1}$	$4,6\cdot10^{3}$	$4,8\cdot10^{4}$	$1,6\cdot10^{1}$	$1,7\cdot10^{2}$
U-236	$8,4\cdot10^{3}$	$4,1\cdot10^{4}$	$2,7\cdot10^{2}$	$1,3\cdot10^{3}$	$6,9\cdot10^{4}$	$7,3\cdot10^{5}$	$2,4\cdot10^{2}$	$2,5\cdot10^{3}$
U-238	$1,1\cdot10^{4}$	$5,4\cdot10^{4}$	$3,7\cdot10^{2}$	$1,8\cdot10^{3}$	$9,2\cdot10^{4}$	$9,7\cdot10^{5}$	$3,2\cdot10^{2}$	$3,3\cdot10^{3}$
Np-237	$1,1\cdot10^{4}$	$5,4\cdot10^{4}$	$3,7\cdot10^{2}$	$1,8\cdot10^{3}$	$9,2\cdot10^{4}$	$9,7\cdot10^{5}$	$3,2\cdot10^{2}$	$3,3\cdot10^{3}$
Pu-238	$8,8\cdot10^{7}$	$4,3\cdot10^{8}$	$3,2\cdot10^{6}$	$1,5\cdot10^{7}$	$8,0\cdot10^{8}$	$8,4\cdot10^{9}$	$2,7\cdot10^{6}$	$2,9\cdot10^{7}$
Pu-241	$6,5\cdot10^{8}$	$3,1\cdot10^{9}$	$4,2\cdot10^{7}$	$2,0\cdot10^{8}$	$1,1\cdot10^{10}$	$1,1\cdot10^{11}$	$3,5\cdot10^{7}$	$3,7\cdot10^{8}$
Pu-242	$8,4\cdot10^{4}$	$4,1\cdot10^{5}$	$2,7\cdot10^{3}$	$1,3\cdot10^{4}$	$6,9\cdot10^{5}$	$7,3\cdot10^{6}$	$2,4\cdot10^{3}$	$2,5\cdot10^{4}$
Am-241	$2,7\cdot10^{7}$	$1,3\cdot10^{8}$	$8,9\cdot10^{5}$	$4,3\cdot10^{6}$	$2,2\cdot10^{8}$	$2,4\cdot10^{9}$	$7,6\cdot10^{5}$	$8,1\cdot10^{6}$
Am-242m	$2,4\cdot10^{5}$	$1,2\cdot10^{6}$	$8,4\cdot10^{3}$	$4,0\cdot10^{4}$	$2,1\cdot10^{6}$	$2,2\cdot10^{7}$	$7,2\cdot10^{3}$	$7,6\cdot10^{4}$
Am-243	$8,4\cdot10^{5}$	$4,1\cdot10^{6}$	$2,7\cdot10^{4}$	$1,3\cdot10^{5}$	$6,9\cdot10^{6}$	$7,3\cdot10^{7}$	$2,4\cdot10^{4}$	$2,5\cdot10^{5}$
Cm-243	$2,7\cdot10^{5}$	$1,3\cdot10^{6}$	$1,2\cdot10^{4}$	$5,8\cdot10^{4}$	$3,1\cdot10^{6}$	$3,3\cdot10^{7}$	$1,0\cdot10^{4}$	$1,1\cdot10^{5}$
Cm-244	$2,6\cdot10^{7}$	$1,3\cdot10^{8}$	$1,4\cdot10^{6}$	$7,0\cdot10^{6}$	$3,7\cdot10^{8}$	$3,9\cdot10^{9}$	$1,2\cdot10^{6}$	$1,3\cdot10^{7}$
Cm-245	$8,4\cdot10^{3}$	$4,1\cdot10^{4}$	$2,7\cdot10^{2}$	$1,3\cdot10^{3}$	$6,9\cdot10^{4}$	$7,3\cdot10^{5}$	$2,4\cdot10^{2}$	$2,5\cdot10^{3}$
Cm-246	$2,2\cdot10^{3}$	$1,1\cdot10^{4}$	$7,3\cdot10^{1}$	$3,5\cdot10^{2}$	$1,8\cdot10^{4}$	$1,9\cdot10^{5}$	$6,3\cdot10^{1}$	$6,6\cdot10^{2}$
Pu-244	$2,0\cdot10^{-2}$	$9,5\cdot10^{-2}$	$6,4\cdot10^{-4}$	$3,1\cdot10^{-3}$	$1,6\cdot10^{-1}$	$1,7\cdot10^{0}$	$5,5\cdot10^{-4}$	$5,8\cdot10^{-3}$

Table 3-4. Realistic and conservative radionuclide inventory for Oskarshamn NPP, waste type level.

Nuclide	O.12		O.07		O.01		O.23		O.02	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Co-60										
Co-60	$2,6\cdot10^{10}$	$2,1\cdot10^{11}$	$1,0\cdot10^{12}$	$8,8\cdot10^{12}$	$8,1\cdot10^{10}$	$3,9\cdot10^{11}$	$2,4\cdot10^{11}$	$1,2\cdot10^{12}$	$6,6\cdot10^{12}$	$7,0\cdot10^{13}$
Ag-108m	$7,1\cdot10^{7}$	$5,6\cdot10^{8}$	$1,8\cdot10^{9}$	$1,5\cdot10^{10}$	$1,7\cdot10^{9}$	$8,3\cdot10^{9}$	$3,5\cdot10^{8}$	$1,7\cdot10^{9}$	$8,3\cdot10^{9}$	$8,7\cdot10^{10}$
Ba-133	$1,4\cdot10^{6}$	$1,1\cdot10^{7}$	$4,3\cdot10^{7}$	$3,7\cdot10^{8}$	$1,5\cdot10^{7}$	$7,4\cdot10^{7}$	$9,9\cdot10^{6}$	$4,8\cdot10^{7}$	$2,5\cdot10^{8}$	$2,6\cdot10^{9}$
Be-10	$7,6\cdot10^{2}$	$6,0\cdot10^{3}$	$1,9\cdot10^{4}$	$1,6\cdot10^{5}$	$1,9\cdot10^{4}$	$8,9\cdot10^{4}$	$3,7\cdot10^{3}$	$1,8\cdot10^{4}$	$8,7\cdot10^{4}$	$9,2\cdot10^{5}$
C-14	$1,3\cdot10^{9}$	$9,9\cdot10^{9}$	$3,1\cdot10^{10}$	$2,7\cdot10^{11}$	$3,1\cdot10^{10}$	$1,5\cdot10^{11}$	$6,1\cdot10^{9}$	$3,0\cdot10^{10}$	$1,4\cdot10^{11}$	$1,5\cdot10^{12}$
Fe-55	$2,1\cdot10^{9}$	$1,7\cdot10^{10}$	$1,3\cdot10^{11}$	$1,1\cdot10^{12}$	$3,6\cdot10^{8}$	$1,8\cdot10^{9}$	$3,0\cdot10^{10}$	$1,4\cdot10^{11}$	$8,7\cdot10^{11}$	$9,2\cdot10^{12}$
H-3	$1,9\cdot10^{7}$	$1,5\cdot10^{8}$	$5,5\cdot10^{8}$	$4,8\cdot10^{9}$	$2,4\cdot10^{8}$	$1,2\cdot10^{9}$	$1,3\cdot10^{8}$	$6,1\cdot10^{8}$	$3,1\cdot10^{9}$	$3,3\cdot10^{10}$
Ho-166m	$5,0\cdot10^{6}$	$3,9\cdot10^{7}$	$1,2\cdot10^{8}$	$1,1\cdot10^{9}$	$1,2\cdot10^{8}$	$5,8\cdot10^{8}$	$2,4\cdot10^{7}$	$1,2\cdot10^{8}$	$5,7\cdot10^{8}$	$6,0\cdot10^{9}$
Mo-93	$6,3\cdot10^{6}$	$5,0\cdot10^{7}$	$1,5\cdot10^{8}$	$1,3\cdot10^{9}$	$1,5\cdot10^{8}$	$7,4\cdot10^{8}$	$3,1\cdot10^{7}$	$1,5\cdot10^{8}$	$7,2\cdot10^{8}$	$7,6\cdot10^{9}$
Nb-93m	$2,9\cdot10^{8}$	$2,3\cdot10^{9}$	$7,9\cdot10^{9}$	$6,9\cdot10^{10}$	$4,3\cdot10^{9}$	$2,1\cdot10^{10}$	$1,8\cdot10^{9}$	$8,5\cdot10^{9}$	$4,3\cdot10^{10}$	$4,6\cdot10^{11}$
Nb-94	$1,3\cdot10^{7}$	$1,0\cdot10^{8}$	$3,1\cdot10^{8}$	$2,7\cdot10^{9}$	$3,1\cdot10^{8}$	$1,5\cdot10^{9}$	$6,2\cdot10^{7}$	$3,0\cdot10^{8}$	$1,4\cdot10^{9}$	$1,5\cdot10^{10}$
Ni-59	$1,3\cdot10^{9}$	$1,0\cdot10^{10}$	$3,1\cdot10^{10}$	$2,7\cdot10^{11}$	$3,1\cdot10^{10}$	$1,5\cdot10^{11}$	$6,2\cdot10^{9}$	$3,0\cdot10^{10}$	$1,5\cdot10^{11}$	$1,5\cdot10^{12}$
Ni-63	$2,0\cdot10^{11}$	$1,5\cdot10^{12}$	$4,9\cdot10^{12}$	$4,3\cdot10^{13}$	$4,5\cdot10^{12}$	$2,2\cdot10^{13}$	$9,9\cdot10^{11}$	$4,8\cdot10^{12}$	$2,3\cdot10^{13}$	$2,5\cdot10^{14}$
Sb-125	$2,2\cdot10^{8}$	$1,8\cdot10^{9}$	$1,3\cdot10^{10}$	$1,1\cdot10^{11}$	$4,1\cdot10^{7}$	$2,0\cdot10^{8}$	$3,1\cdot10^{9}$	$1,5\cdot10^{10}$	$9,1\cdot10^{10}$	$9,6\cdot10^{11}$
Zr-93	$1,3\cdot10^{6}$	$1,0\cdot10^{7}$	$3,1\cdot10^{7}$	$2,7\cdot10^{8}$	$3,1\cdot10^{7}$	$1,5\cdot10^{8}$	$6,2\cdot10^{6}$	$3,0\cdot10^{7}$	$1,5\cdot10^{8}$	$1,5\cdot10^{9}$

Table 3-4. Realistic and conservative radionuclide inventory for Oskarshamn NPP, waste type level. (cont.)

Nuclide	**O.12**		**O.07**		**O.01**		**O.23**		**O.02**	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Cs-137										
Cs-137	$9,9\cdot10^{10}$	$7,8\cdot10^{11}$	$2,9\cdot10^{12}$	$2,5\cdot10^{13}$	$2,8\cdot10^{12}$	$1,4\cdot10^{13}$	$4,7\cdot10^{11}$	$2,3\cdot10^{12}$	$5,8\cdot10^{13}$	$6,1\cdot10^{14}$
Cd-113m	$2,4\cdot10^{7}$	$1,9\cdot10^{8}$	$7,9\cdot10^{8}$	$6,8\cdot10^{9}$	$4,7\cdot10^{8}$	$2,3\cdot10^{9}$	$1,3\cdot10^{8}$	$6,4\cdot10^{8}$	$1,7\cdot10^{10}$	$1,8\cdot10^{11}$
Cl-36	$2,4\cdot10^{6}$	$1,9\cdot10^{7}$	$6,7\cdot10^{7}$	$5,8\cdot10^{8}$	$8,8\cdot10^{7}$	$4,3\cdot10^{8}$	$1,1\cdot10^{7}$	$5,1\cdot10^{7}$	$1,2\cdot10^{9}$	$1,3\cdot10^{10}$
Cs-134	$9,1\cdot10^{7}$	$7,2\cdot10^{8}$	$7,9\cdot10^{9}$	$6,9\cdot10^{10}$	$9,9\cdot10^{5}$	$4,8\cdot10^{6}$	$1,5\cdot10^{9}$	$7,2\cdot10^{9}$	$2,1\cdot10^{11}$	$2,2\cdot10^{12}$
Cs-135	$1,2\cdot10^{6}$	$9,5\cdot10^{6}$	$3,3\cdot10^{7}$	$2,9\cdot10^{8}$	$4,4\cdot10^{7}$	$2,1\cdot10^{8}$	$5,3\cdot10^{6}$	$2,5\cdot10^{7}$	$6,0\cdot10^{8}$	$6,3\cdot10^{9}$
Eu-152	$2,6\cdot10^{6}$	$2,1\cdot10^{7}$	$8,7\cdot10^{7}$	$7,5\cdot10^{8}$	$4,9\cdot10^{7}$	$2,4\cdot10^{8}$	$1,5\cdot10^{7}$	$7,1\cdot10^{7}$	$1,9\cdot10^{9}$	$2,0\cdot10^{10}$
Eu-154	$1,6\cdot10^{9}$	$1,2\cdot10^{10}$	$5,9\cdot10^{10}$	$5,1\cdot10^{11}$	$1,7\cdot10^{10}$	$8,0\cdot10^{10}$	$1,0\cdot10^{10}$	$5,0\cdot10^{10}$	$1,4\cdot10^{12}$	$1,5\cdot10^{13}$
Eu-155	$2,3\cdot10^{8}$	$1,8\cdot10^{9}$	$1,1\cdot10^{10}$	$9,7\cdot10^{10}$	$4,9\cdot10^{8}$	$2,4\cdot10^{9}$	$2,1\cdot10^{9}$	$1,0\cdot10^{10}$	$2,9\cdot10^{11}$	$3,1\cdot10^{12}$
I-129	$7,2\cdot10^{4}$	$5,7\cdot10^{5}$	$2,0\cdot10^{6}$	$1,7\cdot10^{7}$	$2,7\cdot10^{6}$	$1,3\cdot10^{7}$	$3,2\cdot10^{5}$	$1,5\cdot10^{6}$	$3,6\cdot10^{7}$	$3,8\cdot10^{8}$
Pd-107	$2,4\cdot10^{5}$	$1,9\cdot10^{6}$	$6,7\cdot10^{6}$	$5,8\cdot10^{7}$	$8,8\cdot10^{6}$	$4,3\cdot10^{7}$	$1,1\cdot10^{6}$	$5,1\cdot10^{6}$	$1,2\cdot10^{8}$	$1,3\cdot10^{9}$
Pm-147	$3,0\cdot10^{8}$	$2,3\cdot10^{9}$	$2,1\cdot10^{10}$	$1,8\cdot10^{11}$	$2,3\cdot10^{7}$	$1,1\cdot10^{8}$	$3,9\cdot10^{9}$	$1,9\cdot10^{10}$	$5,5\cdot10^{11}$	$5,8\cdot10^{12}$
Ru-106	$1,5\cdot10^{3}$	$1,2\cdot10^{4}$	$3,7\cdot10^{5}$	$3,2\cdot10^{6}$	$7,1\cdot10^{-3}$	$3,4\cdot10^{-2}$	$7,0\cdot10^{4}$	$3,4\cdot10^{5}$	$1,0\cdot10^{7}$	$1,1\cdot10^{8}$
Se-79	$9,6\cdot10^{5}$	$7,6\cdot10^{6}$	$2,7\cdot10^{7}$	$2,3\cdot10^{8}$	$3,5\cdot10^{7}$	$1,7\cdot10^{8}$	$4,2\cdot10^{6}$	$2,0\cdot10^{7}$	$4,8\cdot10^{8}$	$5,1\cdot10^{9}$
Sm-151	$5,3\cdot10^{8}$	$4,2\cdot10^{9}$	$1,5\cdot10^{10}$	$1,3\cdot10^{11}$	$1,8\cdot10^{10}$	$8,7\cdot10^{10}$	$2,4\cdot10^{9}$	$1,2\cdot10^{10}$	$2,8\cdot10^{11}$	$2,9\cdot10^{12}$
Sn-126	$1,2\cdot10^{5}$	$9,5\cdot10^{5}$	$3,3\cdot10^{6}$	$2,9\cdot10^{7}$	$4,4\cdot10^{6}$	$2,1\cdot10^{7}$	$5,3\cdot10^{5}$	$2,5\cdot10^{6}$	$6,0\cdot10^{7}$	$6,3\cdot10^{8}$
Sr-90	$9,5\cdot10^{9}$	$7,5\cdot10^{10}$	$2,8\cdot10^{11}$	$2,5\cdot10^{12}$	$2,7\cdot10^{11}$	$1,3\cdot10^{12}$	$4,6\cdot10^{10}$	$2,2\cdot10^{11}$	$5,6\cdot10^{12}$	$5,9\cdot10^{13}$
Tc-99	$1,2\cdot10^{9}$	$9,5\cdot10^{9}$	$3,3\cdot10^{10}$	$2,9\cdot10^{11}$	$4,4\cdot10^{10}$	$2,1\cdot10^{11}$	$5,3\cdot10^{9}$	$2,5\cdot10^{10}$	$6,0\cdot10^{11}$	$6,3\cdot10^{12}$

Table 3-4. Realistic and conservative radionuclide inventory for Oskarshamn NPP, waste type level. (cont.)

Nuclide	**O.12**		**O.07**		**O.01**		**O.23**		**O.02**	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Pu-236 + Pu-240										
Pu-239	$9{,}0\cdot10^{5}$	$7{,}1\cdot10^{6}$	$1{,}2\cdot10^{8}$	$1{,}0\cdot10^{9}$	$9{,}3\cdot10^{7}$	$4{,}5\cdot10^{8}$	$1{,}5\cdot10^{7}$	$7{,}2\cdot10^{7}$	$5{,}4\cdot10^{6}$	$5{,}7\cdot10^{7}$
Pu-240	$1{,}8\cdot10^{6}$	$1{,}4\cdot10^{7}$	$2{,}4\cdot10^{8}$	$2{,}1\cdot10^{9}$	$1{,}9\cdot10^{8}$	$9{,}0\cdot10^{8}$	$3{,}0\cdot10^{7}$	$1{,}4\cdot10^{8}$	$1{,}1\cdot10^{7}$	$1{,}1\cdot10^{8}$
Pb-210	$2{,}7\cdot10^{-5}$	$2{,}1\cdot10^{-4}$	$3{,}3\cdot10^{-3}$	$2{,}8\cdot10^{-2}$	$2{,}2\cdot10^{-3}$	$1{,}0\cdot10^{-2}$	$4{,}1\cdot10^{-4}$	$2{,}0\cdot10^{-3}$	$1{,}4\cdot10^{-4}$	$1{,}4\cdot10^{-3}$
Ra-226	$5{,}4\cdot10^{-4}$	$4{,}2\cdot10^{-3}$	$7{,}1\cdot10^{-2}$	$6{,}1\cdot10^{-1}$	$5{,}5\cdot10^{-2}$	$2{,}7\cdot10^{-1}$	$8{,}8\cdot10^{-3}$	$4{,}3\cdot10^{-2}$	$3{,}2\cdot10^{-3}$	$3{,}4\cdot10^{-2}$
Ac-227	$5{,}4\cdot10^{-3}$	$4{,}2\cdot10^{-2}$	$6{,}4\cdot10^{-1}$	$5{,}6\cdot10^{0}$	$4{,}2\cdot10^{-1}$	$2{,}0\cdot10^{0}$	$8{,}0\cdot10^{-2}$	$3{,}8\cdot10^{-1}$	$2{,}7\cdot10^{-2}$	$2{,}8\cdot10^{-1}$
Th-229	$8{,}1\cdot10^{-4}$	$6{,}4\cdot10^{-3}$	$1{,}1\cdot10^{-1}$	$9{,}3\cdot10^{-1}$	$8{,}4\cdot10^{-2}$	$4{,}0\cdot10^{-1}$	$1{,}3\cdot10^{-2}$	$6{,}5\cdot10^{-2}$	$4{,}8\cdot10^{-3}$	$5{,}1\cdot10^{-2}$
Th-230	$2{,}4\cdot10^{-1}$	$1{,}9\cdot10^{0}$	$3{,}2\cdot10^{1}$	$2{,}8\cdot10^{2}$	$2{,}5\cdot10^{1}$	$1{,}2\cdot10^{2}$	$4{,}0\cdot10^{0}$	$1{,}9\cdot10^{1}$	$1{,}5\cdot10^{0}$	$1{,}5\cdot10^{1}$
Th-232	$2{,}7\cdot10^{-7}$	$2{,}1\cdot10^{-6}$	$3{,}6\cdot10^{-5}$	$3{,}1\cdot10^{-4}$	$2{,}8\cdot10^{-5}$	$1{,}4\cdot10^{-4}$	$4{,}5\cdot10^{-6}$	$2{,}2\cdot10^{-5}$	$1{,}6\cdot10^{-6}$	$1{,}7\cdot10^{-5}$
Pa-231	$8{,}1\cdot10^{-2}$	$6{,}4\cdot10^{-1}$	$1{,}1\cdot10^{1}$	$9{,}3\cdot10^{1}$	$8{,}4\cdot10^{0}$	$4{,}1\cdot10^{1}$	$1{,}3\cdot10^{0}$	$6{,}5\cdot10^{0}$	$4{,}9\cdot10^{-1}$	$5{,}1\cdot10^{0}$
U-232	$6{,}5\cdot10^{1}$	$5{,}1\cdot10^{2}$	$8{,}3\cdot10^{3}$	$7{,}2\cdot10^{4}$	$6{,}2\cdot10^{3}$	$3{,}0\cdot10^{4}$	$1{,}0\cdot10^{3}$	$5{,}0\cdot10^{3}$	$3{,}7\cdot10^{2}$	$3{,}9\cdot10^{3}$
U-233	$5{,}4\cdot10^{-2}$	$4{,}3\cdot10^{-1}$	$7{,}1\cdot10^{0}$	$6{,}2\cdot10^{1}$	$5{,}6\cdot10^{0}$	$2{,}7\cdot10^{1}$	$8{,}9\cdot10^{-1}$	$4{,}3\cdot10^{0}$	$3{,}2\cdot10^{-1}$	$3{,}4\cdot10^{0}$
U-234	$2{,}7\cdot10^{3}$	$2{,}1\cdot10^{4}$	$3{,}6\cdot10^{5}$	$3{,}1\cdot10^{6}$	$2{,}8\cdot10^{5}$	$1{,}4\cdot10^{6}$	$4{,}5\cdot10^{4}$	$2{,}2\cdot10^{5}$	$1{,}6\cdot10^{4}$	$1{,}7\cdot10^{5}$
U-235	$5{,}4\cdot10^{1}$	$4{,}3\cdot10^{2}$	$7{,}1\cdot10^{3}$	$6{,}2\cdot10^{4}$	$5{,}6\cdot10^{3}$	$2{,}7\cdot10^{4}$	$8{,}9\cdot10^{2}$	$4{,}3\cdot10^{3}$	$3{,}2\cdot10^{2}$	$3{,}4\cdot10^{3}$
U-236	$8{,}1\cdot10^{2}$	$6{,}4\cdot10^{3}$	$1{,}1\cdot10^{5}$	$9{,}3\cdot10^{5}$	$8{,}4\cdot10^{4}$	$4{,}1\cdot10^{5}$	$1{,}3\cdot10^{4}$	$6{,}5\cdot10^{4}$	$4{,}9\cdot10^{3}$	$5{,}1\cdot10^{4}$
U-238	$1{,}1\cdot10^{3}$	$8{,}5\cdot10^{3}$	$1{,}4\cdot10^{5}$	$1{,}2\cdot10^{6}$	$1{,}1\cdot10^{5}$	$5{,}4\cdot10^{5}$	$1{,}8\cdot10^{4}$	$8{,}6\cdot10^{4}$	$6{,}5\cdot10^{3}$	$6{,}8\cdot10^{4}$
Np-237	$1{,}1\cdot10^{3}$	$8{,}5\cdot10^{3}$	$1{,}4\cdot10^{5}$	$1{,}2\cdot10^{6}$	$1{,}1\cdot10^{5}$	$5{,}4\cdot10^{5}$	$1{,}8\cdot10^{4}$	$8{,}6\cdot10^{4}$	$6{,}5\cdot10^{3}$	$6{,}8\cdot10^{4}$
Pu-238	$9{,}1\cdot10^{6}$	$7{,}2\cdot10^{7}$	$1{,}2\cdot10^{9}$	$1{,}0\cdot10^{10}$	$8{,}8\cdot10^{8}$	$4{,}3\cdot10^{9}$	$1{,}5\cdot10^{8}$	$7{,}0\cdot10^{8}$	$5{,}2\cdot10^{7}$	$5{,}5\cdot10^{8}$
Pu-241	$9{,}4\cdot10^{7}$	$7{,}4\cdot10^{8}$	$1{,}1\cdot10^{10}$	$9{,}4\cdot10^{10}$	$6{,}4\cdot10^{9}$	$3{,}1\cdot10^{10}$	$1{,}3\cdot10^{9}$	$6{,}4\cdot10^{9}$	$4{,}3\cdot10^{8}$	$4{,}5\cdot10^{9}$
Pu-242	$8{,}1\cdot10^{3}$	$6{,}4\cdot10^{4}$	$1{,}1\cdot10^{6}$	$9{,}3\cdot10^{6}$	$8{,}4\cdot10^{5}$	$4{,}1\cdot10^{6}$	$1{,}3\cdot10^{5}$	$6{,}5\cdot10^{5}$	$4{,}9\cdot10^{4}$	$5{,}1\cdot10^{5}$
Am-241	$2{,}6\cdot10^{6}$	$2{,}1\cdot10^{7}$	$3{,}4\cdot10^{8}$	$3{,}0\cdot10^{9}$	$2{,}7\cdot10^{8}$	$1{,}3\cdot10^{9}$	$4{,}3\cdot10^{7}$	$2{,}1\cdot10^{8}$	$1{,}5\cdot10^{7}$	$1{,}6\cdot10^{8}$
Am-242m	$2{,}4\cdot10^{4}$	$1{,}9\cdot10^{5}$	$3{,}1\cdot10^{6}$	$2{,}7\cdot10^{7}$	$2{,}4\cdot10^{6}$	$1{,}2\cdot10^{7}$	$3{,}9\cdot10^{5}$	$1{,}9\cdot10^{6}$	$1{,}4\cdot10^{5}$	$1{,}5\cdot10^{6}$
Am-243	$8{,}1\cdot10^{4}$	$6{,}4\cdot10^{5}$	$1{,}1\cdot10^{7}$	$9{,}3\cdot10^{7}$	$8{,}4\cdot10^{6}$	$4{,}0\cdot10^{7}$	$1{,}3\cdot10^{6}$	$6{,}5\cdot10^{6}$	$4{,}8\cdot10^{5}$	$5{,}1\cdot10^{6}$
Cm-243	$3{,}2\cdot10^{4}$	$2{,}5\cdot10^{5}$	$3{,}9\cdot10^{6}$	$3{,}4\cdot10^{7}$	$2{,}7\cdot10^{6}$	$1{,}3\cdot10^{7}$	$4{,}9\cdot10^{5}$	$2{,}3\cdot10^{6}$	$1{,}7\cdot10^{5}$	$1{,}8\cdot10^{6}$
Cm-244	$3{,}5\cdot10^{6}$	$2{,}8\cdot10^{7}$	$4{,}1\cdot10^{8}$	$3{,}6\cdot10^{9}$	$2{,}6\cdot10^{8}$	$1{,}3\cdot10^{9}$	$5{,}1\cdot10^{7}$	$2{,}5\cdot10^{8}$	$1{,}7\cdot10^{7}$	$1{,}8\cdot10^{8}$
Cm-245	$8{,}1\cdot10^{2}$	$6{,}4\cdot10^{3}$	$1{,}1\cdot10^{5}$	$9{,}3\cdot10^{5}$	$8{,}4\cdot10^{4}$	$4{,}0\cdot10^{5}$	$1{,}3\cdot10^{4}$	$6{,}5\cdot10^{4}$	$4{,}8\cdot10^{3}$	$5{,}1\cdot10^{4}$
Cm-246	$2{,}2\cdot10^{2}$	$1{,}7\cdot10^{3}$	$2{,}8\cdot10^{4}$	$2{,}5\cdot10^{5}$	$2{,}2\cdot10^{4}$	$1{,}1\cdot10^{5}$	$3{,}6\cdot10^{3}$	$1{,}7\cdot10^{4}$	$1{,}3\cdot10^{3}$	$1{,}4\cdot10^{4}$
Pu-244	$1{,}9\cdot10^{-3}$	$1{,}5\cdot10^{-2}$	$2{,}5\cdot10^{-1}$	$2{,}2\cdot10^{0}$	$2{,}0\cdot10^{-1}$	$9{,}5\cdot10^{-1}$	$3{,}1\cdot10^{-2}$	$1{,}5\cdot10^{-1}$	$1{,}1\cdot10^{-2}$	$1{,}2\cdot10^{-1}$

Table 3-5. Realistic and conservative radionuclide inventory for Ringhals NPP, waste type level.

Nuclide	R.12		R.01		R.10		R.15		R.23		R.02		R.16	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Co-60														
Co-60	$6,2\cdot10^{10}$	$4,9\cdot10^{11}$	$7,0\cdot10^{11}$	$3,4\cdot10^{12}$	$2,3\cdot10^{11}$	$1,1\cdot10^{12}$	$1,5\cdot10^{12}$	$7,3\cdot10^{12}$	$1,1\cdot10^{12}$	$5,5\cdot10^{12}$	$6,8\cdot10^{11}$	$7,1\cdot10^{12}$	$3,7\cdot10^{13}$	$3,9\cdot10^{14}$
Ag-108m	$7,7\cdot10^{7}$	$6,0\cdot10^{8}$	$7,8\cdot10^{9}$	$3,8\cdot10^{10}$	$2,6\cdot10^{8}$	$1,2\cdot10^{9}$	$1,5\cdot10^{9}$	$7,2\cdot10^{9}$	$1,2\cdot10^{9}$	$6,0\cdot10^{9}$	$1,9\cdot10^{9}$	$2,0\cdot10^{10}$	$3,1\cdot10^{10}$	$3,3\cdot10^{11}$
Ba-133	$2,4\cdot10^{6}$	$1,9\cdot10^{7}$	$8,0\cdot10^{7}$	$3,9\cdot10^{8}$	$8,0\cdot10^{6}$	$3,9\cdot10^{7}$	$5,1\cdot10^{7}$	$2,5\cdot10^{8}$	$3,9\cdot10^{7}$	$1,9\cdot10^{8}$	$3,1\cdot10^{7}$	$3,3\cdot10^{8}$	$1,2\cdot10^{9}$	$1,3\cdot10^{10}$
Be-10	$8,0\cdot10^{2}$	$6,3\cdot10^{3}$	$8,4\cdot10^{4}$	$4,1\cdot10^{5}$	$2,7\cdot10^{3}$	$1,3\cdot10^{4}$	$1,6\cdot10^{4}$	$7,5\cdot10^{4}$	$1,3\cdot10^{4}$	$6,3\cdot10^{4}$	$2,0\cdot10^{4}$	$2,1\cdot10^{5}$	$3,2\cdot10^{5}$	$3,4\cdot10^{6}$
C-14	$1,3\cdot10^{9}$	$1,1\cdot10^{10}$	$1,4\cdot10^{11}$	$6,8\cdot10^{11}$	$4,5\cdot10^{9}$	$2,2\cdot10^{10}$	$2,6\cdot10^{10}$	$1,3\cdot10^{11}$	$2,2\cdot10^{10}$	$1,1\cdot10^{11}$	$3,3\cdot10^{10}$	$3,5\cdot10^{11}$	$5,4\cdot10^{11}$	$5,7\cdot10^{12}$
Fe-55	$6,6\cdot10^{9}$	$5,2\cdot10^{10}$	$5,6\cdot10^{10}$	$2,7\cdot10^{11}$	$3,9\cdot10^{10}$	$1,9\cdot10^{11}$	$2,5\cdot10^{11}$	$1,2\cdot10^{12}$	$1,8\cdot10^{11}$	$8,9\cdot10^{11}$	$1,0\cdot10^{11}$	$1,1\cdot10^{12}$	$6,2\cdot10^{12}$	$6,5\cdot10^{13}$
H-3	$3,1\cdot10^{7}$	$2,4\cdot10^{8}$	$1,2\cdot10^{9}$	$5,8\cdot10^{9}$	$1,0\cdot10^{8}$	$4,8\cdot10^{8}$	$6,3\cdot10^{8}$	$3,0\cdot10^{9}$	$4,9\cdot10^{8}$	$2,4\cdot10^{9}$	$4,2\cdot10^{8}$	$4,4\cdot10^{9}$	$1,5\cdot10^{10}$	$1,6\cdot10^{11}$
Ho-166m	$5,3\cdot10^{6}$	$4,2\cdot10^{7}$	$5,5\cdot10^{8}$	$2,6\cdot10^{9}$	$1,8\cdot10^{7}$	$8,5\cdot10^{7}$	$1,0\cdot10^{8}$	$4,9\cdot10^{8}$	$8,6\cdot10^{7}$	$4,1\cdot10^{8}$	$1,3\cdot10^{8}$	$1,4\cdot10^{9}$	$2,1\cdot10^{9}$	$2,2\cdot10^{10}$
Mo-93	$6,7\cdot10^{6}$	$5,3\cdot10^{7}$	$7,0\cdot10^{8}$	$3,4\cdot10^{9}$	$2,2\cdot10^{7}$	$1,1\cdot10^{8}$	$1,3\cdot10^{8}$	$6,2\cdot10^{8}$	$1,1\cdot10^{8}$	$5,3\cdot10^{8}$	$1,6\cdot10^{8}$	$1,7\cdot10^{9}$	$2,7\cdot10^{9}$	$2,8\cdot10^{10}$
Nb-93m	$4,2\cdot10^{8}$	$3,3\cdot10^{9}$	$2,1\cdot10^{10}$	$1,0\cdot10^{11}$	$1,4\cdot10^{9}$	$6,6\cdot10^{9}$	$8,5\cdot10^{9}$	$4,1\cdot10^{10}$	$6,7\cdot10^{9}$	$3,2\cdot10^{10}$	$6,4\cdot10^{9}$	$6,8\cdot10^{10}$	$2,0\cdot10^{11}$	$2,1\cdot10^{12}$
Nb-94	$1,3\cdot10^{7}$	$1,1\cdot10^{8}$	$1,4\cdot10^{9}$	$6,8\cdot10^{9}$	$4,5\cdot10^{7}$	$2,2\cdot10^{8}$	$2,6\cdot10^{8}$	$1,3\cdot10^{9}$	$2,2\cdot10^{8}$	$1,1\cdot10^{9}$	$3,3\cdot10^{8}$	$3,5\cdot10^{9}$	$5,4\cdot10^{9}$	$5,7\cdot10^{10}$
Ni-59	$1,3\cdot10^{9}$	$1,1\cdot10^{10}$	$1,4\cdot10^{11}$	$6,8\cdot10^{11}$	$4,5\cdot10^{9}$	$2,2\cdot10^{10}$	$2,6\cdot10^{10}$	$1,3\cdot10^{11}$	$2,2\cdot10^{10}$	$1,1\cdot10^{11}$	$3,3\cdot10^{10}$	$3,5\cdot10^{11}$	$5,4\cdot10^{11}$	$5,7\cdot10^{12}$
Ni-63	$2,2\cdot10^{11}$	$1,7\cdot10^{12}$	$2,1\cdot10^{13}$	$1,0\cdot10^{14}$	$7,3\cdot10^{11}$	$3,5\cdot10^{12}$	$4,3\cdot10^{12}$	$2,1\cdot10^{13}$	$3,6\cdot10^{12}$	$1,7\cdot10^{13}$	$5,0\cdot10^{12}$	$5,3\cdot10^{13}$	$9,1\cdot10^{13}$	$9,6\cdot10^{14}$
Sb-125	$6,9\cdot10^{8}$	$5,4\cdot10^{9}$	$5,8\cdot10^{9}$	$2,8\cdot10^{10}$	$4,0\cdot10^{9}$	$1,9\cdot10^{10}$	$2,6\cdot10^{10}$	$1,3\cdot10^{11}$	$1,9\cdot10^{10}$	$9,2\cdot10^{10}$	$1,1\cdot10^{10}$	$1,1\cdot10^{11}$	$6,4\cdot10^{11}$	$6,7\cdot10^{12}$
Zr-93	$1,3\cdot10^{6}$	$1,1\cdot10^{7}$	$1,4\cdot10^{8}$	$6,8\cdot10^{8}$	$4,5\cdot10^{6}$	$2,2\cdot10^{7}$	$2,6\cdot10^{7}$	$1,3\cdot10^{8}$	$2,2\cdot10^{7}$	$1,1\cdot10^{8}$	$3,3\cdot10^{7}$	$3,5\cdot10^{8}$	$5,4\cdot10^{8}$	$5,7\cdot10^{9}$

Table 3-5. Realistic and conservative radionuclide inventory for Ringhals NPP, waste type level. (cont.)

Nuclide	R.12		R.01		R.10		R.15		R.23		R.02		R.16	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Cs-137														
Cs-137	$2,6\cdot10^{11}$	$2,0\cdot10^{12}$	$8,2\cdot10^{12}$	$4,0\cdot10^{13}$	$1,9\cdot10^{10}$	$9,3\cdot10^{10}$	$2,3\cdot10^{12}$	$1,1\cdot10^{13}$	$2,6\cdot10^{11}$	$1,3\cdot10^{12}$	$7,8\cdot10^{12}$	$8,3\cdot10^{13}$	$4,7\cdot10^{13}$	$5,0\cdot10^{14}$
Cd-113m	$7,9\cdot10^{7}$	$6,2\cdot10^{8}$	$1,5\cdot10^{9}$	$7,4\cdot10^{9}$	$5,9\cdot10^{6}$	$2,8\cdot10^{7}$	$7,3\cdot10^{8}$	$3,5\cdot10^{9}$	$8,0\cdot10^{7}$	$3,9\cdot10^{8}$	$1,8\cdot10^{9}$	$1,9\cdot10^{10}$	$1,6\cdot10^{10}$	$1,7\cdot10^{11}$
Cl-36	$5,0\cdot10^{6}$	$3,9\cdot10^{7}$	$2,3\cdot10^{8}$	$1,1\cdot10^{9}$	$3,8\cdot10^{5}$	$1,8\cdot10^{6}$	$4,3\cdot10^{7}$	$2,1\cdot10^{8}$	$5,1\cdot10^{6}$	$2,4\cdot10^{7}$	$2,1\cdot10^{8}$	$2,2\cdot10^{9}$	$8,3\cdot10^{8}$	$8,7\cdot10^{9}$
Cs-134	$6,1\cdot10^{8}$	$4,8\cdot10^{9}$	$3,1\cdot10^{9}$	$1,5\cdot10^{10}$	$1,1\cdot10^{8}$	$5,5\cdot10^{8}$	$1,4\cdot10^{10}$	$6,9\cdot10^{10}$	$1,5\cdot10^{9}$	$7,1\cdot10^{9}$	$2,2\cdot10^{10}$	$2,4\cdot10^{11}$	$3,3\cdot10^{11}$	$3,5\cdot10^{12}$
Cs-135	$2,5\cdot10^{6}$	$2,0\cdot10^{7}$	$1,2\cdot10^{8}$	$5,6\cdot10^{8}$	$1,9\cdot10^{5}$	$9,2\cdot10^{5}$	$2,2\cdot10^{7}$	$1,0\cdot10^{8}$	$2,5\cdot10^{6}$	$1,2\cdot10^{7}$	$1,0\cdot10^{8}$	$1,1\cdot10^{9}$	$4,1\cdot10^{8}$	$4,4\cdot10^{9}$
Eu-152	$8,8\cdot10^{6}$	$6,9\cdot10^{7}$	$1,6\cdot10^{8}$	$7,9\cdot10^{8}$	$6,5\cdot10^{5}$	$3,1\cdot10^{6}$	$8,2\cdot10^{7}$	$3,9\cdot10^{8}$	$8,9\cdot10^{6}$	$4,3\cdot10^{7}$	$2,0\cdot10^{8}$	$2,1\cdot10^{9}$	$1,8\cdot10^{9}$	$1,9\cdot10^{10}$
Eu-154	$6,4\cdot10^{9}$	$5,1\cdot10^{10}$	$6,8\cdot10^{10}$	$3,3\cdot10^{11}$	$4,9\cdot10^{8}$	$2,4\cdot10^{9}$	$6,3\cdot10^{10}$	$3,0\cdot10^{11}$	$6,7\cdot10^{9}$	$3,2\cdot10^{10}$	$1,2\cdot10^{11}$	$1,3\cdot10^{12}$	$1,4\cdot10^{12}$	$1,5\cdot10^{13}$
Eu-155	$1,2\cdot10^{9}$	$9,5\cdot10^{9}$	$5,0\cdot10^{9}$	$2,4\cdot10^{10}$	$1,1\cdot10^{8}$	$5,3\cdot10^{8}$	$1,4\cdot10^{10}$	$6,7\cdot10^{10}$	$1,4\cdot10^{9}$	$7,0\cdot10^{9}$	$2,2\cdot10^{10}$	$2,3\cdot10^{11}$	$3,2\cdot10^{11}$	$3,4\cdot10^{12}$
I-129	$1,5\cdot10^{5}$	$1,2\cdot10^{6}$	$7,0\cdot10^{6}$	$3,4\cdot10^{7}$	$1,1\cdot10^{4}$	$5,5\cdot10^{4}$	$1,3\cdot10^{6}$	$6,2\cdot10^{6}$	$1,5\cdot10^{5}$	$7,3\cdot10^{5}$	$6,2\cdot10^{6}$	$6,5\cdot10^{7}$	$2,5\cdot10^{7}$	$2,6\cdot10^{8}$
Pd-107	$5,0\cdot10^{5}$	$3,9\cdot10^{6}$	$2,3\cdot10^{7}$	$1,1\cdot10^{8}$	$3,8\cdot10^{4}$	$1,8\cdot10^{5}$	$4,3\cdot10^{6}$	$2,1\cdot10^{7}$	$5,1\cdot10^{5}$	$2,4\cdot10^{6}$	$2,1\cdot10^{7}$	$2,2\cdot10^{8}$	$8,3\cdot10^{7}$	$8,7\cdot10^{8}$
Pm-147	$1,8\cdot10^{9}$	$1,4\cdot10^{10}$	$7,2\cdot10^{9}$	$3,5\cdot10^{10}$	$2,6\cdot10^{8}$	$1,2\cdot10^{9}$	$3,2\cdot10^{10}$	$1,6\cdot10^{11}$	$3,3\cdot10^{9}$	$1,6\cdot10^{10}$	$5,1\cdot10^{10}$	$5,4\cdot10^{11}$	$7,4\cdot10^{11}$	$7,8\cdot10^{12}$
Ru-106	$1,4\cdot10^{4}$	$1,1\cdot10^{5}$	$2,9\cdot10^{5}$	$1,4\cdot10^{6}$	$1,1\cdot10^{4}$	$5,1\cdot10^{4}$	$1,3\cdot10^{6}$	$6,5\cdot10^{6}$	$1,4\cdot10^{5}$	$6,7\cdot10^{5}$	$2,1\cdot10^{6}$	$2,2\cdot10^{7}$	$3,1\cdot10^{7}$	$3,2\cdot10^{8}$
Se-79	$2,0\cdot10^{6}$	$1,6\cdot10^{7}$	$9,3\cdot10^{7}$	$4,5\cdot10^{8}$	$1,5\cdot10^{5}$	$7,4\cdot10^{5}$	$1,7\cdot10^{7}$	$8,3\cdot10^{7}$	$2,0\cdot10^{6}$	$9,8\cdot10^{6}$	$8,2\cdot10^{7}$	$8,7\cdot10^{8}$	$3,3\cdot10^{8}$	$3,5\cdot10^{9}$
Sm-151	$1,2\cdot10^{9}$	$9,3\cdot10^{9}$	$4,9\cdot10^{10}$	$2,4\cdot10^{11}$	$9,0\cdot10^{7}$	$4,3\cdot10^{8}$	$1,0\cdot10^{10}$	$5,0\cdot10^{10}$	$1,2\cdot10^{9}$	$5,8\cdot10^{9}$	$4,4\cdot10^{10}$	$4,7\cdot10^{11}$	$2,1\cdot10^{11}$	$2,2\cdot10^{12}$
Sn-126	$2,5\cdot10^{5}$	$2,0\cdot10^{6}$	$1,2\cdot10^{7}$	$5,6\cdot10^{7}$	$1,9\cdot10^{4}$	$9,2\cdot10^{4}$	$2,2\cdot10^{6}$	$1,0\cdot10^{7}$	$2,5\cdot10^{5}$	$1,2\cdot10^{6}$	$1,0\cdot10^{7}$	$1,1\cdot10^{8}$	$4,1\cdot10^{7}$	$4,4\cdot10^{8}$
Sr-90	$2,5\cdot10^{10}$	$2,0\cdot10^{11}$	$7,8\cdot10^{11}$	$3,8\cdot10^{12}$	$1,9\cdot10^{9}$	$9,0\cdot10^{9}$	$2,2\cdot10^{11}$	$1,1\cdot10^{12}$	$2,5\cdot10^{10}$	$1,2\cdot10^{11}$	$7,5\cdot10^{11}$	$7,9\cdot10^{12}$	$4,6\cdot10^{12}$	$4,9\cdot10^{13}$
Tc-99	$2,5\cdot10^{9}$	$2,0\cdot10^{10}$	$1,2\cdot10^{11}$	$5,6\cdot10^{11}$	$1,9\cdot10^{8}$	$9,2\cdot10^{8}$	$2,2\cdot10^{10}$	$1,0\cdot10^{11}$	$2,5\cdot10^{9}$	$1,2\cdot10^{10}$	$1,0\cdot10^{11}$	$1,1\cdot10^{12}$	$4,1\cdot10^{11}$	$4,4\cdot10^{12}$

Table 3-5. Realistic and conservative radionuclide inventory for Ringhals NPP, waste type level. (cont.)

Nuclide	R.12		R.01		R.10		R.15		R.23		R.02		R.16	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Pu-236 + Pu-240														
Pu-239	$8,2\cdot10^{7}$	$6,5\cdot10^{8}$	$5,8\cdot10^{8}$	$2,8\cdot10^{9}$	$1,3\cdot10^{8}$	$6,2\cdot10^{8}$	$8,3\cdot10^{8}$	$4,0\cdot10^{9}$	$1,0\cdot10^{9}$	$5,1\cdot10^{9}$	$4,1\cdot10^{8}$	$4,4\cdot10^{9}$	$2,0\cdot10^{10}$	$2,1\cdot10^{11}$
Pu-240	$1,6\cdot10^{8}$	$1,3\cdot10^{9}$	$1,2\cdot10^{9}$	$5,6\cdot10^{9}$	$2,6\cdot10^{8}$	$1,2\cdot10^{9}$	$1,7\cdot10^{9}$	$8,0\cdot10^{9}$	$2,1\cdot10^{9}$	$1,0\cdot10^{10}$	$8,2\cdot10^{8}$	$8,7\cdot10^{9}$	$4,0\cdot10^{10}$	$4,2\cdot10^{11}$
Pb-210	$2,5\cdot10^{-3}$	$2,0\cdot10^{-2}$	$1,5\cdot10^{-2}$	$7,3\cdot10^{-2}$	$4,2\cdot10^{-3}$	$2,0\cdot10^{-2}$	$2,7\cdot10^{-2}$	$1,3\cdot10^{-1}$	$3,4\cdot10^{-2}$	$1,6\cdot10^{-1}$	$1,3\cdot10^{-2}$	$1,3\cdot10^{-1}$	$6,5\cdot10^{-1}$	$6,9\cdot10^{0}$
Ra-226	$4,9\cdot10^{-2}$	$3,9\cdot10^{-1}$	$3,5\cdot10^{-1}$	$1,7\cdot10^{0}$	$7,6\cdot10^{-2}$	$3,7\cdot10^{-1}$	$4,9\cdot10^{-1}$	$2,4\cdot10^{0}$	$6,2\cdot10^{-1}$	$3,0\cdot10^{0}$	$2,4\cdot10^{-1}$	$2,6\cdot10^{0}$	$1,2\cdot10^{1}$	$1,3\cdot10^{2}$
Ac-227	$4,9\cdot10^{-1}$	$3,9\cdot10^{0}$	$3,0\cdot10^{0}$	$1,4\cdot10^{1}$	$8,2\cdot10^{-1}$	$4,0\cdot10^{0}$	$5,3\cdot10^{0}$	$2,6\cdot10^{1}$	$6,7\cdot10^{0}$	$3,2\cdot10^{1}$	$2,5\cdot10^{0}$	$2,7\cdot10^{1}$	$1,3\cdot10^{2}$	$1,4\cdot10^{3}$
Th-229	$7,4\cdot10^{-2}$	$5,8\cdot10^{-1}$	$5,2\cdot10^{-1}$	$2,5\cdot10^{0}$	$1,2\cdot10^{-1}$	$5,6\cdot10^{-1}$	$7,4\cdot10^{-1}$	$3,6\cdot10^{0}$	$9,4\cdot10^{-1}$	$4,5\cdot10^{0}$	$3,7\cdot10^{-1}$	$3,9\cdot10^{0}$	$1,8\cdot10^{1}$	$1,9\cdot10^{2}$
Th-230	$2,2\cdot10^{1}$	$1,8\cdot10^{2}$	$1,6\cdot10^{2}$	$7,6\cdot10^{2}$	$3,5\cdot10^{1}$	$1,7\cdot10^{2}$	$2,2\cdot10^{2}$	$1,1\cdot10^{3}$	$2,8\cdot10^{2}$	$1,4\cdot10^{3}$	$1,1\cdot10^{2}$	$1,2\cdot10^{3}$	$5,4\cdot10^{3}$	$5,7\cdot10^{4}$
Th-232	$2,5\cdot10^{-5}$	$2,0\cdot10^{-4}$	$1,7\cdot10^{-4}$	$8,4\cdot10^{-4}$	$3,9\cdot10^{-5}$	$1,9\cdot10^{-4}$	$2,5\cdot10^{-4}$	$1,2\cdot10^{-3}$	$3,1\cdot10^{-4}$	$1,5\cdot10^{-3}$	$1,2\cdot10^{-4}$	$1,3\cdot10^{-3}$	$6,0\cdot10^{-3}$	$6,3\cdot10^{-2}$
Pa-231	$7,4\cdot10^{0}$	$5,9\cdot10^{1}$	$5,2\cdot10^{1}$	$2,5\cdot10^{2}$	$1,2\cdot10^{1}$	$5,6\cdot10^{1}$	$7,4\cdot10^{1}$	$3,6\cdot10^{2}$	$9,4\cdot10^{1}$	$4,5\cdot10^{2}$	$3,7\cdot10^{1}$	$3,9\cdot10^{2}$	$1,8\cdot10^{3}$	$1,9\cdot10^{4}$
U-232	$5,9\cdot10^{3}$	$4,7\cdot10^{4}$	$4,0\cdot10^{4}$	$1,9\cdot10^{5}$	$9,4\cdot10^{3}$	$4,6\cdot10^{4}$	$6,1\cdot10^{4}$	$2,9\cdot10^{5}$	$7,7\cdot10^{4}$	$3,7\cdot10^{5}$	$3,0\cdot10^{4}$	$3,1\cdot10^{5}$	$1,5\cdot10^{6}$	$1,5\cdot10^{7}$
U-233	$5,0\cdot10^{0}$	$3,9\cdot10^{1}$	$3,5\cdot10^{1}$	$1,7\cdot10^{2}$	$7,7\cdot10^{0}$	$3,7\cdot10^{1}$	$5,0\cdot10^{1}$	$2,4\cdot10^{2}$	$6,3\cdot10^{1}$	$3,0\cdot10^{2}$	$2,5\cdot10^{1}$	$2,6\cdot10^{2}$	$1,2\cdot10^{3}$	$1,3\cdot10^{4}$
U-234	$2,5\cdot10^{5}$	$2,0\cdot10^{6}$	$1,7\cdot10^{6}$	$8,4\cdot10^{6}$	$3,9\cdot10^{5}$	$1,9\cdot10^{6}$	$2,5\cdot10^{6}$	$1,2\cdot10^{7}$	$3,1\cdot10^{6}$	$1,5\cdot10^{7}$	$1,2\cdot10^{6}$	$1,3\cdot10^{7}$	$6,0\cdot10^{7}$	$6,3\cdot10^{8}$
U-235	$5,0\cdot10^{3}$	$3,9\cdot10^{4}$	$3,5\cdot10^{4}$	$1,7\cdot10^{5}$	$7,7\cdot10^{3}$	$3,7\cdot10^{4}$	$5,0\cdot10^{4}$	$2,4\cdot10^{5}$	$6,3\cdot10^{4}$	$3,0\cdot10^{5}$	$2,5\cdot10^{4}$	$2,6\cdot10^{5}$	$1,2\cdot10^{6}$	$1,3\cdot10^{7}$
U-236	$7,4\cdot10^{4}$	$5,9\cdot10^{5}$	$5,2\cdot10^{5}$	$2,5\cdot10^{6}$	$1,2\cdot10^{5}$	$5,6\cdot10^{5}$	$7,5\cdot10^{5}$	$3,6\cdot10^{6}$	$9,4\cdot10^{5}$	$4,5\cdot10^{6}$	$3,7\cdot10^{5}$	$3,9\cdot10^{6}$	$1,8\cdot10^{7}$	$1,9\cdot10^{8}$
U-238	$9,9\cdot10^{4}$	$7,8\cdot10^{5}$	$7,0\cdot10^{5}$	$3,4\cdot10^{6}$	$1,5\cdot10^{5}$	$7,4\cdot10^{5}$	$9,9\cdot10^{5}$	$4,8\cdot10^{6}$	$1,3\cdot10^{6}$	$6,1\cdot10^{6}$	$4,9\cdot10^{5}$	$5,2\cdot10^{6}$	$2,4\cdot10^{7}$	$2,5\cdot10^{8}$
Np-237	$9,9\cdot10^{4}$	$7,8\cdot10^{5}$	$7,0\cdot10^{5}$	$3,4\cdot10^{6}$	$1,5\cdot10^{5}$	$7,4\cdot10^{5}$	$9,9\cdot10^{5}$	$4,8\cdot10^{6}$	$1,3\cdot10^{6}$	$6,1\cdot10^{6}$	$4,9\cdot10^{5}$	$5,2\cdot10^{6}$	$2,4\cdot10^{7}$	$2,5\cdot10^{8}$
Pu-238	$8,3\cdot10^{8}$	$6,6\cdot10^{9}$	$5,6\cdot10^{9}$	$2,7\cdot10^{10}$	$1,3\cdot10^{9}$	$6,3\cdot10^{9}$	$8,5\cdot10^{9}$	$4,1\cdot10^{10}$	$1,1\cdot10^{10}$	$5,2\cdot10^{10}$	$4,2\cdot10^{9}$	$4,4\cdot10^{10}$	$2,0\cdot10^{11}$	$2,2\cdot10^{12}$
Pu-241	$8,7\cdot10^{9}$	$6,9\cdot10^{10}$	$4,9\cdot10^{10}$	$2,4\cdot10^{11}$	$1,5\cdot10^{10}$	$7,2\cdot10^{10}$	$9,7\cdot10^{10}$	$4,7\cdot10^{11}$	$1,2\cdot10^{11}$	$5,9\cdot10^{11}$	$4,5\cdot10^{10}$	$4,8\cdot10^{11}$	$2,4\cdot10^{12}$	$2,5\cdot10^{13}$
Pu-242	$7,4\cdot10^{5}$	$5,9\cdot10^{6}$	$5,2\cdot10^{6}$	$2,5\cdot10^{7}$	$1,2\cdot10^{6}$	$5,6\cdot10^{6}$	$7,5\cdot10^{6}$	$3,6\cdot10^{7}$	$9,4\cdot10^{6}$	$4,5\cdot10^{7}$	$3,7\cdot10^{6}$	$3,9\cdot10^{7}$	$1,8\cdot10^{8}$	$1,9\cdot10^{9}$
Am-241	$2,4\cdot10^{8}$	$1,9\cdot10^{9}$	$1,7\cdot10^{9}$	$8,1\cdot10^{9}$	$3,7\cdot10^{8}$	$1,8\cdot10^{9}$	$2,4\cdot10^{9}$	$1,2\cdot10^{10}$	$3,0\cdot10^{9}$	$1,5\cdot10^{10}$	$1,2\cdot10^{9}$	$1,3\cdot10^{10}$	$5,8\cdot10^{10}$	$6,1\cdot10^{11}$
Am-242m	$2,2\cdot10^{6}$	$1,7\cdot10^{7}$	$1,5\cdot10^{7}$	$7,4\cdot10^{7}$	$3,5\cdot10^{6}$	$1,7\cdot10^{7}$	$2,2\cdot10^{7}$	$1,1\cdot10^{8}$	$2,8\cdot10^{7}$	$1,4\cdot10^{8}$	$1,1\cdot10^{7}$	$1,2\cdot10^{8}$	$5,4\cdot10^{8}$	$5,7\cdot10^{9}$
Am-243	$7,4\cdot10^{6}$	$5,8\cdot10^{7}$	$5,2\cdot10^{7}$	$2,5\cdot10^{8}$	$1,2\cdot10^{7}$	$5,6\cdot10^{7}$	$7,4\cdot10^{7}$	$3,6\cdot10^{8}$	$9,4\cdot10^{7}$	$4,5\cdot10^{8}$	$3,7\cdot10^{7}$	$3,9\cdot10^{8}$	$1,8\cdot10^{9}$	$1,9\cdot10^{10}$
Cm-243	$2,9\cdot10^{6}$	$2,3\cdot10^{7}$	$1,8\cdot10^{7}$	$8,9\cdot10^{7}$	$4,8\cdot10^{6}$	$2,3\cdot10^{7}$	$3,1\cdot10^{7}$	$1,5\cdot10^{8}$	$3,9\cdot10^{7}$	$1,9\cdot10^{8}$	$1,5\cdot10^{7}$	$1,6\cdot10^{8}$	$7,5\cdot10^{8}$	$7,9\cdot10^{9}$
Cm-244	$3,2\cdot10^{8}$	$2,5\cdot10^{9}$	$1,9\cdot10^{9}$	$9,1\cdot10^{9}$	$5,4\cdot10^{8}$	$2,6\cdot10^{9}$	$3,5\cdot10^{9}$	$1,7\cdot10^{10}$	$4,4\cdot10^{9}$	$2,1\cdot10^{10}$	$1,7\cdot10^{9}$	$1,7\cdot10^{10}$	$8,5\cdot10^{10}$	$9,0\cdot10^{11}$
Cm-245	$7,4\cdot10^{4}$	$5,8\cdot10^{5}$	$5,2\cdot10^{5}$	$2,5\cdot10^{6}$	$1,2\cdot10^{5}$	$5,6\cdot10^{5}$	$7,4\cdot10^{5}$	$3,6\cdot10^{6}$	$9,4\cdot10^{5}$	$4,5\cdot10^{6}$	$3,7\cdot10^{5}$	$3,9\cdot10^{6}$	$1,8\cdot10^{7}$	$1,9\cdot10^{8}$
Cm-246	$2,0\cdot10^{4}$	$1,6\cdot10^{5}$	$1,4\cdot10^{5}$	$6,7\cdot10^{5}$	$3,1\cdot10^{4}$	$1,5\cdot10^{5}$	$2,0\cdot10^{5}$	$9,6\cdot10^{5}$	$2,5\cdot10^{5}$	$1,2\cdot10^{6}$	$9,9\cdot10^{4}$	$1,0\cdot10^{6}$	$4,8\cdot10^{6}$	$5,0\cdot10^{7}$
Pu-244	$1,7\cdot10^{-1}$	$1,4\cdot10^{0}$	$1,2\cdot10^{0}$	$5,9\cdot10^{0}$	$2,7\cdot10^{-1}$	$1,3\cdot10^{0}$	$1,7\cdot10^{0}$	$8,4\cdot10^{0}$	$2,2\cdot10^{0}$	$1,1\cdot10^{1}$	$8,7\cdot10^{-1}$	$9,1\cdot10^{0}$	$4,2\cdot10^{1}$	$4,4\cdot10^{2}$

Table 3-6. Realistic and conservative radionuclide inventory for Studsvik, waste type level.

Nuclide	S.04		S.09		S.11		S.12		S.13		S.14		S.19	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Co-60														
Co-60	$4{,}9\cdot10^{8}$	$5{,}2\cdot10^{9}$	$3{,}4\cdot10^{9}$	$1{,}7\cdot10^{10}$	$6{,}6\cdot10^{9}$	$6{,}9\cdot10^{10}$	$9{,}2\cdot10^{9}$	$7{,}3\cdot10^{10}$	$1{,}0\cdot10^{10}$	$9{,}0\cdot10^{10}$	$7{,}8\cdot10^{9}$	$6{,}2\cdot10^{10}$		
Ag-108m	$3{,}8\cdot10^{5}$	$4{,}1\cdot10^{6}$	$2{,}3\cdot10^{6}$	$1{,}1\cdot10^{7}$	$4{,}7\cdot10^{7}$	$5{,}0\cdot10^{8}$	$5{,}6\cdot10^{7}$	$4{,}4\cdot10^{8}$	$1{,}9\cdot10^{7}$	$1{,}7\cdot10^{8}$	$9{,}8\cdot10^{6}$	$7{,}8\cdot10^{7}$		
Ba-133	$1{,}6\cdot10^{4}$	$1{,}7\cdot10^{5}$	$1{,}1\cdot10^{5}$	$5{,}1\cdot10^{5}$	$7{,}4\cdot10^{5}$	$7{,}8\cdot10^{6}$	$7{,}9\cdot10^{5}$	$6{,}2\cdot10^{6}$	$4{,}2\cdot10^{5}$	$3{,}7\cdot10^{6}$	$3{,}2\cdot10^{5}$	$2{,}5\cdot10^{6}$		
Be-10	$4{,}0\cdot10^{0}$	$4{,}2\cdot10^{1}$	$2{,}4\cdot10^{1}$	$1{,}2\cdot10^{2}$	$5{,}0\cdot10^{2}$	$5{,}3\cdot10^{3}$	$6{,}0\cdot10^{2}$	$4{,}7\cdot10^{3}$	$2{,}0\cdot10^{2}$	$1{,}8\cdot10^{3}$	$1{,}0\cdot10^{2}$	$8{,}1\cdot10^{2}$		
C-14	$6{,}6\cdot10^{6}$	$7{,}0\cdot10^{7}$	$4{,}0\cdot10^{7}$	$1{,}9\cdot10^{8}$	$8{,}3\cdot10^{8}$	$8{,}8\cdot10^{9}$	$9{,}9\cdot10^{8}$	$7{,}8\cdot10^{9}$	$3{,}4\cdot10^{8}$	$2{,}9\cdot10^{9}$	$1{,}7\cdot10^{8}$	$1{,}4\cdot10^{9}$	$2{,}0\cdot10^{11}$	$1{,}7\cdot10^{12}$
Fe-55	$8{,}0\cdot10^{7}$	$8{,}4\cdot10^{8}$	$5{,}8\cdot10^{8}$	$2{,}8\cdot10^{9}$	$7{,}2\cdot10^{7}$	$7{,}6\cdot10^{8}$	$4{,}7\cdot10^{8}$	$3{,}7\cdot10^{9}$	$1{,}6\cdot10^{9}$	$1{,}4\cdot10^{10}$	$8{,}2\cdot10^{8}$	$6{,}4\cdot10^{9}$		
H-3	$2{,}0\cdot10^{5}$	$2{,}1\cdot10^{6}$	$1{,}3\cdot10^{6}$	$6{,}1\cdot10^{6}$	$1{,}1\cdot10^{7}$	$1{,}1\cdot10^{8}$	$1{,}1\cdot10^{7}$	$8{,}8\cdot10^{7}$	$5{,}5\cdot10^{6}$	$4{,}7\cdot10^{7}$	$4{,}0\cdot10^{6}$	$3{,}2\cdot10^{7}$		
Ho-166m	$2{,}6\cdot10^{4}$	$2{,}8\cdot10^{5}$	$1{,}6\cdot10^{5}$	$7{,}6\cdot10^{5}$	$3{,}3\cdot10^{6}$	$3{,}5\cdot10^{7}$	$3{,}9\cdot10^{6}$	$3{,}1\cdot10^{7}$	$1{,}3\cdot10^{6}$	$1{,}2\cdot10^{7}$	$6{,}8\cdot10^{5}$	$5{,}3\cdot10^{6}$		
Mo-93	$3{,}3\cdot10^{4}$	$3{,}5\cdot10^{5}$	$2{,}0\cdot10^{5}$	$9{,}6\cdot10^{5}$	$4{,}1\cdot10^{6}$	$4{,}4\cdot10^{7}$	$4{,}9\cdot10^{6}$	$3{,}9\cdot10^{7}$	$1{,}7\cdot10^{6}$	$1{,}5\cdot10^{7}$	$8{,}6\cdot10^{5}$	$6{,}7\cdot10^{6}$		
Nb-93m	$2{,}6\cdot10^{6}$	$2{,}7\cdot10^{7}$	$1{,}6\cdot10^{7}$	$7{,}9\cdot10^{7}$	$1{,}7\cdot10^{8}$	$1{,}8\cdot10^{9}$	$1{,}8\cdot10^{8}$	$1{,}4\cdot10^{9}$	$8{,}0\cdot10^{7}$	$7{,}0\cdot10^{8}$	$5{,}5\cdot10^{7}$	$4{,}4\cdot10^{8}$		
Nb-94	$6{,}7\cdot10^{4}$	$7{,}0\cdot10^{5}$	$4{,}0\cdot10^{5}$	$1{,}9\cdot10^{6}$	$8{,}3\cdot10^{6}$	$8{,}8\cdot10^{7}$	$9{,}9\cdot10^{6}$	$7{,}8\cdot10^{7}$	$3{,}4\cdot10^{6}$	$3{,}0\cdot10^{7}$	$1{,}7\cdot10^{6}$	$1{,}4\cdot10^{7}$		
Ni-59	$6{,}7\cdot10^{6}$	$7{,}0\cdot10^{7}$	$4{,}0\cdot10^{7}$	$1{,}9\cdot10^{8}$	$8{,}3\cdot10^{8}$	$8{,}8\cdot10^{9}$	$9{,}9\cdot10^{8}$	$7{,}8\cdot10^{9}$	$3{,}4\cdot10^{8}$	$3{,}0\cdot10^{9}$	$1{,}7\cdot10^{8}$	$1{,}4\cdot10^{9}$		
Ni-63	$1{,}1\cdot10^{9}$	$1{,}2\cdot10^{10}$	$6{,}9\cdot10^{9}$	$3{,}3\cdot10^{10}$	$1{,}3\cdot10^{11}$	$1{,}4\cdot10^{12}$	$1{,}5\cdot10^{11}$	$1{,}2\cdot10^{12}$	$5{,}3\cdot10^{10}$	$4{,}6\cdot10^{11}$	$2{,}8\cdot10^{10}$	$2{,}2\cdot10^{11}$		
Sb-125	$8{,}3\cdot10^{6}$	$8{,}7\cdot10^{7}$	$6{,}0\cdot10^{7}$	$2{,}9\cdot10^{8}$	$8{,}0\cdot10^{6}$	$8{,}4\cdot10^{7}$	$5{,}0\cdot10^{7}$	$3{,}9\cdot10^{8}$	$1{,}7\cdot10^{8}$	$1{,}5\cdot10^{9}$	$8{,}5\cdot10^{7}$	$6{,}7\cdot10^{8}$		
Zr-93	$6{,}7\cdot10^{3}$	$7{,}0\cdot10^{4}$	$4{,}0\cdot10^{4}$	$1{,}9\cdot10^{5}$	$8{,}3\cdot10^{5}$	$8{,}8\cdot10^{6}$	$9{,}9\cdot10^{5}$	$7{,}8\cdot10^{6}$	$3{,}4\cdot10^{5}$	$3{,}0\cdot10^{6}$	$1{,}7\cdot10^{5}$	$1{,}4\cdot10^{6}$		

Table 3-6. Realistic and conservative radionuclide inventory for Studsvik, waste type level. (cont.)

Nuclide	S.04		S.09		S.11		S.12		S.13		S.14		S.19	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Cs-137														
Cs-137	$1,5\cdot10^{9}$	$1,6\cdot10^{10}$	$1,6\cdot10^{11}$	$7,5\cdot10^{11}$	$3,6\cdot10^{12}$	$3,9\cdot10^{13}$	$6,8\cdot10^{10}$	$5,4\cdot10^{11}$	$1,1\cdot10^{10}$	$9,5\cdot10^{10}$	$6,8\cdot10^{8}$	$5,4\cdot10^{9}$		
Cd-113m	$5,2\cdot10^{5}$	$5,5\cdot10^{6}$	$5,5\cdot10^{7}$	$2,7\cdot10^{8}$	$8,3\cdot10^{8}$	$8,8\cdot10^{9}$	$1,4\cdot10^{7}$	$1,1\cdot10^{8}$	$2,9\cdot10^{6}$	$2,5\cdot10^{7}$	$2,1\cdot10^{5}$	$1,7\cdot10^{6}$		
Cl-36	$2,5\cdot10^{4}$	$2,7\cdot10^{5}$	$2,5\cdot10^{6}$	$1,2\cdot10^{7}$	$8,5\cdot10^{7}$	$9,0\cdot10^{8}$	$1,9\cdot10^{6}$	$1,5\cdot10^{7}$	$2,4\cdot10^{5}$	$2,1\cdot10^{6}$	$1,3\cdot10^{4}$	$1,0\cdot10^{5}$		
Cs-134	$1,0\cdot10^{7}$	$1,1\cdot10^{8}$	$1,3\cdot10^{9}$	$6,2\cdot10^{9}$	$3,6\cdot10^{7}$	$3,8\cdot10^{8}$	$1,8\cdot10^{7}$	$1,4\cdot10^{8}$	$4,0\cdot10^{7}$	$3,5\cdot10^{8}$	$1,5\cdot10^{6}$	$1,2\cdot10^{7}$		
Cs-135	$1,3\cdot10^{4}$	$1,3\cdot10^{5}$	$1,3\cdot10^{6}$	$6,1\cdot10^{6}$	$4,2\cdot10^{7}$	$4,5\cdot10^{8}$	$9,4\cdot10^{5}$	$7,4\cdot10^{6}$	$1,2\cdot10^{5}$	$1,1\cdot10^{6}$	$6,4\cdot10^{3}$	$5,0\cdot10^{4}$		
Eu-152	$5,8\cdot10^{4}$	$6,1\cdot10^{5}$	$6,2\cdot10^{6}$	$3,0\cdot10^{7}$	$9,0\cdot10^{7}$	$9,5\cdot10^{8}$	$1,5\cdot10^{6}$	$1,1\cdot10^{7}$	$3,2\cdot10^{5}$	$2,8\cdot10^{6}$	$2,4\cdot10^{4}$	$1,9\cdot10^{5}$	$3,8\cdot10^{10}$	$3,3\cdot10^{11}$
Eu-154	$4,6\cdot10^{7}$	$4,9\cdot10^{8}$	$5,2\cdot10^{9}$	$2,5\cdot10^{10}$	$4,4\cdot10^{10}$	$4,6\cdot10^{11}$	$6,7\cdot10^{8}$	$5,3\cdot10^{9}$	$2,1\cdot10^{8}$	$1,8\cdot10^{9}$	$1,7\cdot10^{7}$	$1,3\cdot10^{8}$	$8,2\cdot10^{8}$	$7,1\cdot10^{9}$
Eu-155	$1,0\cdot10^{7}$	$1,1\cdot10^{8}$	$1,2\cdot10^{9}$	$5,9\cdot10^{9}$	$2,8\cdot10^{9}$	$2,9\cdot10^{10}$	$6,2\cdot10^{7}$	$4,9\cdot10^{8}$	$4,1\cdot10^{7}$	$3,5\cdot10^{8}$	$3,1\cdot10^{6}$	$2,4\cdot10^{7}$		
I-129	$7,6\cdot10^{2}$	$8,0\cdot10^{3}$	$7,6\cdot10^{4}$	$3,7\cdot10^{5}$	$2,5\cdot10^{6}$	$2,7\cdot10^{7}$	$5,7\cdot10^{4}$	$4,5\cdot10^{5}$	$7,3\cdot10^{3}$	$6,3\cdot10^{4}$	$3,8\cdot10^{2}$	$3,0\cdot10^{3}$		
Pd-107	$2,5\cdot10^{3}$	$2,7\cdot10^{4}$	$2,5\cdot10^{5}$	$1,2\cdot10^{6}$	$8,5\cdot10^{6}$	$9,0\cdot10^{7}$	$1,9\cdot10^{5}$	$1,5\cdot10^{6}$	$2,4\cdot10^{4}$	$2,1\cdot10^{5}$	$1,3\cdot10^{3}$	$1,0\cdot10^{4}$		
Pm-147	$2,4\cdot10^{7}$	$2,5\cdot10^{8}$	$2,9\cdot10^{9}$	$1,4\cdot10^{10}$	$4,5\cdot10^{8}$	$4,8\cdot10^{9}$	$6,1\cdot10^{7}$	$4,8\cdot10^{8}$	$9,1\cdot10^{7}$	$7,9\cdot10^{8}$	$4,6\cdot10^{6}$	$3,6\cdot10^{7}$		
Ru-106	$9,8\cdot10^{2}$	$1,0\cdot10^{4}$	$1,2\cdot10^{5}$	$5,8\cdot10^{5}$	$5,7\cdot10^{-1}$	$6,0\cdot10^{0}$	$3,1\cdot10^{2}$	$2,4\cdot10^{3}$	$3,8\cdot10^{3}$	$3,3\cdot10^{4}$	$3,6\cdot10^{1}$	$2,8\cdot10^{2}$		
Se-79	$1,0\cdot10^{4}$	$1,1\cdot10^{5}$	$1,0\cdot10^{6}$	$4,9\cdot10^{6}$	$3,4\cdot10^{7}$	$3,6\cdot10^{8}$	$7,5\cdot10^{5}$	$5,9\cdot10^{6}$	$9,7\cdot10^{4}$	$8,5\cdot10^{5}$	$5,1\cdot10^{3}$	$4,0\cdot10^{4}$		
Sm-151	$6,4\cdot10^{6}$	$6,7\cdot10^{7}$	$6,4\cdot10^{8}$	$3,1\cdot10^{9}$	$1,9\cdot10^{10}$	$2,0\cdot10^{11}$	$4,0\cdot10^{8}$	$3,2\cdot10^{9}$	$5,5\cdot10^{7}$	$4,8\cdot10^{8}$	$3,1\cdot10^{6}$	$2,4\cdot10^{7}$		
Sn-126	$1,3\cdot10^{3}$	$1,3\cdot10^{4}$	$1,3\cdot10^{5}$	$6,1\cdot10^{5}$	$4,2\cdot10^{6}$	$4,5\cdot10^{7}$	$9,4\cdot10^{4}$	$7,4\cdot10^{5}$	$1,2\cdot10^{4}$	$1,1\cdot10^{5}$	$6,4\cdot10^{2}$	$5,0\cdot10^{3}$		
Sr-90	$1,5\cdot10^{8}$	$1,6\cdot10^{9}$	$1,5\cdot10^{10}$	$7,3\cdot10^{10}$	$3,5\cdot10^{11}$	$3,7\cdot10^{12}$	$6,5\cdot10^{9}$	$5,1\cdot10^{10}$	$1,1\cdot10^{9}$	$9,1\cdot10^{9}$	$6,6\cdot10^{7}$	$5,2\cdot10^{8}$		
Tc-99	$1,3\cdot10^{7}$	$1,3\cdot10^{8}$	$1,3\cdot10^{9}$	$6,1\cdot10^{9}$	$4,2\cdot10^{10}$	$4,5\cdot10^{11}$	$9,4\cdot10^{8}$	$7,4\cdot10^{9}$	$1,2\cdot10^{8}$	$1,1\cdot10^{9}$	$6,4\cdot10^{6}$	$5,0\cdot10^{7}$		

Table 3-6. Realistic and conservative radionuclide inventory for Studsvik, waste type level. (cont.)

Nuclide	S.04		S.09		S.11		S.12		S.13		S.14		S.19	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Pu-236 + Pu-240														
Pu-239	$6,2\cdot10^{8}$	$6,5\cdot10^{9}$	$3,8\cdot10^{6}$	$1,8\cdot10^{7}$	$1,7\cdot10^{9}$	$1,8\cdot10^{10}$	$6,3\cdot10^{6}$	$5,0\cdot10^{7}$	$6,0\cdot10^{7}$	$5,2\cdot10^{8}$	$7,5\cdot10^{6}$	$5,9\cdot10^{7}$		
Pu-240	$1,2\cdot10^{9}$	$1,3\cdot10^{10}$	$7,5\cdot10^{6}$	$3,6\cdot10^{7}$	$3,3\cdot10^{9}$	$3,5\cdot10^{10}$	$1,3\cdot10^{7}$	$9,9\cdot10^{7}$	$1,2\cdot10^{8}$	$1,0\cdot10^{9}$	$1,5\cdot10^{7}$	$1,2\cdot10^{8}$		
Pb-210	$2,0\cdot10^{-2}$	$2,1\cdot10^{-1}$	$1,2\cdot10^{-4}$	$5,7\cdot10^{-4}$	$3,9\cdot10^{-2}$	$4,1\cdot10^{-1}$	$1,7\cdot10^{-4}$	$1,3\cdot10^{-3}$	$1,6\cdot10^{-3}$	$1,4\cdot10^{-2}$	$2,1\cdot10^{-4}$	$1,7\cdot10^{-3}$		
Ra-226	$3,7\cdot10^{-1}$	$3,9\cdot10^{0}$	$2,2\cdot10^{-3}$	$1,1\cdot10^{-2}$	$9,9\cdot10^{-1}$	$1,0\cdot10^{1}$	$3,7\cdot10^{-3}$	$2,9\cdot10^{-2}$	$3,6\cdot10^{-2}$	$3,1\cdot10^{-1}$	$4,4\cdot10^{-3}$	$3,5\cdot10^{-2}$		
Ac-227	$4,0\cdot10^{0}$	$4,2\cdot10^{1}$	$2,3\cdot10^{-2}$	$1,1\cdot10^{-1}$	$7,6\cdot10^{0}$	$8,0\cdot10^{1}$	$3,3\cdot10^{-2}$	$2,6\cdot10^{-1}$	$3,1\cdot10^{-1}$	$2,7\cdot10^{0}$	$4,2\cdot10^{-2}$	$3,3\cdot10^{-1}$		
Th-229	$5,6\cdot10^{-1}$	$5,9\cdot10^{0}$	$3,4\cdot10^{-3}$	$1,6\cdot10^{-2}$	$1,5\cdot10^{0}$	$1,6\cdot10^{1}$	$5,6\cdot10^{-3}$	$4,5\cdot10^{-2}$	$5,4\cdot10^{-2}$	$4,7\cdot10^{-1}$	$6,7\cdot10^{-3}$	$5,3\cdot10^{-2}$		
Th-230	$1,7\cdot10^{2}$	$1,8\cdot10^{3}$	$1,0\cdot10^{0}$	$4,9\cdot10^{0}$	$4,5\cdot10^{2}$	$4,8\cdot10^{3}$	$1,7\cdot10^{0}$	$1,3\cdot10^{1}$	$1,6\cdot10^{1}$	$1,4\cdot10^{2}$	$2,0\cdot10^{0}$	$1,6\cdot10^{1}$		
Th-232	$1,9\cdot10^{-4}$	$2,0\cdot10^{-3}$	$1,1\cdot10^{-6}$	$5,5\cdot10^{-6}$	$5,0\cdot10^{-4}$	$5,3\cdot10^{-3}$	$1,9\cdot10^{-6}$	$1,5\cdot10^{-5}$	$1,8\cdot10^{-5}$	$1,6\cdot10^{-4}$	$2,2\cdot10^{-6}$	$1,8\cdot10^{-5}$		
Pa-231	$5,6\cdot10^{1}$	$5,9\cdot10^{2}$	$3,4\cdot10^{-1}$	$1,6\cdot10^{0}$	$1,5\cdot10^{2}$	$1,6\cdot10^{3}$	$5,7\cdot10^{-1}$	$4,5\cdot10^{0}$	$5,4\cdot10^{0}$	$4,7\cdot10^{1}$	$6,7\cdot10^{-1}$	$5,3\cdot10^{0}$		
U-232	$4,6\cdot10^{4}$	$4,8\cdot10^{5}$	$2,7\cdot10^{2}$	$1,3\cdot10^{3}$	$1,1\cdot10^{5}$	$1,2\cdot10^{6}$	$4,3\cdot10^{2}$	$3,4\cdot10^{3}$	$4,1\cdot10^{3}$	$3,6\cdot10^{4}$	$5,3\cdot10^{2}$	$4,1\cdot10^{3}$		
U-233	$3,7\cdot10^{1}$	$3,9\cdot10^{2}$	$2,3\cdot10^{-1}$	$1,1\cdot10^{0}$	$1,0\cdot10^{2}$	$1,1\cdot10^{3}$	$3,8\cdot10^{-1}$	$3,0\cdot10^{0}$	$3,6\cdot10^{0}$	$3,1\cdot10^{1}$	$4,5\cdot10^{-1}$	$3,5\cdot10^{0}$		
U-234	$1,9\cdot10^{6}$	$2,0\cdot10^{7}$	$1,1\cdot10^{4}$	$5,5\cdot10^{4}$	$5,0\cdot10^{6}$	$5,3\cdot10^{7}$	$1,9\cdot10^{4}$	$1,5\cdot10^{5}$	$1,8\cdot10^{5}$	$1,6\cdot10^{6}$	$2,2\cdot10^{4}$	$1,8\cdot10^{5}$		
U-235	$3,7\cdot10^{4}$	$3,9\cdot10^{5}$	$2,3\cdot10^{2}$	$1,1\cdot10^{3}$	$1,0\cdot10^{5}$	$1,1\cdot10^{6}$	$3,8\cdot10^{2}$	$3,0\cdot10^{3}$	$3,6\cdot10^{3}$	$3,1\cdot10^{4}$	$4,5\cdot10^{2}$	$3,5\cdot10^{3}$		
U-236	$5,6\cdot10^{5}$	$5,9\cdot10^{6}$	$3,4\cdot10^{3}$	$1,6\cdot10^{4}$	$1,5\cdot10^{6}$	$1,6\cdot10^{7}$	$5,7\cdot10^{3}$	$4,5\cdot10^{4}$	$5,4\cdot10^{4}$	$4,7\cdot10^{5}$	$6,7\cdot10^{3}$	$5,3\cdot10^{4}$		
U-238	$7,4\cdot10^{5}$	$7,9\cdot10^{6}$	$4,5\cdot10^{3}$	$2,2\cdot10^{4}$	$2,0\cdot10^{6}$	$2,1\cdot10^{7}$	$7,6\cdot10^{3}$	$5,9\cdot10^{4}$	$7,2\cdot10^{4}$	$6,3\cdot10^{5}$	$9,0\cdot10^{3}$	$7,1\cdot10^{4}$		
Np-237	$7,4\cdot10^{5}$	$7,9\cdot10^{6}$	$4,5\cdot10^{3}$	$2,2\cdot10^{4}$	$2,0\cdot10^{6}$	$2,1\cdot10^{7}$	$7,5\cdot10^{3}$	$5,9\cdot10^{4}$	$7,2\cdot10^{4}$	$6,3\cdot10^{5}$	$9,0\cdot10^{3}$	$7,1\cdot10^{4}$		
Pu-238	$6,4\cdot10^{9}$	$6,7\cdot10^{10}$	$3,8\cdot10^{7}$	$1,8\cdot10^{8}$	$1,6\cdot10^{10}$	$1,7\cdot10^{11}$	$6,1\cdot10^{7}$	$4,8\cdot10^{8}$	$5,8\cdot10^{8}$	$5,0\cdot10^{9}$	$7,4\cdot10^{7}$	$5,8\cdot10^{8}$		
Pu-241	$7,4\cdot10^{10}$	$7,8\cdot10^{11}$	$4,2\cdot10^{8}$	$2,0\cdot10^{9}$	$1,1\cdot10^{11}$	$1,2\cdot10^{12}$	$5,5\cdot10^{8}$	$4,3\cdot10^{9}$	$5,0\cdot10^{9}$	$4,3\cdot10^{10}$	$7,1\cdot10^{8}$	$5,6\cdot10^{9}$		
Pu-242	$5,6\cdot10^{6}$	$5,9\cdot10^{7}$	$3,4\cdot10^{4}$	$1,6\cdot10^{5}$	$1,5\cdot10^{7}$	$1,6\cdot10^{8}$	$5,7\cdot10^{4}$	$4,5\cdot10^{5}$	$5,4\cdot10^{5}$	$4,7\cdot10^{6}$	$6,7\cdot10^{4}$	$5,3\cdot10^{5}$		
Am-241	$1,8\cdot10^{9}$	$1,9\cdot10^{10}$	$1,1\cdot10^{7}$	$5,3\cdot10^{7}$	$4,8\cdot10^{9}$	$5,0\cdot10^{10}$	$1,8\cdot10^{7}$	$1,4\cdot10^{8}$	$1,7\cdot10^{8}$	$1,5\cdot10^{9}$	$2,2\cdot10^{7}$	$1,7\cdot10^{8}$		
Am-242m	$1,7\cdot10^{7}$	$1,8\cdot10^{8}$	$1,0\cdot10^{5}$	$4,9\cdot10^{5}$	$4,3\cdot10^{7}$	$4,5\cdot10^{8}$	$1,7\cdot10^{5}$	$1,3\cdot10^{6}$	$1,6\cdot10^{6}$	$1,4\cdot10^{7}$	$2,0\cdot10^{5}$	$1,6\cdot10^{6}$		
Am-243	$5,6\cdot10^{7}$	$5,9\cdot10^{8}$	$3,4\cdot10^{5}$	$1,6\cdot10^{6}$	$1,5\cdot10^{8}$	$1,6\cdot10^{9}$	$5,6\cdot10^{5}$	$4,5\cdot10^{6}$	$5,4\cdot10^{6}$	$4,7\cdot10^{7}$	$6,7\cdot10^{5}$	$5,3\cdot10^{6}$		
Cm-243	$2,3\cdot10^{7}$	$2,5\cdot10^{8}$	$1,4\cdot10^{5}$	$6,6\cdot10^{5}$	$4,8\cdot10^{7}$	$5,1\cdot10^{8}$	$2,0\cdot10^{5}$	$1,6\cdot10^{6}$	$1,9\cdot10^{6}$	$1,6\cdot10^{7}$	$2,5\cdot10^{5}$	$2,0\cdot10^{6}$		
Cm-244	$2,7\cdot10^{9}$	$2,8\cdot10^{10}$	$1,5\cdot10^{7}$	$7,3\cdot10^{7}$	$4,7\cdot10^{9}$	$4,9\cdot10^{10}$	$2,1\cdot10^{7}$	$1,7\cdot10^{8}$	$1,9\cdot10^{8}$	$1,7\cdot10^{9}$	$2,7\cdot10^{7}$	$2,1\cdot10^{8}$		
Cm-245	$5,6\cdot10^{5}$	$5,9\cdot10^{6}$	$3,4\cdot10^{3}$	$1,6\cdot10^{4}$	$1,5\cdot10^{6}$	$1,6\cdot10^{7}$	$5,7\cdot10^{3}$	$4,5\cdot10^{4}$	$5,4\cdot10^{4}$	$4,7\cdot10^{5}$	$6,7\cdot10^{3}$	$5,3\cdot10^{4}$		
Cm-246	$1,5\cdot10^{5}$	$1,6\cdot10^{6}$	$9,0\cdot10^{2}$	$4,3\cdot10^{3}$	$4,0\cdot10^{5}$	$4,2\cdot10^{6}$	$1,5\cdot10^{3}$	$1,2\cdot10^{4}$	$1,4\cdot10^{4}$	$1,2\cdot10^{5}$	$1,8\cdot10^{3}$	$1,4\cdot10^{4}$		
Pu-244	$1,3\cdot10^{0}$	$1,4\cdot10^{1}$	$7,9\cdot10^{-3}$	$3,8\cdot10^{-2}$	$3,5\cdot10^{0}$	$3,7\cdot10^{1}$	$1,3\cdot10^{-2}$	$1,0\cdot10^{-1}$	$1,3\cdot10^{-1}$	$1,1\cdot10^{0}$	$1,6\cdot10^{-2}$	$1,2\cdot10^{-1}$		

Table 3-7. Realistic and conservative radionuclide inventory for Studsvik, waste type level, part 2.

Nuclide	S.21		S.22		S.23		S.24	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Co-60								
Co-60	$1,2\cdot10^{9}$	$5,9\cdot10^{9}$	$9,1\cdot10^{7}$	$9,6\cdot10^{8}$	$1,3\cdot10^{11}$	$6,3\cdot10^{11}$		
Ag-108m	$4,1\cdot10^{6}$	$2,0\cdot10^{7}$	$1,1\cdot10^{6}$	$1,2\cdot10^{7}$	$8,9\cdot10^{8}$	$4,3\cdot10^{9}$		
Ba-133	$6,6\cdot10^{4}$	$3,2\cdot10^{5}$	$1,3\cdot10^{4}$	$1,3\cdot10^{5}$	$1,2\cdot10^{7}$	$6,0\cdot10^{7}$		
Be-10	$4,4\cdot10^{1}$	$2,1\cdot10^{2}$	$1,2\cdot10^{1}$	$1,2\cdot10^{2}$	$9,5\cdot10^{3}$	$4,6\cdot10^{4}$		
C-14	$7,3\cdot10^{7}$	$3,5\cdot10^{8}$	$1,9\cdot10^{7}$	$2,0\cdot10^{8}$	$1,6\cdot10^{10}$	$7,6\cdot10^{10}$		
Fe-55	$1,7\cdot10^{8}$	$8,4\cdot10^{8}$	$8,6\cdot10^{5}$	$9,0\cdot10^{6}$	$7,2\cdot10^{9}$	$3,5\cdot10^{10}$		
H-3	$9,0\cdot10^{5}$	$4,3\cdot10^{6}$	$1,9\cdot10^{5}$	$2,0\cdot10^{6}$	$1,8\cdot10^{8}$	$8,6\cdot10^{8}$		
Ho-166m	$2,9\cdot10^{5}$	$1,4\cdot10^{6}$	$7,6\cdot10^{4}$	$8,0\cdot10^{5}$	$6,2\cdot10^{7}$	$3,0\cdot10^{8}$		
Mo-93	$3,6\cdot10^{5}$	$1,8\cdot10^{6}$	$9,7\cdot10^{4}$	$1,0\cdot10^{6}$	$7,9\cdot10^{7}$	$3,8\cdot10^{8}$		
Nb-93m	$1,4\cdot10^{7}$	$6,8\cdot10^{7}$	$3,2\cdot10^{6}$	$3,4\cdot10^{7}$	$2,9\cdot10^{9}$	$1,4\cdot10^{10}$		
Nb-94	$7,3\cdot10^{5}$	$3,5\cdot10^{6}$	$1,9\cdot10^{5}$	$2,1\cdot10^{6}$	$1,6\cdot10^{8}$	$7,7\cdot10^{8}$		
Ni-59	$7,3\cdot10^{7}$	$3,5\cdot10^{8}$	$1,9\cdot10^{7}$	$2,1\cdot10^{8}$	$1,6\cdot10^{10}$	$7,7\cdot10^{10}$		
Ni-63	$1,1\cdot10^{10}$	$5,3\cdot10^{10}$	$2,9\cdot10^{9}$	$3,1\cdot10^{10}$	$2,4\cdot10^{12}$	$1,2\cdot10^{13}$		
Sb-125	$1,8\cdot10^{7}$	$8,7\cdot10^{7}$	$9,4\cdot10^{4}$	$1,0\cdot10^{6}$	$7,5\cdot10^{8}$	$3,6\cdot10^{9}$		
Zr-93	$7,3\cdot10^{4}$	$3,5\cdot10^{5}$	$1,9\cdot10^{4}$	$2,1\cdot10^{5}$	$1,6\cdot10^{7}$	$7,7\cdot10^{7}$		

Table 3-7. Realistic and conservative radionuclide inventory for Studsvik, waste type level, part 2. (cont.)

Nuclide	**S.21**		**S.22**		**S.23**		**S.24**	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Cs-137								
Cs-137	$4,9\cdot10^{9}$	$2,4\cdot10^{10}$	$2,5\cdot10^{10}$	$2,6\cdot10^{11}$	$3,0\cdot10^{11}$	$1,5\cdot10^{12}$		
Cd-113m	$1,2\cdot10^{6}$	$5,8\cdot10^{6}$	$5,0\cdot10^{6}$	$5,3\cdot10^{7}$	$5,6\cdot10^{7}$	$2,7\cdot10^{8}$		
Cl-36	$1,2\cdot10^{5}$	$5,6\cdot10^{5}$	$6,5\cdot10^{5}$	$6,9\cdot10^{6}$	$8,7\cdot10^{6}$	$4,2\cdot10^{7}$		
Cs-134	$9,4\cdot10^{6}$	$4,5\cdot10^{7}$	$1,6\cdot10^{5}$	$1,7\cdot10^{6}$	$1,1\cdot10^{8}$	$5,5\cdot10^{8}$		
Cs-135	$5,8\cdot10^{4}$	$2,8\cdot10^{5}$	$3,3\cdot10^{5}$	$3,4\cdot10^{6}$	$4,4\cdot10^{6}$	$2,1\cdot10^{7}$		
Eu-152	$1,3\cdot10^{5}$	$6,3\cdot10^{5}$	$5,3\cdot10^{5}$	$5,6\cdot10^{6}$	$6,0\cdot10^{6}$	$2,9\cdot10^{7}$		
Eu-154	$7,6\cdot10^{7}$	$3,7\cdot10^{8}$	$2,3\cdot10^{8}$	$2,4\cdot10^{9}$	$2,5\cdot10^{9}$	$1,2\cdot10^{10}$		
Eu-155	$1,1\cdot10^{7}$	$5,4\cdot10^{7}$	$1,2\cdot10^{7}$	$1,3\cdot10^{8}$	$2,0\cdot10^{8}$	$9,5\cdot10^{8}$		
I-129	$3,5\cdot10^{3}$	$1,7\cdot10^{4}$	$2,0\cdot10^{4}$	$2,1\cdot10^{5}$	$2,6\cdot10^{5}$	$1,3\cdot10^{6}$		
Pd-107	$1,2\cdot10^{4}$	$5,6\cdot10^{4}$	$6,5\cdot10^{4}$	$6,9\cdot10^{5}$	$8,7\cdot10^{5}$	$4,2\cdot10^{6}$		
Pm-147	$2,2\cdot10^{7}$	$1,0\cdot10^{8}$	$1,9\cdot10^{6}$	$2,0\cdot10^{7}$	$2,7\cdot10^{8}$	$1,3\cdot10^{9}$		
Ru-106	$8,8\cdot10^{2}$	$4,2\cdot10^{3}$	$5,9\cdot10^{-3}$	$6,2\cdot10^{-2}$	$1,1\cdot10^{4}$	$5,1\cdot10^{4}$		
Se-79	$4,6\cdot10^{4}$	$2,2\cdot10^{5}$	$2,6\cdot10^{5}$	$2,8\cdot10^{6}$	$3,5\cdot10^{6}$	$1,7\cdot10^{7}$		
Sm-151	$2,6\cdot10^{7}$	$1,2\cdot10^{8}$	$1,4\cdot10^{8}$	$1,5\cdot10^{9}$	$1,8\cdot10^{9}$	$8,8\cdot10^{9}$		
Sn-126	$5,8\cdot10^{3}$	$2,8\cdot10^{4}$	$3,3\cdot10^{4}$	$3,4\cdot10^{5}$	$4,4\cdot10^{5}$	$2,1\cdot10^{6}$		
Sr-90	$4,7\cdot10^{8}$	$2,3\cdot10^{9}$	$2,4\cdot10^{9}$	$2,5\cdot10^{10}$	$2,9\cdot10^{10}$	$1,4\cdot10^{11}$		
Tc-99	$5,8\cdot10^{7}$	$2,8\cdot10^{8}$	$3,3\cdot10^{8}$	$3,4\cdot10^{9}$	$4,4\cdot10^{9}$	$2,1\cdot10^{10}$		

Table 3-7. Realistic and conservative radionuclide inventory for Studsvik, waste type level, part 2. (cont.)

Nuclide	**S.21**		**S.22**		**S.23**		**S.24**	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Pu-236 + Pu-240								
Pu-239	$6,5\cdot10^{6}$	$3,2\cdot10^{7}$	$2,5\cdot10^{9}$	$2,7\cdot10^{10}$	$9,3\cdot10^{7}$	$4,5\cdot10^{8}$		
Pu-240	$1,3\cdot10^{7}$	$6,3\cdot10^{7}$	$5,1\cdot10^{9}$	$5,4\cdot10^{10}$	$1,9\cdot10^{8}$	$9,0\cdot10^{8}$		
Pb-210	$1,6\cdot10^{-4}$	$7,8\cdot10^{-4}$	$5,9\cdot10^{-2}$	$6,3\cdot10^{-1}$	$2,5\cdot10^{-3}$	$1,2\cdot10^{-2}$		
Ra-226	$3,9\cdot10^{-3}$	$1,9\cdot10^{-2}$	$1,5\cdot10^{0}$	$1,6\cdot10^{1}$	$5,5\cdot10^{-2}$	$2,7\cdot10^{-1}$		
Ac-227	$3,1\cdot10^{-2}$	$1,5\cdot10^{-1}$	$1,2\cdot10^{1}$	$1,2\cdot10^{2}$	$4,8\cdot10^{-1}$	$2,3\cdot10^{0}$		
Th-229	$5,9\cdot10^{-3}$	$2,8\cdot10^{-2}$	$2,3\cdot10^{0}$	$2,4\cdot10^{1}$	$8,4\cdot10^{-2}$	$4,0\cdot10^{-1}$		
Th-230	$1,8\cdot10^{0}$	$8,5\cdot10^{0}$	$6,9\cdot10^{2}$	$7,3\cdot10^{3}$	$2,5\cdot10^{1}$	$1,2\cdot10^{2}$		
Th-232	$2,0\cdot10^{-6}$	$9,5\cdot10^{-6}$	$7,6\cdot10^{-4}$	$8,1\cdot10^{-3}$	$2,8\cdot10^{-5}$	$1,3\cdot10^{-4}$		
Pa-231	$5,9\cdot10^{-1}$	$2,8\cdot10^{0}$	$2,3\cdot10^{2}$	$2,4\cdot10^{3}$	$8,4\cdot10^{0}$	$4,0\cdot10^{1}$		
U-232	$4,4\cdot10^{2}$	$2,1\cdot10^{3}$	$1,7\cdot10^{5}$	$1,8\cdot10^{6}$	$6,4\cdot10^{3}$	$3,1\cdot10^{4}$		
U-233	$3,9\cdot10^{-1}$	$1,9\cdot10^{0}$	$1,5\cdot10^{2}$	$1,6\cdot10^{3}$	$5,6\cdot10^{0}$	$2,7\cdot10^{1}$		
U-234	$2,0\cdot10^{4}$	$9,5\cdot10^{4}$	$7,6\cdot10^{6}$	$8,1\cdot10^{7}$	$2,8\cdot10^{5}$	$1,3\cdot10^{6}$		
U-235	$3,9\cdot10^{2}$	$1,9\cdot10^{3}$	$1,5\cdot10^{5}$	$1,6\cdot10^{6}$	$5,6\cdot10^{3}$	$2,7\cdot10^{4}$		
U-236	$5,9\cdot10^{3}$	$2,8\cdot10^{4}$	$2,3\cdot10^{6}$	$2,4\cdot10^{7}$	$8,4\cdot10^{4}$	$4,0\cdot10^{5}$		
U-238	$7,8\cdot10^{3}$	$3,8\cdot10^{4}$	$3,1\cdot10^{6}$	$3,2\cdot10^{7}$	$1,1\cdot10^{5}$	$5,4\cdot10^{5}$		
Np-237	$7,8\cdot10^{3}$	$3,8\cdot10^{4}$	$3,1\cdot10^{6}$	$3,2\cdot10^{7}$	$1,1\cdot10^{5}$	$5,4\cdot10^{5}$		
Pu-238	$6,2\cdot10^{7}$	$3,0\cdot10^{8}$	$2,4\cdot10^{10}$	$2,5\cdot10^{11}$	$9,0\cdot10^{8}$	$4,4\cdot10^{9}$		
Pu-241	$5,0\cdot10^{8}$	$2,4\cdot10^{9}$	$1,8\cdot10^{11}$	$1,8\cdot10^{12}$	$8,0\cdot10^{9}$	$3,9\cdot10^{10}$		
Pu-242	$5,9\cdot10^{4}$	$2,8\cdot10^{5}$	$2,3\cdot10^{7}$	$2,4\cdot10^{8}$	$8,4\cdot10^{5}$	$4,0\cdot10^{6}$		
Am-241	$1,9\cdot10^{7}$	$9,0\cdot10^{7}$	$7,3\cdot10^{9}$	$7,7\cdot10^{10}$	$2,7\cdot10^{8}$	$1,3\cdot10^{9}$	$5,0\cdot10^{11}$	$5,3\cdot10^{12}$
Am-242m	$1,7\cdot10^{5}$	$8,2\cdot10^{5}$	$6,6\cdot10^{7}$	$6,9\cdot10^{8}$	$2,4\cdot10^{6}$	$1,2\cdot10^{7}$		
Am-243	$5,9\cdot10^{5}$	$2,8\cdot10^{6}$	$2,3\cdot10^{8}$	$2,4\cdot10^{9}$	$8,4\cdot10^{6}$	$4,0\cdot10^{7}$		
Cm-243	$2,0\cdot10^{5}$	$9,5\cdot10^{5}$	$7,4\cdot10^{7}$	$7,8\cdot10^{8}$	$3,0\cdot10^{6}$	$1,4\cdot10^{7}$		
Cm-244	$2,0\cdot10^{7}$	$9,5\cdot10^{7}$	$7,1\cdot10^{9}$	$7,5\cdot10^{10}$	$3,1\cdot10^{8}$	$1,5\cdot10^{9}$		
Cm-245	$5,9\cdot10^{3}$	$2,8\cdot10^{4}$	$2,3\cdot10^{6}$	$2,4\cdot10^{7}$	$8,4\cdot10^{4}$	$4,0\cdot10^{5}$		
Cm-246	$1,6\cdot10^{3}$	$7,5\cdot10^{3}$	$6,1\cdot10^{5}$	$6,4\cdot10^{6}$	$2,2\cdot10^{4}$	$1,1\cdot10^{5}$		
Pu-244	$1,4\cdot10^{-2}$	$6,6\cdot10^{-2}$	$5,3\cdot10^{0}$	$5,7\cdot10^{1}$	$2,0\cdot10^{-1}$	$9,4\cdot10^{-1}$		

Table 3-8. Realistic and conservative radionuclide inventory for ’odd waste’, waste type level.

Nuclide	**Odd waste BLA**		**Odd waste BTF**		**Odd waste BMA**	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Co-60						
Co-60	$9,7\cdot10^{10}$	$9,7\cdot10^{10}$	$3,6\cdot10^{12}$	$3,6\cdot10^{12}$	$2,2\cdot10^{12}$	$2,2\cdot10^{12}$
Ag-108m	$2,1\cdot10^{8}$	$2,1\cdot10^{8}$	$6,7\cdot10^{9}$	$6,7\cdot10^{9}$	$3,7\cdot10^{9}$	$3,7\cdot10^{9}$
Ba-133	$4,8\cdot10^{6}$	$4,8\cdot10^{6}$	$1,6\cdot10^{8}$	$1,6\cdot10^{8}$	$8,0\cdot10^{7}$	$8,0\cdot10^{7}$
Be-10	$2,2\cdot10^{3}$	$2,2\cdot10^{3}$	$7,1\cdot10^{4}$	$7,1\cdot10^{4}$	$3,9\cdot10^{4}$	$3,9\cdot10^{4}$
C-14	$3,7\cdot10^{9}$	$3,7\cdot10^{9}$	$6,9\cdot10^{11}$	$6,9\cdot10^{11}$	$6,5\cdot10^{10}$	$6,5\cdot10^{10}$
Fe-55	$8,9\cdot10^{9}$	$8,9\cdot10^{9}$	$4,0\cdot10^{11}$	$4,0\cdot10^{11}$	$5,9\cdot10^{11}$	$5,9\cdot10^{11}$
H-3	$6,3\cdot10^{7}$	$6,3\cdot10^{7}$	$2,1\cdot10^{9}$	$2,1\cdot10^{9}$	$1,0\cdot10^{9}$	$1,0\cdot10^{9}$
Ho-166m	$1,4\cdot10^{7}$	$1,4\cdot10^{7}$	$4,7\cdot10^{8}$	$4,7\cdot10^{8}$	$2,6\cdot10^{8}$	$2,6\cdot10^{8}$
Mo-93	$1,8\cdot10^{7}$	$1,8\cdot10^{7}$	$5,9\cdot10^{8}$	$5,9\cdot10^{8}$	$3,2\cdot10^{8}$	$3,2\cdot10^{8}$
Nb-93m	$9,2\cdot10^{8}$	$9,2\cdot10^{8}$	$3,1\cdot10^{10}$	$3,1\cdot10^{10}$	$1,5\cdot10^{10}$	$1,5\cdot10^{10}$
Nb-94	$3,7\cdot10^{7}$	$3,7\cdot10^{7}$	$1,2\cdot10^{9}$	$1,2\cdot10^{9}$	$6,5\cdot10^{8}$	$6,5\cdot10^{8}$
Ni-59	$3,7\cdot10^{9}$	$3,7\cdot10^{9}$	$1,2\cdot10^{11}$	$1,2\cdot10^{11}$	$6,5\cdot10^{10}$	$6,5\cdot10^{10}$
Ni-63	$5,8\cdot10^{11}$	$5,8\cdot10^{11}$	$1,9\cdot10^{13}$	$1,9\cdot10^{13}$	$1,0\cdot10^{13}$	$1,0\cdot10^{13}$
Sb-125	$9,4\cdot10^{8}$	$9,4\cdot10^{8}$	$4,2\cdot10^{10}$	$4,2\cdot10^{10}$	$6,0\cdot10^{10}$	$6,0\cdot10^{10}$
Zr-93	$3,7\cdot10^{6}$	$3,7\cdot10^{6}$	$1,2\cdot10^{8}$	$1,2\cdot10^{8}$	$6,5\cdot10^{7}$	$6,5\cdot10^{7}$

Table 3-8. Realistic and conservative radionuclide inventory for ’odd waste’, waste type level. (cont.)

Nuclide	Odd waste BLA		Odd waste BTF		Odd waste BMA	
	Realistic	Cons.	Realistic	Cons.	Realistic	Cons.
Correlated to Cs-137						
Cs-137	$3,5\cdot10^{11}$	$3,5\cdot10^{11}$	$9,3\cdot10^{12}$	$9,3\cdot10^{12}$	$4,4\cdot10^{12}$	$4,4\cdot10^{12}$
Cd-113m	$9,7\cdot10^{7}$	$9,7\cdot10^{7}$	$2,5\cdot10^{9}$	$2,5\cdot10^{9}$	$1,1\cdot10^{9}$	$1,1\cdot10^{9}$
Cl-36	$7,7\cdot10^{6}$	$7,7\cdot10^{6}$	$2,1\cdot10^{8}$	$2,1\cdot10^{8}$	$1,1\cdot10^{8}$	$1,1\cdot10^{8}$
Cs-134	$5,9\cdot10^{8}$	$5,9\cdot10^{8}$	$2,3\cdot10^{10}$	$2,3\cdot10^{10}$	$5,7\cdot10^{10}$	$5,7\cdot10^{10}$
Cs-135	$3,9\cdot10^{6}$	$3,9\cdot10^{6}$	$1,0\cdot10^{8}$	$1,0\cdot10^{8}$	$5,3\cdot10^{7}$	$5,3\cdot10^{7}$
Eu-152	$1,1\cdot10^{7}$	$1,1\cdot10^{7}$	$1,1\cdot10^{11}$	$1,1\cdot10^{11}$	$1,2\cdot10^{8}$	$1,2\cdot10^{8}$
Eu-154	$7,2\cdot10^{9}$	$7,2\cdot10^{9}$	$1,9\cdot10^{11}$	$1,9\cdot10^{11}$	$8,3\cdot10^{10}$	$8,3\cdot10^{10}$
Eu-155	$1,2\cdot10^{9}$	$1,2\cdot10^{9}$	$3,4\cdot10^{10}$	$3,4\cdot10^{10}$	$2,0\cdot10^{10}$	$2,0\cdot10^{10}$
I-129	$2,3\cdot10^{5}$	$2,3\cdot10^{5}$	$6,3\cdot10^{6}$	$6,3\cdot10^{6}$	$3,2\cdot10^{6}$	$3,2\cdot10^{6}$
Pd-107	$7,7\cdot10^{5}$	$7,7\cdot10^{5}$	$2,1\cdot10^{7}$	$2,1\cdot10^{7}$	$1,1\cdot10^{7}$	$1,1\cdot10^{7}$
Pm-147	$1,8\cdot10^{9}$	$1,8\cdot10^{9}$	$6,1\cdot10^{10}$	$6,1\cdot10^{10}$	$8,0\cdot10^{10}$	$8,0\cdot10^{10}$
Ru-106	$1,3\cdot10^{4}$	$1,3\cdot10^{4}$	$1,1\cdot10^{6}$	$1,1\cdot10^{6}$	$1,0\cdot10^{8}$	$1,0\cdot10^{8}$
Se-79	$3,1\cdot10^{6}$	$3,1\cdot10^{6}$	$8,4\cdot10^{7}$	$8,4\cdot10^{7}$	$4,2\cdot10^{7}$	$4,2\cdot10^{7}$
Sm-151	$1,8\cdot10^{9}$	$1,8\cdot10^{9}$	$4,7\cdot10^{10}$	$4,7\cdot10^{10}$	$2,3\cdot10^{10}$	$2,3\cdot10^{10}$
Sn-126	$3,9\cdot10^{5}$	$3,9\cdot10^{5}$	$1,0\cdot10^{7}$	$1,0\cdot10^{7}$	$5,3\cdot10^{6}$	$5,3\cdot10^{6}$
Sr-90	$3,4\cdot10^{10}$	$3,4\cdot10^{10}$	$9,0\cdot10^{11}$	$9,0\cdot10^{11}$	$4,3\cdot10^{11}$	$4,3\cdot10^{11}$
Tc-99	$3,9\cdot10^{9}$	$3,9\cdot10^{9}$	$1,0\cdot10^{11}$	$1,0\cdot10^{11}$	$5,3\cdot10^{10}$	$5,3\cdot10^{10}$

Table 3-8. Realistic and conservative radionuclide inventory for ’odd waste’, waste type level. (cont.)

Nuclide	Odd waste BLA		Odd waste BTF		Odd waste BMA	
	Realistic	**Cons.**	**Realistic**	**Cons.**	**Realistic**	**Cons.**
Correlated to Pu-236 + Pu-240						
Pu-239	$8,0\cdot10^{7}$	$8,0\cdot10^{7}$	$5,2\cdot10^{8}$	$5,2\cdot10^{8}$	$4,6\cdot10^{8}$	$4,6\cdot10^{8}$
Pu-240	$1,6\cdot10^{8}$	$1,6\cdot10^{8}$	$1,0\cdot10^{9}$	$1,0\cdot10^{9}$	$9,3\cdot10^{8}$	$9,3\cdot10^{8}$
Pb-210	$2,4\cdot10^{-3}$	$2,4\cdot10^{-3}$	$1,4\cdot10^{-2}$	$1,4\cdot10^{-2}$	$1,4\cdot10^{-2}$	$1,4\cdot10^{-2}$
Ra-226	$4,8\cdot10^{-2}$	$4,8\cdot10^{-2}$	$3,1\cdot10^{-1}$	$3,1\cdot10^{-1}$	$2,8\cdot10^{-1}$	$2,8\cdot10^{-1}$
Ac-227	$4,7\cdot10^{-1}$	$4,7\cdot10^{-1}$	$2,7\cdot10^{0}$	$2,7\cdot10^{0}$	$2,8\cdot10^{0}$	$2,8\cdot10^{0}$
Th-229	$7,2\cdot10^{-2}$	$7,2\cdot10^{-2}$	$4,6\cdot10^{-1}$	$4,6\cdot10^{-1}$	$4,2\cdot10^{-1}$	$4,2\cdot10^{-1}$
Th-230	$2,2\cdot10^{1}$	$2,2\cdot10^{1}$	$1,4\cdot10^{2}$	$1,4\cdot10^{2}$	$1,3\cdot10^{2}$	$1,3\cdot10^{2}$
Th-232	$2,4\cdot10^{-5}$	$2,4\cdot10^{-5}$	$1,6\cdot10^{-4}$	$1,6\cdot10^{-4}$	$1,4\cdot10^{-4}$	$1,4\cdot10^{-4}$
Pa-231	$7,2\cdot10^{0}$	$7,2\cdot10^{0}$	$4,7\cdot10^{1}$	$4,7\cdot10^{1}$	$4,2\cdot10^{1}$	$4,2\cdot10^{1}$
U-232	$5,7\cdot10^{3}$	$5,7\cdot10^{3}$	$3,6\cdot10^{4}$	$3,6\cdot10^{4}$	$3,3\cdot10^{4}$	$3,3\cdot10^{4}$
U-233	$4,8\cdot10^{0}$	$4,8\cdot10^{0}$	$3,1\cdot10^{1}$	$3,1\cdot10^{1}$	$2,8\cdot10^{1}$	$2,8\cdot10^{1}$
U-234	$2,4\cdot10^{5}$	$2,4\cdot10^{5}$	$1,6\cdot10^{6}$	$1,6\cdot10^{6}$	$1,4\cdot10^{6}$	$1,4\cdot10^{6}$
U-235	$4,8\cdot10^{3}$	$4,8\cdot10^{3}$	$3,1\cdot10^{4}$	$3,1\cdot10^{4}$	$2,8\cdot10^{4}$	$2,8\cdot10^{4}$
U-236	$7,2\cdot10^{4}$	$7,2\cdot10^{4}$	$4,7\cdot10^{5}$	$4,7\cdot10^{5}$	$4,2\cdot10^{5}$	$4,2\cdot10^{5}$
U-238	$9,6\cdot10^{4}$	$9,6\cdot10^{4}$	$6,2\cdot10^{5}$	$6,2\cdot10^{5}$	$5,6\cdot10^{5}$	$5,6\cdot10^{5}$
Np-237	$9,6\cdot10^{4}$	$9,6\cdot10^{4}$	$6,2\cdot10^{5}$	$6,2\cdot10^{5}$	$5,6\cdot10^{5}$	$5,6\cdot10^{5}$
Pu-238	$8,0\cdot10^{8}$	$8,0\cdot10^{8}$	$5,0\cdot10^{9}$	$5,0\cdot10^{9}$	$4,7\cdot10^{9}$	$4,7\cdot10^{9}$
Pu-241	$8,3\cdot10^{9}$	$8,3\cdot10^{9}$	$4,6\cdot10^{10}$	$4,6\cdot10^{10}$	$5,0\cdot10^{10}$	$5,0\cdot10^{10}$
Pu-242	$7,2\cdot10^{5}$	$7,2\cdot10^{5}$	$4,7\cdot10^{6}$	$4,7\cdot10^{6}$	$4,2\cdot10^{6}$	$4,2\cdot10^{6}$
Am-241	$2,3\cdot10^{8}$	$2,3\cdot10^{8}$	$1,5\cdot10^{9}$	$1,5\cdot10^{9}$	$1,3\cdot10^{9}$	$1,3\cdot10^{9}$
Am-242m	$2,1\cdot10^{6}$	$2,1\cdot10^{6}$	$1,4\cdot10^{7}$	$1,4\cdot10^{7}$	$1,2\cdot10^{7}$	$1,2\cdot10^{7}$
Am-243	$7,2\cdot10^{6}$	$7,2\cdot10^{6}$	$4,6\cdot10^{7}$	$4,6\cdot10^{7}$	$4,2\cdot10^{7}$	$4,2\cdot10^{7}$
Cm-243	$2,8\cdot10^{6}$	$2,8\cdot10^{6}$	$1,7\cdot10^{7}$	$1,7\cdot10^{7}$	$1,7\cdot10^{7}$	$1,7\cdot10^{7}$
Cm-244	$3,1\cdot10^{8}$	$3,1\cdot10^{8}$	$1,7\cdot10^{9}$	$1,7\cdot10^{9}$	$1,8\cdot10^{9}$	$1,8\cdot10^{9}$
Cm-245	$7,2\cdot10^{4}$	$7,2\cdot10^{4}$	$4,6\cdot10^{5}$	$4,6\cdot10^{5}$	$4,2\cdot10^{5}$	$4,2\cdot10^{5}$
Cm-246	$1,9\cdot10^{4}$	$1,9\cdot10^{4}$	$1,2\cdot10^{5}$	$1,2\cdot10^{5}$	$1,1\cdot10^{5}$	$1,1\cdot10^{5}$
Pu-244	$1,7\cdot10^{-1}$	$1,7\cdot10^{-1}$	$1,1\cdot10^{0}$	$1,1\cdot10^{0}$	$9,8\cdot10^{-1}$	$9,8\cdot10^{-1}$

4 Realistic nuclide inventory

The realistic inventory has been calculated according to the methods described in chapter 1.3. The result is an inventory that consists of approximately $1,0\cdot10^{15}$ Bq (31 December 2030). In Table 4-1 the inventory is presented for all the nuclides.

Table 4-1. Realistic inventory 31 December 2030 (odd waste is excluded).

Nuclide	Total	Silo	BTF	BMA	BLA
Correlated to Co-60:					
Co-60	$1,9\cdot10^{14}$	$1,7\cdot10^{14}$	$1,3\cdot10^{12}$	$1,4\cdot10^{13}$	$1,2\cdot10^{11}$
Ag-108m	$1,4\cdot10^{11}$	$1,2\cdot10^{11}$	$2,4\cdot10^{9}$	$2,4\cdot10^{10}$	$2,5\cdot10^{8}$
Ba-133	$5,1\cdot10^{9}$	$4,6\cdot10^{9}$	$5,7\cdot10^{7}$	$5,2\cdot10^{8}$	$5,8\cdot10^{6}$
Be-10	$1,5\cdot10^{6}$	$1,2\cdot10^{6}$	$2,5\cdot10^{4}$	$2,5\cdot10^{5}$	$2,7\cdot10^{3}$
C-14	$2,7\cdot10^{12}$	$2,0\cdot10^{12}$	$2,4\cdot10^{11}$	$4,2\cdot10^{11}$	$4,5\cdot10^{9}$
Fe-55	$6,3\cdot10^{13}$	$5,9\cdot10^{13}$	$1,4\cdot10^{11}$	$3,8\cdot10^{12}$	$1,1\cdot10^{10}$
H-3	$6,2\cdot10^{10}$	$5,5\cdot10^{10}$	$7,4\cdot10^{8}$	$6,7\cdot10^{9}$	$7,6\cdot10^{7}$
Ho-166m	$9,8\cdot10^{9}$	$8,0\cdot10^{9}$	$1,6\cdot10^{8}$	$1,6\cdot10^{9}$	$1,8\cdot10^{7}$
Mo-93	$1,2\cdot10^{10}$	$1,0\cdot10^{10}$	$2,1\cdot10^{8}$	$2,1\cdot10^{9}$	$2,2\cdot10^{7}$
Nb-93m	$8,3\cdot10^{11}$	$7,2\cdot10^{11}$	$1,1\cdot10^{10}$	$9,8\cdot10^{10}$	$1,1\cdot10^{9}$
Nb-94	$2,5\cdot10^{10}$	$2,0\cdot10^{10}$	$4,1\cdot10^{8}$	$4,2\cdot10^{9}$	$4,5\cdot10^{7}$
Ni-59	$2,5\cdot10^{12}$	$2,0\cdot10^{12}$	$4,1\cdot10^{10}$	$4,2\cdot10^{11}$	$4,5\cdot10^{9}$
Ni-63	$4,1\cdot10^{14}$	$3,4\cdot10^{14}$	$6,6\cdot10^{12}$	$6,5\cdot10^{13}$	$7,1\cdot10^{11}$
Sb-125	$6,4\cdot10^{12}$	$6,0\cdot10^{12}$	$1,5\cdot10^{10}$	$3,9\cdot10^{11}$	$1,1\cdot10^{9}$
Zr-93	$2,5\cdot10^{9}$	$2,0\cdot10^{9}$	$4,1\cdot10^{7}$	$4,2\cdot10^{8}$	$4,5\cdot10^{6}$
Correlated to Cs-137:					
Cs-137	$2,7\cdot10^{14}$	$2,4\cdot10^{14}$	$3,2\cdot10^{12}$	$2,8\cdot10^{13}$	$4,3\cdot10^{11}$
Cd-113m	$8,6\cdot10^{10}$	$7,8\cdot10^{10}$	$8,7\cdot10^{8}$	$7,3\cdot10^{9}$	$1,2\cdot10^{8}$
Cl-36	$5,2\cdot10^{9}$	$4,5\cdot10^{9}$	$7,3\cdot10^{7}$	$6,8\cdot10^{8}$	$9,4\cdot10^{6}$
Cs-134	$1,1\cdot10^{13}$	$1,1\cdot10^{13}$	$8,1\cdot10^{9}$	$3,6\cdot10^{11}$	$7,3\cdot10^{8}$
Cs-135	$2,6\cdot10^{9}$	$2,2\cdot10^{9}$	$3,7\cdot10^{7}$	$3,4\cdot10^{8}$	$4,7\cdot10^{6}$
Eu-152	$4,7\cdot10^{10}$	$8,7\cdot10^{9}$	$3,8\cdot10^{10}$	$8,0\cdot10^{8}$	$1,3\cdot10^{7}$
Eu-154	$8,0\cdot10^{12}$	$7,4\cdot10^{12}$	$6,6\cdot10^{10}$	$5,4\cdot10^{11}$	$8,8\cdot10^{9}$
Eu-155	$2,4\cdot10^{12}$	$2,3\cdot10^{12}$	$1,2\cdot10^{10}$	$1,3\cdot10^{11}$	$1,5\cdot10^{9}$
I-129	$1,6\cdot10^{8}$	$1,3\cdot10^{8}$	$2,2\cdot10^{6}$	$2,0\cdot10^{7}$	$2,8\cdot10^{5}$
Pd-107	$5,2\cdot10^{8}$	$4,5\cdot10^{8}$	$7,3\cdot10^{6}$	$6,8\cdot10^{7}$	$9,4\cdot10^{5}$
Pm-147	$1,3\cdot10^{13}$	$1,3\cdot10^{13}$	$2,1\cdot10^{10}$	$5,2\cdot10^{11}$	$2,2\cdot10^{9}$
Ru-106	$2,8\cdot10^{10}$	$2,8\cdot10^{10}$	$3,9\cdot10^{5}$	$6,7\cdot10^{8}$	$1,7\cdot10^{4}$
Se-79	$2,1\cdot10^{9}$	$1,8\cdot10^{9}$	$2,9\cdot10^{7}$	$2,7\cdot10^{8}$	$3,8\cdot10^{6}$
Sm-151	$1,2\cdot10^{12}$	$1,1\cdot10^{12}$	$1,7\cdot10^{10}$	$1,5\cdot10^{11}$	$2,1\cdot10^{9}$
Sn-126	$2,6\cdot10^{8}$	$2,2\cdot10^{8}$	$3,7\cdot10^{6}$	$3,4\cdot10^{7}$	$4,7\cdot10^{5}$
Sr-90	$2,6\cdot10^{13}$	$2,3\cdot10^{13}$	$3,1\cdot10^{11}$	$2,7\cdot10^{12}$	$4,1\cdot10^{10}$
Tc-99	$2,6\cdot10^{12}$	$2,2\cdot10^{12}$	$3,7\cdot10^{10}$	$3,4\cdot10^{11}$	$4,7\cdot10^{9}$

Table 4-1. Realistic inventory 31 December 2030 (odd waste is excluded) (cont.)

Nuclide	**Total**	**Silo**	**BTF**	**BMA**	**BLA**
Correlated to Pu-239 + Pu-240:					
Pu-239	$3,0\cdot10^{10}$	$2,6\cdot10^{10}$	$1,8\cdot10^{8}$	$3,0\cdot10^{9}$	$9,7\cdot10^{7}$
Pu-240	$5,9\cdot10^{10}$	$5,3\cdot10^{10}$	$3,6\cdot10^{8}$	$6,0\cdot10^{9}$	$1,9\cdot10^{8}$
Pb-210	$9,2\cdot10^{-1}$	$8,2\cdot10^{-1}$	$4,9\cdot10^{-3}$	$9,1\cdot10^{-2}$	$2,9\cdot10^{-3}$
Ra-226	$1,8\cdot10^{1}$	$1,6\cdot10^{1}$	$1,1\cdot10^{-1}$	$1,8\cdot10^{0}$	$5,8\cdot10^{-2}$
Ac-227	$1,8\cdot10^{2}$	$1,6\cdot10^{2}$	$9,6\cdot10^{-1}$	$1,8\cdot10^{1}$	$5,8\cdot10^{-1}$
Th-229	$2,7\cdot10^{1}$	$2,4\cdot10^{1}$	$1,6\cdot10^{-1}$	$2,7\cdot10^{0}$	$8,8\cdot10^{-2}$
Th-230	$8,0\cdot10^{3}$	$7,1\cdot10^{3}$	$4,9\cdot10^{1}$	$8,1\cdot10^{2}$	$2,6\cdot10^{1}$
Th-232	$8,9\cdot10^{-3}$	$7,9\cdot10^{-3}$	$5,4\cdot10^{-5}$	$9,0\cdot10^{-4}$	$2,9\cdot10^{-5}$
Pa-231	$2,7\cdot10^{3}$	$2,4\cdot10^{3}$	$1,6\cdot10^{1}$	$2,7\cdot10^{2}$	$8,8\cdot10^{0}$
U-232	$2,1\cdot10^{6}$	$1,9\cdot10^{6}$	$1,2\cdot10^{4}$	$2,1\cdot10^{5}$	$7,0\cdot10^{3}$
U-233	$1,8\cdot10^{3}$	$1,6\cdot10^{3}$	$1,1\cdot10^{1}$	$1,8\cdot10^{2}$	$5,8\cdot10^{0}$
U-234	$8,9\cdot10^{7}$	$7,9\cdot10^{7}$	$5,4\cdot10^{5}$	$9,0\cdot10^{6}$	$2,9\cdot10^{5}$
U-235	$1,8\cdot10^{6}$	$1,6\cdot10^{6}$	$1,1\cdot10^{4}$	$1,8\cdot10^{5}$	$5,8\cdot10^{3}$
U-236	$2,7\cdot10^{7}$	$2,4\cdot10^{7}$	$1,6\cdot10^{5}$	$2,7\cdot10^{6}$	$8,8\cdot10^{4}$
U-238	$3,6\cdot10^{7}$	$3,2\cdot10^{7}$	$2,2\cdot10^{5}$	$3,6\cdot10^{6}$	$1,2\cdot10^{5}$
Np-237	$3,6\cdot10^{7}$	$3,2\cdot10^{7}$	$2,2\cdot10^{5}$	$3,6\cdot10^{6}$	$1,2\cdot10^{5}$
Pu-238	$3,0\cdot10^{11}$	$2,7\cdot10^{11}$	$1,8\cdot10^{9}$	$3,0\cdot10^{10}$	$9,8\cdot10^{8}$
Pu-241	$3,2\cdot10^{12}$	$2,9\cdot10^{12}$	$1,6\cdot10^{10}$	$3,2\cdot10^{11}$	$1,0\cdot10^{10}$
Pu-242	$2,7\cdot10^{8}$	$2,4\cdot10^{8}$	$1,6\cdot10^{6}$	$2,7\cdot10^{7}$	$8,8\cdot10^{5}$
Am-241	$5,9\cdot10^{11}$	$5,8\cdot10^{11}$	$5,2\cdot10^{8}$	$8,6\cdot10^{9}$	$2,8\cdot10^{8}$
Am-242m	$8,0\cdot10^{8}$	$7,1\cdot10^{8}$	$4,8\cdot10^{6}$	$8,0\cdot10^{7}$	$2,6\cdot10^{6}$
Am-243	$2,7\cdot10^{9}$	$2,4\cdot10^{9}$	$1,6\cdot10^{7}$	$2,7\cdot10^{8}$	$8,8\cdot10^{6}$
Cm-243	$1,1\cdot10^{9}$	$9,5\cdot10^{8}$	$5,8\cdot10^{6}$	$1,1\cdot10^{8}$	$3,4\cdot10^{6}$
Cm-244	$1,2\cdot10^{11}$	$1,1\cdot10^{11}$	$6,1\cdot10^{8}$	$1,2\cdot10^{10}$	$3,8\cdot10^{8}$
Cm-245	$2,7\cdot10^{7}$	$2,4\cdot10^{7}$	$1,6\cdot10^{5}$	$2,7\cdot10^{6}$	$8,8\cdot10^{4}$
Cm-246	$7,1\cdot10^{6}$	$6,3\cdot10^{6}$	$4,3\cdot10^{4}$	$7,1\cdot10^{5}$	$2,3\cdot10^{4}$
Pu-244	$6,2\cdot10^{1}$	$5,5\cdot10^{1}$	$3,8\cdot10^{-1}$	$6,3\cdot10^{0}$	$2,0\cdot10^{-1}$
Total	$1,0\cdot10^{15}$	$8,8\cdot10^{14}$	$1,2\cdot10^{13}$	$1,2\cdot10^{14}$	$1,4\cdot10^{12}$

5 Conservative nuclide inventor

The conservative inventory in Table 5-1 is based on the realistic inventory as described in chapter 1.3.5. These numbers are the ones that are used in the calculations performed in the SAFE project.

Table 5-1. Conservative inventory 31 December 2030 for SFR-1.

Nuclide	Total	Silo	BTF	BMA	BLA
Correlated to Co-60:					
Co-60	$1,9\cdot10^{15}$	$1,8\cdot10^{15}$	$1,4\cdot10^{13}$	$7,1\cdot10^{13}$	$1,0\cdot10^{12}$
Ag-108m	$1,4\cdot10^{12}$	$1,2\cdot10^{12}$	$2,7\cdot10^{10}$	$1,2\cdot10^{11}$	$2,2\cdot10^{9}$
Ba-133	$5,1\cdot10^{10}$	$4,8\cdot10^{10}$	$6,6\cdot10^{8}$	$2,6\cdot10^{9}$	$5,1\cdot10^{7}$
Be-10	$1,4\cdot10^{7}$	$1,3\cdot10^{7}$	$2,9\cdot10^{5}$	$1,3\cdot10^{6}$	$2,3\cdot10^{4}$
C-14	$2,6\cdot10^{13}$	$2,1\cdot10^{13}$	$2,8\cdot10^{12}$	$2,1\cdot10^{12}$	$3,9\cdot10^{10}$
Fe-55	$6,5\cdot10^{14}$	$6,3\cdot10^{14}$	$1,6\cdot10^{12}$	$1,9\cdot10^{13}$	$9,5\cdot10^{10}$
H-3	$6,2\cdot10^{11}$	$5,8\cdot10^{11}$	$8,5\cdot10^{9}$	$3,3\cdot10^{10}$	$6,6\cdot10^{8}$
Ho-166m	$9,4\cdot10^{10}$	$8,4\cdot10^{10}$	$1,9\cdot10^{9}$	$8,2\cdot10^{9}$	$1,5\cdot10^{8}$
Mo-93	$1,2\cdot10^{11}$	$1,1\cdot10^{11}$	$2,4\cdot10^{9}$	$1,0\cdot10^{10}$	$1,9\cdot10^{8}$
Nb-93m	$8,2\cdot10^{12}$	$7,6\cdot10^{12}$	$1,2\cdot10^{11}$	$4,9\cdot10^{11}$	$9,7\cdot10^{9}$
Nb-94	$2,4\cdot10^{11}$	$2,1\cdot10^{11}$	$4,8\cdot10^{9}$	$2,1\cdot10^{10}$	$3,9\cdot10^{8}$
Ni-59	$2,4\cdot10^{13}$	$2,1\cdot10^{13}$	$4,8\cdot10^{11}$	$2,1\cdot10^{12}$	$3,9\cdot10^{10}$
Ni-63	$4,0\cdot10^{15}$	$3,6\cdot10^{15}$	$7,6\cdot10^{13}$	$3,2\cdot10^{14}$	$6,2\cdot10^{12}$
Sb-125	$6,6\cdot10^{13}$	$6,4\cdot10^{13}$	$1,7\cdot10^{11}$	$1,9\cdot10^{12}$	$9,9\cdot10^{9}$
Zr-93	$2,4\cdot10^{10}$	$2,1\cdot10^{10}$	$4,8\cdot10^{8}$	$2,1\cdot10^{9}$	$3,9\cdot10^{7}$
Correlated to Cs-137:					
Cs-137	$2,7\cdot10^{15}$	$2,5\cdot10^{15}$	$3,7\cdot10^{13}$	$1,4\cdot10^{14}$	$3,7\cdot10^{12}$
Cd-113m	$8,7\cdot10^{11}$	$8,2\cdot10^{11}$	$1,0\cdot10^{10}$	$3,6\cdot10^{10}$	$1,0\cdot10^{9}$
Cl-36	$5,1\cdot10^{10}$	$4,7\cdot10^{10}$	$8,4\cdot10^{8}$	$3,4\cdot10^{9}$	$8,2\cdot10^{7}$
Cs-134	$1,1\cdot10^{14}$	$1,1\cdot10^{14}$	$9,4\cdot10^{10}$	$1,8\cdot10^{12}$	$6,3\cdot10^{9}$
Cs-135	$2,6\cdot10^{10}$	$2,4\cdot10^{10}$	$4,2\cdot10^{8}$	$1,7\cdot10^{9}$	$4,1\cdot10^{7}$
Eu-152	$5,3\cdot10^{11}$	$9,2\cdot10^{10}$	$4,4\cdot10^{11}$	$4,0\cdot10^{9}$	$1,1\cdot10^{8}$
Eu-154	$8,2\cdot10^{13}$	$7,9\cdot10^{13}$	$7,6\cdot10^{11}$	$2,7\cdot10^{12}$	$7,6\cdot10^{10}$
Eu-155	$2,5\cdot10^{13}$	$2,4\cdot10^{13}$	$1,4\cdot10^{11}$	$6,3\cdot10^{11}$	$1,3\cdot10^{10}$
I-129	$1,5\cdot10^{9}$	$1,4\cdot10^{9}$	$2,5\cdot10^{7}$	$1,0\cdot10^{8}$	$2,5\cdot10^{6}$
Pd-107	$5,1\cdot10^{9}$	$4,7\cdot10^{9}$	$8,4\cdot10^{7}$	$3,4\cdot10^{8}$	$8,2\cdot10^{6}$
Pm-147	$1,4\cdot10^{14}$	$1,3\cdot10^{14}$	$2,5\cdot10^{11}$	$2,6\cdot10^{12}$	$1,9\cdot10^{10}$
Ru-106	$2,9\cdot10^{11}$	$2,9\cdot10^{11}$	$4,5\cdot10^{6}$	$3,4\cdot10^{9}$	$1,5\cdot10^{5}$
Se-79	$2,1\cdot10^{10}$	$1,9\cdot10^{10}$	$3,4\cdot10^{8}$	$1,4\cdot10^{9}$	$3,3\cdot10^{7}$
Sm-151	$1,2\cdot10^{13}$	$1,1\cdot10^{13}$	$1,9\cdot10^{11}$	$7,5\cdot10^{11}$	$1,9\cdot10^{10}$
Sn-126	$2,6\cdot10^{9}$	$2,4\cdot10^{9}$	$4,2\cdot10^{7}$	$1,7\cdot10^{8}$	$4,1\cdot10^{6}$
Sr-90	$2,6\cdot10^{14}$	$2,4\cdot10^{14}$	$3,6\cdot10^{12}$	$1,4\cdot10^{13}$	$3,6\cdot10^{11}$
Tc-99	$2,6\cdot10^{13}$	$2,4\cdot10^{13}$	$4,2\cdot10^{11}$	$1,7\cdot10^{12}$	$4,1\cdot10^{10}$

Table 5-1. Conservative inventory 31 December 2030 for SFR-1. (cont.)

Nuclide	Total	Silo	BTF	BMA	BLA
Correlated to Pu-239 + Pu-240:					
Pu-239	$3,0\cdot10^{11}$	$2,8\cdot10^{11}$	$2,1\cdot10^{9}$	$1,5\cdot10^{10}$	$8,5\cdot10^{8}$
Pu-240	$5,9\cdot10^{11}$	$5,6\cdot10^{11}$	$4,2\cdot10^{9}$	$3,0\cdot10^{10}$	$1,7\cdot10^{9}$
Pb-210	$9,2\cdot10^{0}$	$8,6\cdot10^{0}$	$5,6\cdot10^{-2}$	$4,5\cdot10^{-1}$	$2,5\cdot10^{-2}$
Ra-226	$1,8\cdot10^{2}$	$1,7\cdot10^{2}$	$1,2\cdot10^{0}$	$8,8\cdot10^{0}$	$5,0\cdot10^{-1}$
Ac-227	$1,8\cdot10^{3}$	$1,7\cdot10^{3}$	$1,1\cdot10^{1}$	$8,9\cdot10^{1}$	$5,0\cdot10^{0}$
Th-229	$2,7\cdot10^{2}$	$2,5\cdot10^{2}$	$1,9\cdot10^{0}$	$1,3\cdot10^{1}$	$7,6\cdot10^{-1}$
Th-230	$8,0\cdot10^{4}$	$7,5\cdot10^{4}$	$5,6\cdot10^{2}$	$4,0\cdot10^{3}$	$2,3\cdot10^{2}$
Th-232	$8,9\cdot10^{-2}$	$8,4\cdot10^{-2}$	$6,3\cdot10^{-4}$	$4,5\cdot10^{-3}$	$2,5\cdot10^{-4}$
Pa-231	$2,7\cdot10^{4}$	$2,5\cdot10^{4}$	$1,9\cdot10^{2}$	$1,3\cdot10^{3}$	$7,6\cdot10^{1}$
U-232	$2,1\cdot10^{7}$	$2,0\cdot10^{7}$	$1,4\cdot10^{5}$	$1,1\cdot10^{6}$	$6,1\cdot10^{4}$
U-233	$1,8\cdot10^{4}$	$1,7\cdot10^{4}$	$1,3\cdot10^{2}$	$8,9\cdot10^{2}$	$5,1\cdot10^{1}$
U-234	$8,9\cdot10^{8}$	$8,4\cdot10^{8}$	$6,3\cdot10^{6}$	$4,5\cdot10^{7}$	$2,5\cdot10^{6}$
U-235	$1,8\cdot10^{7}$	$1,7\cdot10^{7}$	$1,3\cdot10^{5}$	$8,9\cdot10^{5}$	$5,1\cdot10^{4}$
U-236	$2,7\cdot10^{8}$	$2,5\cdot10^{8}$	$1,9\cdot10^{6}$	$1,3\cdot10^{7}$	$7,6\cdot10^{5}$
U-238	$3,6\cdot10^{8}$	$3,3\cdot10^{8}$	$2,5\cdot10^{6}$	$1,8\cdot10^{7}$	$1,0\cdot10^{6}$
Np-237	$3,6\cdot10^{8}$	$3,3\cdot10^{8}$	$2,5\cdot10^{6}$	$1,8\cdot10^{7}$	$1,0\cdot10^{6}$
Pu-238	$3,0\cdot10^{12}$	$2,8\cdot10^{12}$	$2,0\cdot10^{10}$	$1,5\cdot10^{11}$	$8,5\cdot10^{9}$
Pu-241	$3,2\cdot10^{13}$	$3,1\cdot10^{13}$	$1,8\cdot10^{11}$	$1,6\cdot10^{12}$	$8,8\cdot10^{10}$
Pu-242	$2,7\cdot10^{9}$	$2,5\cdot10^{9}$	$1,9\cdot10^{7}$	$1,3\cdot10^{8}$	$7,6\cdot10^{6}$
Am-241	$6,1\cdot10^{12}$	$6,1\cdot10^{12}$	$6,0\cdot10^{9}$	$4,3\cdot10^{10}$	$2,5\cdot10^{9}$
Am-242m	$8,0\cdot10^{9}$	$7,5\cdot10^{9}$	$5,5\cdot10^{7}$	$4,0\cdot10^{8}$	$2,3\cdot10^{7}$
Am-243	$2,7\cdot10^{10}$	$2,5\cdot10^{10}$	$1,9\cdot10^{8}$	$1,3\cdot10^{9}$	$7,6\cdot10^{7}$
Cm-243	$1,1\cdot10^{10}$	$1,0\cdot10^{10}$	$6,8\cdot10^{7}$	$5,3\cdot10^{8}$	$3,0\cdot10^{7}$
Cm-244	$1,2\cdot10^{12}$	$1,1\cdot10^{12}$	$7,0\cdot10^{9}$	$5,9\cdot10^{10}$	$3,3\cdot10^{9}$
Cm-245	$2,7\cdot10^{8}$	$2,5\cdot10^{8}$	$1,9\cdot10^{6}$	$1,3\cdot10^{7}$	$7,6\cdot10^{5}$
Cm-246	$7,1\cdot10^{7}$	$6,7\cdot10^{7}$	$5,0\cdot10^{5}$	$3,6\cdot10^{6}$	$2,0\cdot10^{5}$
Pu-244	$6,2\cdot10^{2}$	$5,8\cdot10^{2}$	$4,4\cdot10^{0}$	$3,1\cdot10^{1}$	$1,8\cdot10^{0}$
Total	$1,0\cdot10^{16}$	$9,3\cdot10^{15}$	$1,4\cdot10^{14}$	$5,9\cdot10^{14}$	$1,2\cdot10^{13}$

6 Uncertainties

The one uncertainty that overshadows all other is if the concept of correlation factors.

Large uncertainties are involved in the use of general correlation factors to estimate the activity content in specific waste types. The use of correlation factors is one possibility to estimate a reference radionuclide inventory for the purpose of safety assessment studies, when waste-type specific information is not at hand. The outcome of the safety assessment will, however, give indications on which radionuclides it is of major concern to reduce the uncertainties in the reference inventory.

The largest uncertainty is related to the general correlation factors selected. The correlation factors evaluated for specific radionuclides vary within orders of magnitude, which gives an indication of the uncertainty interval. In addition, no statistical evaluations have been made in this study to prove that correlations between the key nuclides (Co-60, Cs-137 and Pu-239+240) and the other nuclides exist.

7 References

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Appendix C

Waste types in BLA

1 General

1.1 Waste in BLA

In SFR in the BLA – rock cavern for low-level waste – short-lived waste from the nuclear power plants and the Studsvik research site are disposed off. The BLA cavern is approximately 160 m long, 15 m wide and has a height of 12,5 m. The cavern is very simple to its construction, basically there is only a concrete floor on which containers are placed. During the operational phase a ceiling has been placed over the waste in order to minimise water dripping on to the waste. This roof will be dismantled when the repository is closed.

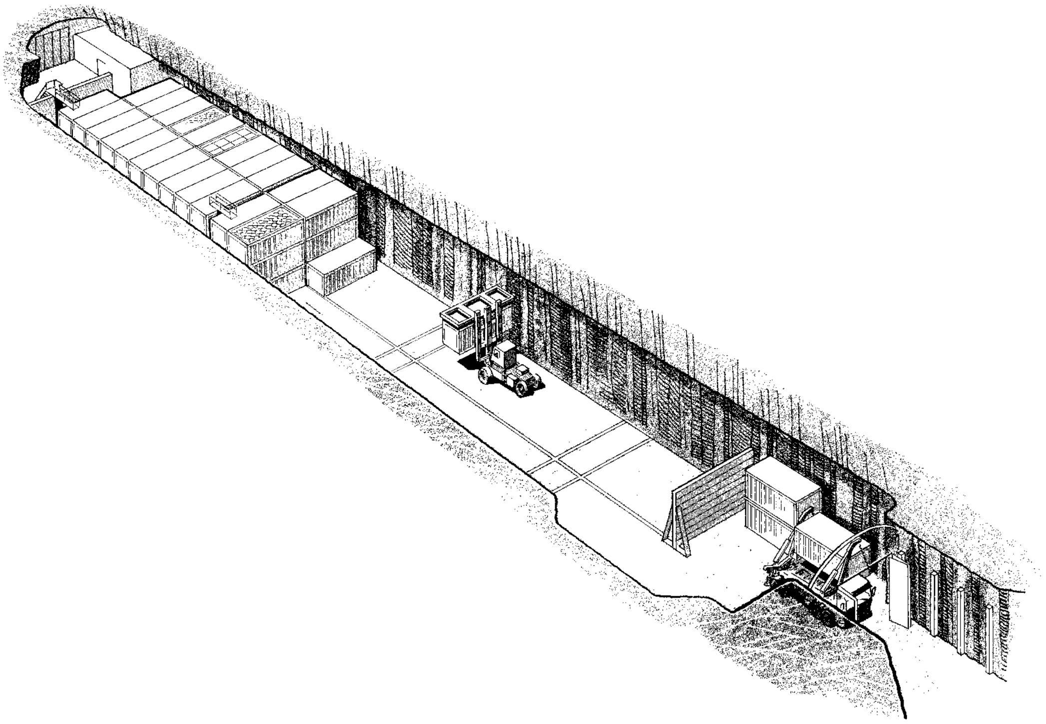

Figure 1-1. *BLA.*

The waste materials are metal scrap (iron/steel, aluminium); cellulose (e.g. wood, textile, paper), other organic materials (e.g. plastics, cables) and other waste like insulation (e.g. rock wool).

The dose rate allowed on the waste packages is maximum 2 mSv/h at the surface of the packages. The amounts of radionuclides are low, dominating nuclide are Co-60. Other criteria for acceptance are:

- Construction, geometry, dimensions and weight must be suited to the handling system in SFR and the transportation system in general and in BLA in particular. The strength of the packages must be sufficient to withstand normal and unnormal handling.
- Each package must have an individual identity and the radionuclide content of gamma emitting nuclides shall be known.

- Surface contamination should not exceed 40 kBq/m2 for gamma and beta emitting nuclides and 4 kBq/m2 for alpha emitting nuclides.
- The internal dosrates and integrated dose must not affect the barrier properties in the repository.
- The chemical and physical properties and the structure of the waste should be known.
- Chemical aggressive or explosive material, pressurised gas and free liquid are not allowed.
- Gas production from the waste must not be to big.
- The waste shall have enough resistance towards corrosion that the integrity of the package is kept until sealing of the repository.
- Burnable waste must not be subject to self-ignition.
- Complexing agents should if possible be avoided.

All waste are normally packed in ISO containers. Inside the ISO container the waste could also have inner packages e.g. steel drums, bales, boxes etc. Some of the waste has been compacted.

1.2 Definitions

Surface area is defined as the area subject to anaerobic corrosion and gas production after sealing of the repository.

1.3 Uncertainties – general

- The presented waste types describes the types that has been, is in or can be foreseen to be produced in Sweden. New waste types may be present in the future.
- Almost all data is based on literature values, smaller changes may not been properly documented.
- All future production is based on a relative simple prognosis model. This model, described in appendix A, was chosen since the uncertainties about processes etc are large.
- No regard has been taken to improvements in processes etc.
- A reference package has been chosen based on best estimates. Actual packages may differ considerably from this reference package, the uncertainty for the whole population of packages is judged to be smaller.
- Big components as heat exchangers etc could in the future be of interest to dispose off in BLA. See chapter 10 in this appendix.
- Void presented in this report is based on best estimates, the estimates can be quite crude.

2 B.12

2.1 Waste type description

2.1.1 Waste package

The B.12 waste type consists of a standard ISO-container containing iron/steel, aluminium, cellulose and other organic materials generated at the Barsebäck nuclear power plant. The material is classified as low level waste.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.
- The contents of toxic material should fall within the limits for SFR-1. That means avoidance of toxic material. Small amounts of lead and PVC could follow this waste stream.

Packaging

The ISO container is made of steel with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The container is often referred to as '20 feet half height container'. The weight of steel is approximately 1900 kg and the surface area of the container is approximately 104 m^2. The floor of the container could be of plywood or steel. The plywood floor weighs approximately 310 kg. The variation of weight between containers is between 1800 kg – 2300 kg.

Other containers are possible, 10 feet full or half height and 20 feet full height could be used.

Treatment and conditioning

The raw waste is collected from controlled areas from various places in the power plant. Some coarse sorting is made at each collection point before transported to central treatment.

The waste is normally packed in plastic bags or steel drums and then placed in the ISO container. A few containers include super compacted drums.

The void varies but is estimated to 7,5 m^3 in a container.

2.1.2 Materials – chemical composition

The amounts of different materials in a B.12 container are given in Table 2-1. Data comes from /SKB, 1987; Berntsson, 1990; Jönsson 2000/. The mix of different waste materials has changed from time to time depending if incineration is used, on different maintenance work or other reasons.

The weight of the raw waste material is normally 10 000 kg per package including the weight of the container /Johansson, 2000/. The weight on the waste material can vary from approximately 5000–15000 kg depending on different waste materials.

Table 2-1. Amount of different material in a typical package B.12.

Material	Weight (kg)	Area (m^2)	Weight %*
Iron/steel	0-10000	0-508	0-100
Aluminium	0-200	0-30	0-2
Cellulose (including wood, paper, textiles, absorbed water)	0-5000		0-50
Other organic material (including plastics, rubber, cable)	0-3500		0-35
Other material (including insulation like mineral wool etc)	0-2500		0-25

* Upper limit calculated as per cent of the ratio between mass of material and 10 000 kg.

2.1.3 Radionuclide inventory

Before the waste is transported from Barsebäck NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $5,4 \cdot 10^9$ Bq for Co-60 and between 0 and $3,2 \cdot 10^8$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h but normally it is between 0–1,5 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

2.1.4 Waste production

The waste type has been in production since 1991 and is still in production. The number of packages produced until 1998-12-31 is 188, the annual production is estimated to 12, see appendix A.

2.2 Reference waste type description

2.2.1 Waste package and material

The number of packages that will be produced is estimated to 272 packages during the operation of Barsebäck.

Table 2-2 shows the content of different materials and steel surface areas of the packaging in typical package from Barsebäck.

The assumed composition of the waste in a reference waste package of B.12 is given in Table 2-3. The surface area on a metal components in the waste are estimated assuming planar plates with a thickness of 5 mm, and assuming a density of 7860 kg/m^3 for carbon and stainless steel and 2700 kg/m^3 for aluminium.

Table 2-2. Estimated reference packaging composition and surface area and thickness of components in an ISO container of B.12.

Component	Material	Weight	Surface area	Thickness
ISO container	Carbon steel	1900 kg	104 m^2	1,5 mm
Plywood	Cellulose	310 kg		

Table 2-3. Estimated reference waste composition and surface area and thickness of components in one B.12.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	4500	229	5
Aluminium	100	15	5
Cellulose (including wood, paper, textiles, absorbed water)	500 (2000)		
Other organic material (including plastics, rubber, cable)	3000		
Other material (including insulation like mineral wool etc)	400		

The total amounts of different materials in all the packages of B.12 are summarised in Table 2-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 2-5. The waste volume is estimated from the weights of the waste components in Table 2-3 and approximate densities of the different material. Average void is estimated to 50 % in a package.

Void and waste volume is specified in Table 2-5.

Table 2-4. Reference composition and surface area of metallic components in 272 containers B.12.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	1 224 000	62 228	516 800	28 288	1 740 800	90 516
Aluminium	27 200	4 080			27 200	4 080
Cellulose	136 000		84 320		220 320	
Other organic material	816 000				816 000	
Other material	108 800				108 800	

Table 2-5. Volumes in 1 and 272 reference waste packages of B.12.

	Volume in 1 package (m^3)	Volumes in 272 packages (m^3)
Waste	11,5	3128
Void	7,5	2040

2.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 2-6.

Table 2-6. Radionuclide composition of a reference waste package of the type B.12.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1,0\cdot10^{9}$	Pu-239	$2,5\cdot10^{1}$
Ag-108m	$6,3\cdot10^{4}$	Pu-240	$5,1\cdot10^{1}$
Ba-133	$1,0\cdot10^{4}$	Pb-210	$1,5\cdot10^{-9}$
Be-10	$6,3\cdot10^{-1}$	Ra-226	$1,5\cdot10^{-8}$
C-14	$1,0\cdot10^{6}$	Ac-227	$3,1\cdot10^{-7}$
Fe-55	$1,0\cdot10^{9}$	Th-229	$2,3\cdot10^{-8}$
H-3	$1,0\cdot10^{5}$	Th-230	$6,9\cdot10^{-6}$
Ho-166m	$4,2\cdot10^{3}$	Th-232	$7,6\cdot10^{-12}$
Mo-93	$5,2\cdot10^{3}$	Pa-231	$2,3\cdot10^{-6}$
Nb-93m	$1,0\cdot10^{6}$	U-232	$2,3\cdot10^{-3}$
Nb-94	$1,0\cdot10^{4}$	U-233	$1,5\cdot10^{-6}$
Ni-59	$1,0\cdot10^{6}$	U-234	$7,6\cdot10^{-2}$
Ni-63	$2,1\cdot10^{8}$	U-235	$1,5\cdot10^{-3}$
Sb-125	$1,0\cdot10^{8}$	U-236	$2,3\cdot10^{-2}$
Zr-93	$1,0\cdot10^{3}$	U-238	$3,1\cdot10^{-2}$
		Np-237	$3,1\cdot10^{-2}$
Correlated to Cs-137		Pu-238	$3,1\cdot10^{2}$
Cs-137	$2,4\cdot10^{7}$	Pu-241	$7,6\cdot10^{3}$
Cd-113m	$1,4\cdot10^{4}$	Pu-242	$2,3\cdot10^{-1}$
Cl-36	$2,4\cdot10^{2}$	Am-241	$7,6\cdot10^{1}$
Cs-134	$2,4\cdot10^{7}$	Am-242m	$7,6\cdot10^{-1}$
Cs-135	$1,2\cdot10^{2}$	Am-243	$2,3\cdot10^{0}$
Eu-152	$1,6\cdot10^{3}$	Cm-243	$1,5\cdot10^{0}$
Eu-154	$2,4\cdot10^{6}$	Cm-244	$2,3\cdot10^{2}$
Eu-155	$1,6\cdot10^{6}$	Cm-245	$2,3\cdot10^{-2}$
I-129	$7,1\cdot10^{0}$	Cm-246	$6,1\cdot10^{-3}$
Pd-107	$2,4\cdot10^{1}$	Pu-244	$5,3\cdot10^{-8}$
Pm-147	$2,1\cdot10^{7}$		
Ru-106	$1,2\cdot10^{5}$		
Se-79	$9,4\cdot10^{1}$		
Sm-151	$7,1\cdot10^{4}$		
Sn-126	$1,2\cdot10^{1}$		
Sr-90	$2,4\cdot10^{6}$		
Tc-99	$1,2\cdot10^{5}$		

A reference waste package of the type B.12 has a surface dose rate of 2 mSv/h and no surface contamination.

2.3 Uncertainties

- General uncertainties are described in chapter 1.3.

3 B.20

3.1 Waste type description

3.1.1 Waste package

The B.20 waste type consists of a standard ISO-container containing 200 l drums of steel with bitumen conditioned ion-exchange resins generated at the Barsebäck nuclear power plant. Each container includes 36 drums. The material is classified as low level waste.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.

Packaging

The ISO container is made of steel with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The container is often referred to as ‘20 feet half height container’. The weight of steel is approximately 1900 kg and the surface area of the container is approximately 104 m^2. The floor of the container could be of plywood or steel. The plywood floor weighs approximately 310 kg. The variation of weight between containers is between 1800 kg – 2300 kg.

The drums are exactly like waste type B.05 (see appendix E) or B.06 (see appendix F) except the amount of radionuclides and doserates. For all details of the drums about composition, treatment etc see the appendices E and F. The steel weight of 36 drums is 828 kg.

Treatment and conditioning

36 drums are placed in a container.

The void varies but is estimated to 7,4 m^3 in a container.

3.1.2 Materials – chemical composition

The amounts of different materials in a B.20 container are given in Table 3-1. Data comes from /Berntsson, 1991/.

The weight of a container and waste is between 9600 kg and 9800 kg /Johansson, 2000/. The weight on the waste material can vary but weighs approximately 200 kg per drum.

Table 3-1. Amount of different materials in a typical package B.20.

Material	Weight (kg)	Weight %
Ion exchange resin	1 800	25
Bitumen	5 400	75

3.1.3 Radionuclide inventory

Before the waste is transported from Barsebäck NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $6{,}3\cdot10^6$ Bq for Co-60 and between 0 and $1{,}5\cdot10^4$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h but normally it is between 0–0,4 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

3.1.4 Waste production

The waste type was in production until 1985. The number of packages produced was 12. No more production is foreseen, see appendix A.

3.2 Reference waste type description

3.2.1 Waste package and material

The number of packages that will be produced is estimated to 12 packages during the operation of Barsebäck.

Table 3-2 shows the content of different materials and steel surface areas of the packaging in typical package from Barsebäck.

The assumed composition of the waste in a reference waste package of B.20 is given in Table 3-3.

Table 3-2. Estimated reference packaging composition and surface area and thickness of components in an ISO container of B.20.

Component	Material	Weight	Surface area	Thickness
ISO container	Carbon steel	1900 kg	104 m^2	1,5 mm
Plywood	Cellulose	310 kg		
Steel drums (36)	Carbon steel	828 kg	109 m^2	1,25 mm

Table 3-3. Estimated reference waste composition and surface area and thickness of components in one B.20.

Material	Weight (kg)
Ion-exchange resin	1800
Bitumen	5400

The total amounts of different materials in all the packages of B.20 are summarised in Table 3-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 3-5. The waste volume is estimated from the weights of the waste components in Table 3-3 and approximate densities of the different material. Average void is estimated to 45 % in a package.

Void and waste volume is specified in Table 3-5.

Table 3-4. Reference composition and surface area of metallic components in 12 containers B.20 (including 36 drums).

Content	Waste weight (kg)	Packaging weight (kg)	Packaging area (m^2)	Waste packages weight (kg)	Waste packages area (m^2)
Iron/steel		32 736	2 556	32 736	2 556
Cellulose		3 720		3 720	
Ion-exchange resin	21 600			21 600	
Bitumen	64 800			64 800	

Table 3-5. Volumes in 1 and 12 reference waste packages of B.20 (including drums).

	Volume in 1 package (m^3)	Volumes in 12 packages (m^3)
Waste	11,7	140
Void	7,4	89

3.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 3-6. The transuranic elements have been calculated in a different way and it is not possible to calculate a reference waste type. An inventory for transuranic elements for all drums at the year 2030 is presented in appendix B.

Table 3-6. Radionuclide composition of a reference waste package of the type B.20.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Cs-137	
Co-60	$2,6\cdot10^{6}$	Cs-137	$4,9\cdot10^{3}$
Ag-108m	$1,6\cdot10^{2}$	Cd-113m	$3,0\cdot10^{0}$
Ba-133	$2,6\cdot10^{1}$	Cl-36	$4,9\cdot10^{-2}$
Be-10	$1,6\cdot10^{-3}$	Cs-134	$4,9\cdot10^{3}$
C-14	$2,6\cdot10^{3}$	Cs-135	$2,5\cdot10^{-2}$
Fe-55	$2,6\cdot10^{6}$	Eu-152	$3,4\cdot10^{-1}$
H-3	$2,6\cdot10^{2}$	Eu-154	$4,9\cdot10^{2}$
Ho-166m	$1,1\cdot10^{1}$	Eu-155	$3,4\cdot10^{2}$
Mo-93	$1,3\cdot10^{1}$	I-129	$1,5\cdot10^{-3}$
Nb-93m	$2,6\cdot10^{3}$	Pd-107	$4,9\cdot10^{-3}$
Nb-94	$2,6\cdot10^{1}$	Pm-147	$4,4\cdot10^{3}$
Ni-59	$2,6\cdot10^{3}$	Ru-106	$2,5\cdot10^{1}$
Ni-63	$5,3\cdot10^{5}$	Se-79	$2,0\cdot10^{-2}$
Sb-125	$2,6\cdot10^{5}$	Sm-151	$1,5\cdot10^{1}$
Zr-93	$2,6\cdot10^{0}$	Sn-126	$2,5\cdot10^{-3}$
		Sr-90	$4,9\cdot10^{2}$
		Tc-99	$2,5\cdot10^{1}$

A reference waste package of the type B.20 has a surface dose rate of 2 mSv/h and no surface contamination.

3.3 Uncertainties

- General uncertainties are described in chapter 1.3.

4 F.12

4.1 Waste type description

4.1.1 Waste package

The F.12 waste type consists of a standard ISO-container containing iron/steel, aluminium, cellulose and other organic materials generated at the Forsmark nuclear power plant. The material is classified as low level waste.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.
- The contents of toxic material should fall within the limits set up earlier for SFR-1. That means avoidance of toxic material. Small amounts of lead and PVC could follow this waste stream.

Packaging

The ISO container is made of steel with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The container is often referred to as '20 feet half height container'. The weight of steel is approximately 1900 kg and the surface area of the container is approximately 104 m^2. The floor of the container could be of plywood or steel. The plywood floor weighs approximately 310 kg. The variation of weight between containers is between 1800 kg – 2300 kg.

Other containers are possible, 10 feet full or half height and 20 feet full height could be used.

Treatment and conditioning

The raw waste is collected from controlled areas from various places in the power plant. Some coarse sorting is made at each collection point before transported to central treatment.

The waste is normally packed in plastic bags or steel drums and then placed in the ISO container. A few containers include super compacted drums with steel waste.

The void varies but is estimated to 7,5 m^3 in a container.

4.1.2 Materials – chemical composition

The amounts of different materials in a F.12 container are given in Table 4-1. Data comes from /Meijer, 1987; Lindberg et al, 1992; Larsson, 2000/. The mix of different waste materials has changed from time to time depending if incineration is used, on different maintenance work or other reasons.

The weight of the raw waste material is normally 10 000 kg per package including the weight of the container /Johansson, 2000/. The weight on the waste material can vary from approximately 5000–15000 kg depending on different waste materials.

Table 4-1. Amount of different material in a typical package F.12.

Material	Weight (kg)	Area (m^2)	Weight %
Iron/steel	0-10000	0-508	0-100
Aluminium	0-200	0-30	0-2
Cellulose (including wood, paper, textiles, absorbed water)	0-5000		0-50
Other organic material (including plastics, rubber, cable)	0-3500		0-35
Other material (including insulation like mineral wool etc)	0-2500		0-25

* Upper limit calculated as per cent of the ratio between mass of material and 10 000 kg.

4.1.3 Radionuclide inventory

Before the waste is transported from Forsmark NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $1{,}7 \cdot 10^{10}$ Bq for Co-60 and between 0 and $9{,}1 \cdot 10^{8}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h but normally it is between 0–0,8 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

4.1.4 Waste production

The waste type has been in production since 1991 and is still in production. The number of packages produced until 1998 is 20, the annual production is estimated to 0,5, see appendix A.

4.2 Reference waste type description

4.2.1 Waste package and material

The number of packages that will be produced is estimated to 28 packages during the operation of Forsmark.

Table 4-2 shows the content of different materials and steel surface areas of the packaging in typical package from Forsmark.

The assumed composition of the waste in a reference waste package of F.12 is given in Table 4-3. The surface area on a metal components in the waste are estimated assuming planar plates with a thickness of 5 mm, and assuming a density of 7860 kg/m^3 for carbon and stainless steel and 2700 kg/m^3 for aluminium.

Table 4-2. Estimated reference packaging composition and surface area and thickness of components in an ISO container of F.12.

Component	Material	Weight	Surface area	Thickness
ISO container	Carbon steel	1900 kg	104 m^2	1,5 mm
Plywood	Cellulose	310 kg		

Table 4-3. Estimated reference waste composition and surface area and thickness of components in one F.12.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	4500	229	5
Aluminium	100	15	5
Cellulose (including wood, paper, textiles, absorbed water)	500 (2000)		
Other organic material (including plastics, rubber, cable)	3000		
Other material (including insulation like mineral wool etc)	400		

The total amounts of different materials in all the packages of F.12 are summarised in Table 4-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 4-5. The waste volume is estimated from the weights of the waste components in Table 4-3 and approximate densities of the different material. Average void is estimated to 50 % in a package.

Void and waste volume is specified in Table 4-5.

Table 4-4. Reference composition and surface area of metallic components in 28 containers F.12.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	126 000	6 412	53 200	2 912	179 200	9 324
Aluminium	2 800	420			2 800	420
Cellulose	14 000				14 000	
Other organic material	84 000				84 000	
Other material	11 200				11 200	

Table 4-5. Volumes in 1 and 28 reference waste packages of F.12.

	Volume in 1 package (m^3)	Volumes in 28 packages (m^3)
Waste	11,5	322
Void	7,5	210

4.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 4-6.

Table 4-6. Radionuclide composition of a reference waste package of the type F.12.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1{,}5\cdot 10^{10}$	Pu-239	$8{,}7\cdot 10^{3}$
Ag-108m	$9{,}0\cdot 10^{5}$	Pu-240	$1{,}7\cdot 10^{4}$
Ba-133	$1{,}5\cdot 10^{5}$	Pb-210	$5{,}2\cdot 10^{-7}$
Be-10	$9{,}0\cdot 10^{0}$	Ra-226	$5{,}2\cdot 10^{-6}$
C-14	$1{,}5\cdot 10^{7}$	Ac-227	$1{,}0\cdot 10^{-4}$
Fe-55	$1{,}5\cdot 10^{10}$	Th-229	$7{,}9\cdot 10^{-6}$
H-3	$1{,}5\cdot 10^{6}$	Th-230	$2{,}4\cdot 10^{-3}$
Ho-166m	$6{,}0\cdot 10^{4}$	Th-232	$2{,}6\cdot 10^{-9}$
Mo-93	$7{,}5\cdot 10^{4}$	Pa-231	$7{,}9\cdot 10^{-4}$
Nb-93m	$1{,}5\cdot 10^{7}$	U-232	$7{,}9\cdot 10^{-1}$
Nb-94	$1{,}5\cdot 10^{5}$	U-233	$5{,}2\cdot 10^{-4}$
Ni-59	$1{,}5\cdot 10^{7}$	U-234	$2{,}6\cdot 10^{1}$
Ni-63	$3{,}0\cdot 10^{9}$	U-235	$5{,}2\cdot 10^{-1}$
Sb-125	$1{,}5\cdot 10^{9}$	U-236	$7{,}9\cdot 10^{0}$
Zr-93	$1{,}5\cdot 10^{4}$	U-238	$1{,}0\cdot 10^{1}$
		Np-237	$1{,}0\cdot 10^{1}$
Correlated to Cs-137		Pu-238	$1{,}0\cdot 10^{5}$
Cs-137	$1{,}7\cdot 10^{8}$	Pu-241	$2{,}6\cdot 10^{6}$
Cd-113m	$9{,}9\cdot 10^{4}$	Pu-242	$7{,}9\cdot 10^{1}$
Cl-36	$1{,}7\cdot 10^{3}$	Am-241	$2{,}6\cdot 10^{4}$
Cs-134	$1{,}7\cdot 10^{8}$	Am-242m	$2{,}6\cdot 10^{2}$
Cs-135	$8{,}3\cdot 10^{2}$	Am-243	$7{,}9\cdot 10^{2}$
Eu-152	$1{,}2\cdot 10^{4}$	Cm-243	$5{,}2\cdot 10^{2}$
Eu-154	$1{,}7\cdot 10^{7}$	Cm-244	$7{,}9\cdot 10^{4}$
Eu-155	$1{,}2\cdot 10^{7}$	Cm-245	$7{,}9\cdot 10^{0}$
I-129	$5{,}0\cdot 10^{1}$	Cm-246	$2{,}1\cdot 10^{0}$
Pd-107	$1{,}7\cdot 10^{2}$	Pu-244	$1{,}8\cdot 10^{-5}$
Pm-147	$1{,}5\cdot 10^{8}$		
Ru-106	$8{,}3\cdot 10^{5}$		
Se-79	$6{,}6\cdot 10^{2}$		
Sm-151	$5{,}0\cdot 10^{5}$		
Sn-126	$8{,}3\cdot 10^{1}$		
Sr-90	$1{,}7\cdot 10^{7}$		
Tc-99	$8{,}3\cdot 10^{5}$		

A reference waste package of the type F.12 has a surface dose rate of 2 mSv/h and no surface contamination.

4.3 Uncertainties

- General uncertainties are described in chapter 1.3.

5 F.20

5.1 Waste type description

5.1.1 Waste package

The F.20 waste type consists of a standard ISO-container containing 200 l drums of steel with bitumen conditioned ion-exchange resins generated at the Forsmark nuclear power plant. Each container includes 36 drums. The material is classified as low level waste.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.

Packaging

The ISO container is made of steel with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The container is often referred to as '20 feet half height container'. The weight of steel is approximately 1900 kg and the surface area of the container is approximately 104 m^2. The floor of the container could be of plywood or steel. The plywood floor weighs approximately 310 kg. The variation of weight between containers is between 1800 kg – 2300 kg.

The drums are exactly like waste type F.05 (see appendix E) except the amount of radionuclides and the doserates. For all details of the drums about composition, treatment etc see the appendix E. The steel weight of 36 drums is 900 kg.

Treatment and conditioning

36 drums are placed in a container.

The void varies but is estimated to 7 m^3 in a container.

5.1.2 Materials – chemical composition

The amounts of different materials in a F.20 container are given in Table 5-1. Data comes from /Lindberg et al, 1991/.

The weight of a container and waste is between 6600 kg and 7200 kg /Johansson, 2000/. The weight on the waste material can vary but weighs approximately 200 kg per drum.

Table 5-1. Amount of different materials in a typical package F.20.

Material	Weight (kg)	Weight %
Ion exchange resin	4680	60
Bitumen	3420	40

5.1.3 Radionuclide inventory

Before the waste is transported from Forsmark NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $8{,}4\cdot10^9$ Bq for Co-60 and between 0 and $4{,}2\cdot10^8$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h but normally it is between 0–0,1 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

5.1.4 Waste production

The waste type was in production until 1982. The number of packages produced was 15. No more production is foreseen, see appendix A.

5.2 Reference waste type description

5.2.1 Waste package and material

The number of packages that will be produced is estimated to 15 packages during the operation of Forsmark.

Table 5-2 shows the content of different materials and steel surface areas of the packaging in typical package from Forsmark.

The assumed composition of the waste in a reference waste package of F.20 is given in Table 5-3.

Table 5-2. Estimated reference packaging composition and surface area and thickness of components in a ISO container of F.20.

Component	Material	Weight	Surface area	Thickness
ISO container	Carbon steel	1900 kg	104 m^2	1,5 mm
Plywood	Cellulose	310 kg		
Steel drums (36)	Carbon steel	900 kg	90 m^2	1,25 mm

Table 5-3. Estimated reference waste composition and surface area and thickness of components in one F.20.

Material	Weight (kg)
Ion-exchange resin	4680
Bitumen	3450

The total amounts of different materials in all the packages of F.20 are summarised in Table 5-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 5-5. The waste volume is estimated from the weights of the waste components in Table 5-3 and approximate densities of the different material. Average void is estimated to 45 % in a package.

Void and waste volume is specified in Table 5-5.

Table 5-4. Reference composition and surface area of metallic components in 15 containers F.20 (including 36 drums).

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		42 000	2 910	42 000	2 910
Cellulose		4 650		4 650	
Ion-exchange resin	70 200			70 200	
Bitumen	51 300			51 300	

Table 5-5. Volumes in 1 and 15 reference waste packages of F.20 (including drums).

	Volume in 1 package (m^3)	Volumes in 272 packages (m^3)
Waste	12	180
Void	7	105

5.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 5-6. The transuranic elements have been calculated in a different way and it is not possible to calculate a reference waste type. An inventory for transuranic elements for all drums at the year 2030 is presented in appendix B.

Table 5-6. Radionuclide composition of a reference waste package of the type F.20.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Cs-137	
Co-60	$2{,}8 \cdot 10^9$	Cs-137	$1{,}1 \cdot 10^8$
Ag-108m	$1{,}7 \cdot 10^5$	Cd-113m	$6{,}7 \cdot 10^4$
Ba-133	$2{,}8 \cdot 10^4$	Cl-36	$1{,}1 \cdot 10^3$
Be-10	$1{,}7 \cdot 10^0$	Cs-134	$1{,}1 \cdot 10^8$
C-14	$2{,}8 \cdot 10^6$	Cs-135	$5{,}6 \cdot 10^2$
Fe-55	$2{,}8 \cdot 10^9$	Eu-152	$7{,}8 \cdot 10^3$
H-3	$2{,}8 \cdot 10^5$	Eu-154	$1{,}1 \cdot 10^7$
Ho-166m	$1{,}1 \cdot 10^4$	Eu-155	$7{,}8 \cdot 10^6$
Mo-93	$1{,}4 \cdot 10^4$	I-129	$3{,}4 \cdot 10^1$
Nb-93m	$2{,}8 \cdot 10^6$	Pd-107	$1{,}1 \cdot 10^2$
Nb-94	$2{,}8 \cdot 10^4$	Pm-147	$1{,}0 \cdot 10^8$
Ni-59	$2{,}8 \cdot 10^6$	Ru-106	$5{,}6 \cdot 10^5$
Ni-63	$5{,}6 \cdot 10^8$	Se-79	$4{,}5 \cdot 10^2$
Sb-125	$2{,}8 \cdot 10^8$	Sm-151	$3{,}4 \cdot 10^5$
Zr-93	$2{,}8 \cdot 10^3$	Sn-126	$5{,}6 \cdot 10^1$
		Sr-90	$1{,}1 \cdot 10^7$
		Tc-99	$5{,}6 \cdot 10^5$

A reference waste package of the type F.20 has a surface dose rate of 2 mSv/h and no surface contamination.

5.3 Uncertainties

- General uncertainties are described in chapter 1.3.

6 O.12

6.1 Waste type description

6.1.1 Waste package

The O.12 waste type consists of a standard ISO-container containing iron/steel, aluminium, cellulose and other organic materials generated at the Oskarshamn nuclear power plant. The material is classified as low level waste.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.
- The contents of toxic material should fall within the limits set up earlier for SFR-1. That means avoidance of toxic material. Small amounts of lead and PVC could follow this waste stream.

Packaging

The ISO container is made of steel with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The container is often referred to as '20 feet half height container'. The weight of steel is approximately 1900 kg and the surface area of the container is approximately 104 m^2. The floor of the container could be of plywood or steel. The plywood floor weighs approximately 310 kg. The variation of weight between containers is between 1800 kg – 2300 kg.

Other containers are possible, 10 feet full or half height and 20 feet full height could be used.

Treatment and conditioning

The raw waste is collected from controlled areas from various places in the power plant. Some coarse sorting is made at each collection point before transported to central treatment.

The waste is normally packed in plastic bags or steel drums and then placed in the ISO container. A few containers include super compacted drums with steel waste.

The void varies but is estimated to 7,5 m^3 in a container.

6.1.2 Materials – chemical composition

The amounts of different materials in an O.12 container are given in Table 6-1. Data comes from /Meijer, 1987; Ingemansson, 1999, 2000/. The mix of different waste materials has changed from time to time depending if incineration is used, on different maintenance work or other reasons.

The weight of the raw waste material is normally 10 000 kg per package including the weight of the container /Johansson, 2000/. The weight on the waste material can vary from approximately 5000–15000 kg depending on different waste materials.

Table 6-1. Amount of different material in a typical package O.12.

Material	Weight (kg)	Area (m^2)	Weight %
Iron/steel	0-10000	0-508	0-100
Aluminium	0-200	0-30	0-2
Cellulose (including wood, paper, textiles, absorbed water)	0-5000		0-50
Other organic material (including plastics, rubber, cable)	0-3500		0-35
Other material (including insulation like mineral wool etc)	0-2500		0-25

* Upper limit calculated as per cent of the ratio between mass of material and 10 000 kg.

6.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $6,2 \cdot 10^{10}$ Bq for Co-60 and between 0 and $5,1 \cdot 10^{11}$ Bq for Cs-137 (based on types B.12, F.12 and R.12). Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h. No information is available on normal doserates, but probably the doserates are like the normal dosrates for types B.12, F.12 and R.12. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

6.1.4 Waste production

The waste type has not been produced yet, the annual production is estimated to 5, see appendix A.

6.2 Reference waste type description

6.2.1 Waste package and material

The number of packages that will be produced is estimated to 80 packages during the operation of Oskarshamn.

Table 6-2 shows the content of different materials and steel surface areas of the packaging in typical package from Oskarshamn.

The assumed composition of the waste in a reference waste package of O.12 is given in Table 6-3. The surface area on a metal components in the waste are estimated assuming planar plates with a thickness of 5 mm, and assuming a density of 7860 kg/m^3 for carbon and stainless steel and 2700 kg/m^3 for aluminium.

Table 6-2. Estimated reference packaging composition and surface area and thickness of components in a ISO container of O.12.

Component	Material	Weight	Surface area	Thickness
ISO container	Carbon steel	1900 kg	104 m^2	1,5 mm
Plywood	Cellulose	310 kg		

Table 6-3. Estimated reference waste composition and surface area and thickness of components in one O.12.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	4500	229	5
Aluminium	100	15	5
Cellulose (including wood, paper, textiles, absorbed water)	500 (2000)		
Other organic material (including plastics, rubber, cable)	3000		
Other material (including insulation like mineral wool etc)	400		

The total amounts of different materials in all the packages of O.12 are summarised in Table 6-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 6-5. The waste volume is estimated from the weights of the waste components in Table 6-3 and approximate densities of the different material. Average void is estimated to 50 % in a package.

Void and waste volume is specified in Table 6-5.

Table 6-4. Reference composition and surface area of metallic components in 80 containers O.12.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	360 000	18 320	15 2000	8 320	512 000	266 640
Aluminium	8 000	1 200			8 000	8 000
Cellulose	40 000				40 000	
Other organic material	240 000				240 000	
Other material	32 000				32 000	

Table 6-5. Volumes in 1 and 80 reference waste packages of O.12.

	Volume in 1 package (m^3)	Volumes in 80 packages (m^3)
Waste	11,5	920
Void	7,5	600

6.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in table 6-6.

Table 6-6. Radionuclide composition of a reference waste package of the type O.12.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$4,3\cdot10^{9}$	Pu-239	$1,1\cdot10^{4}$
Ag-108m	$2,6\cdot10^{5}$	Pu-240	$2,3\cdot10^{4}$
Ba-133	$4,3\cdot10^{4}$	Pb-210	$6,8\cdot10^{-7}$
Be-10	$2,6\cdot10^{0}$	Ra-226	$6,8\cdot10^{-6}$
C-14	$4,3\cdot10^{6}$	Ac-227	$1,4\cdot10^{-4}$
Fe-55	$4,3\cdot10^{9}$	Th-229	$1,0\cdot10^{-5}$
H-3	$4,3\cdot10^{5}$	Th-230	$3,1\cdot10^{-3}$
Ho-166m	$1,7\cdot10^{4}$	Th-232	$3,4\cdot10^{-9}$
Mo-93	$2,1\cdot10^{4}$	Pa-231	$1,0\cdot10^{-3}$
Nb-93m	$4,3\cdot10^{6}$	U-232	$1,0\cdot10^{0}$
Nb-94	$4,3\cdot10^{4}$	U-233	$6,8\cdot10^{-4}$
Ni-59	$4,3\cdot10^{6}$	U-234	$3,4\cdot10^{1}$
Ni-63	$8,5\cdot10^{8}$	U-235	$6,8\cdot10^{-1}$
Sb-125	$4,3\cdot10^{8}$	U-236	$1,0\cdot10^{1}$
Zr-93	$4,3\cdot10^{3}$	U-238	$1,4\cdot10^{1}$
		Np-237	$1,4\cdot10^{1}$
Correlated to Cs-137		Pu-238	$1,4\cdot10^{5}$
Cs-137	$8,1\cdot10^{8}$	Pu-241	$3,4\cdot10^{6}$
Cd-113m	$4,9\cdot10^{5}$	Pu-242	$1,0\cdot10^{2}$
Cl-36	$8,1\cdot10^{3}$	Am-241	$3,4\cdot10^{4}$
Cs-134	$8,1\cdot10^{8}$	Am-242m	$3,4\cdot10^{2}$
Cs-135	$4,0\cdot10^{3}$	Am-243	$1,0\cdot10^{3}$
Eu-152	$5,7\cdot10^{4}$	Cm-243	$6,8\cdot10^{2}$
Eu-154	$8,1\cdot10^{7}$	Cm-244	$1,0\cdot10^{5}$
Eu-155	$5,7\cdot10^{7}$	Cm-245	$1,0\cdot10^{1}$
I-129	$2,4\cdot10^{2}$	Cm-246	$2,7\cdot10^{0}$
Pd-107	$8,1\cdot10^{2}$	Pu-244	$2,4\cdot10^{-5}$
Pm-147	$7,3\cdot10^{8}$		
Ru-106	$4,0\cdot10^{6}$		
Se-79	$3,2\cdot10^{3}$		
Sm-151	$2,4\cdot10^{6}$		
Sn-126	$4,0\cdot10^{2}$		
Sr-90	$8,1\cdot10^{7}$		
Tc-99	$4,0\cdot10^{6}$		

A reference waste package of the type O.12 has a surface dose rate of 2 mSv/h and no surface contamination.

6.3 Uncertainties

- General uncertainties are described in chapter 1.3.

7 R.12

7.1 Waste type description

7.1.1 Waste package

The R.12 waste type consists of a standard ISO-container containing iron/steel, aluminium, cellulose and other organic materials generated at the Ringhals nuclear power plant. The material is classified as low level waste.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.
- The contents of toxic material should fall within the limits set up earlier for SFR-1. That means avoidance of toxic material. Small amounts of lead and PVC could follow this waste stream.

Packaging

The ISO container is made of steel with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The container is often referred to as '20 feet half height container'. The weight of steel is approximately 1900 kg and the surface area of the container is approximately 104 m^2. The floor of the container could be of plywood or steel. The plywood floor weighs approximately 310 kg. The variation of weight between containers is between 1800 kg – 2300 kg.

Other containers are possible, 10 feet full or half height and 20 feet full height could be used.

Treatment and conditioning

The raw waste is collected from controlled areas from various places in the power plant. Some coarse sorting is made at each collection point before transported to central treatment.

The waste is normally packed in plastic bags or steel drums and then placed in the ISO container. A few containers include super compacted drums with steel waste.

The void varies but is estimated to 7,5 m^3 in a container.

7.1.2 Materials – chemical composition

The amounts of different materials in a R.12 container are given in table 7-1. Data comes from /Meijer, 1987; Ahlqvist, 1990; Hansson, 2000/. The mix of different waste materials has changed from time to time depending if incineration is used, on different maintenance work or other reasons.

The weight of the raw waste material is normally 10 000 kg per package including the weight of the container /Johansson, 2000/. The weight on the waste material can vary from approximately 5000–15000 kg depending on different waste materials.

Table 7-1. Amount of different material in a typical package R.12.

Material	Weight (kg)	Area (m^2)	Weight %
Iron/steel	0-10000	0-508	0-100
Aluminium	0-200	0-30	0-2
Cellulose (including wood, paper, textiles, absorbed water)	0-5000		0-50
Other organic material (including plastics, rubber, cable)	0-3500		0-35
Other material (including insulation like mineral wool etc)	0-2500		0-25

* Upper limit calculated as per cent of the ratio between mass of material and 10 000 kg.

7.1.3 Radionuclide inventory

Before the waste is transported from Ringhals NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $6{,}2\cdot10^{11}$ Bq for Co-60 and between 0 and $5{,}1\cdot10^{10}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h but normally it is between 0–1,5 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

7.1.4 Waste production

The waste type has been in production since 1991 and is still in production. The number of packages produced until 1998 is 35, the annual production is estimated to 4,2, see appendix A.

7.2 Reference waste type description

7.2.1 Waste package and material

The number of packages that will be produced is estimated to 103 packages during the operation of Ringhals.

Table 7-2 shows the content of different materials and steel surface areas of the packaging in typical package from Ringhals.

The assumed composition of the waste in a reference waste package of R.12 is given in Table 7-3. The surface area on a components in the waste are estimated assuming planar plates with a thickness of 5 mm, and assuming a density of 7860 kg/m^3 for carbon and stainless steel and 2700 kg/m^3 for aluminium.

Table 7-2. Estimated reference packaging composition and surface area and thickness of components in a ISO container of R.12.

Component	Material	Weight	Surface area	Thickness
ISO container	Carbon steel	1900 kg	104 m^2	1,5 mm
Plywood	Cellulose	310 kg		

Table 7-3. Estimated reference waste composition and surface area and thickness of components in one R.12.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	4500	229	5
Aluminium	100	15	5
Cellulose (including wood, paper, textiles, absorbed water)	500 (2000)		
Other organic material (including plastics, rubber, cable)	3000		
Other material (including insulation like mineral wool etc)	400		

The total amounts of different materials in all the packages of R.12 are summarised in Table 7-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 7-5. The waste volume is estimated from the weights of the waste components in Table 7-3 and approximate densities of the different material. Average void is estimated to 50 % in a package.

Void and waste volume is specified in Table 7-5.

Table 7-4. Reference composition and surface area of metallic components in 103 containers R.12.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	463 500	23 587	195 700	10 712	659 200	34 299
Aluminium	10 300	1 545			10 300	1 545
Cellulose	51 500		30 900		83 430	
Other organic material	309 000				309 000	
Other material	41 200				41 200	

Table 7-5. Volumes in 1 and 103 reference waste packages of R.12.

	Volume in 1 package (m^3)	Volumes in 103 packages (m^3)
Waste	11,5	1185
Void	7,5	772

7.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 7-6.

Table 7-6. Radionuclide composition of a reference waste package of the type R.12.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1,3\cdot10^{10}$	Pu-239	$1,2\cdot10^{6}$
Ag-108m	$7,8\cdot10^{5}$	Pu-240	$2,4\cdot10^{6}$
Ba-133	$1,3\cdot10^{5}$	Pb-210	$7,1\cdot10^{-5}$
Be-10	$7,8\cdot10^{0}$	Ra-226	$7,1\cdot10^{-4}$
C-14	$1,3\cdot10^{7}$	Ac-227	$1,4\cdot10^{-2}$
Fe-55	$1,3\cdot10^{10}$	Th-229	$1,1\cdot10^{-3}$
H-3	$1,3\cdot10^{6}$	Th-230	$3,2\cdot10^{-1}$
Ho-166m	$5,2\cdot10^{4}$	Th-232	$3,6\cdot10^{-7}$
Mo-93	$6,5\cdot10^{4}$	Pa-231	$1,1\cdot10^{-1}$
Nb-93m	$1,3\cdot10^{7}$	U-232	$1,1\cdot10^{2}$
Nb-94	$1,3\cdot10^{5}$	U-233	$7,1\cdot10^{-2}$
Ni-59	$1,3\cdot10^{7}$	U-234	$3,6\cdot10^{3}$
Ni-63	$2,6\cdot10^{9}$	U-235	$7,1\cdot10^{1}$
Sb-125	$1,3\cdot10^{9}$	U-236	$1,1\cdot10^{3}$
Zr-93	$1,3\cdot10^{4}$	U-238	$1,4\cdot10^{3}$
		Np-237	$1,4\cdot10^{3}$
Correlated to Cs-137		Pu-238	$1,4\cdot10^{7}$
Cs-137	$4,8\cdot10^{9}$	Pu-241	$3,6\cdot10^{8}$
Cd-113m	$2,9\cdot10^{6}$	Pu-242	$1,1\cdot10^{4}$
Cl-36	$4,8\cdot10^{4}$	Am-241	$3,6\cdot10^{6}$
Cs-134	$4,8\cdot10^{9}$	Am-242m	$3,6\cdot10^{4}$
Cs-135	$2,4\cdot10^{4}$	Am-243	$1,1\cdot10^{5}$
Eu-152	$3,4\cdot10^{5}$	Cm-243	$7,1\cdot10^{4}$
Eu-154	$4,8\cdot10^{8}$	Cm-244	$1,1\cdot10^{7}$
Eu-155	$3,4\cdot10^{8}$	Cm-245	$1,1\cdot10^{3}$
I-129	$1,4\cdot10^{3}$	Cm-246	$2,8\cdot10^{2}$
Pd-107	$4,8\cdot10^{3}$	Pu-244	$2,5\cdot10^{-3}$
Pm-147	$4,3\cdot10^{9}$		
Ru-106	$2,4\cdot10^{7}$		
Se-79	$1,9\cdot10^{4}$		
Sm-151	$1,4\cdot10^{7}$		
Sn-126	$2,4\cdot10^{3}$		
Sr-90	$4,8\cdot10^{8}$		
Tc-99	$2,4\cdot10^{7}$		

A reference waste package of the type R.12 has a surface dose rate of 2 mSv/h and no surface contamination.

7.3 Uncertainties

- General uncertainties are described in chapter 1.3.

8 S.12

8.1 Waste type description

8.1.1 Waste package

The S.12 waste type consists of a standard ISO-container containing iron/steel, aluminium, cellulose and other organic materials generated at the Studsvik Research site. The material is classified as low level waste.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.
- The contents of toxic material should fall within the limits set up earlier for SFR-1. That means avoidance of toxic material. Small amounts of lead and PVC could follow this waste stream.

Packaging

The ISO container is made of steel with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The container is often referred to as '20 feet half height container'. The weight of steel is approximately 1900 kg and the surface area of the container is approximately 104 m^2. The floor of the container could be of plywood or steel. The plywood floor weighs approximately 310 kg. The variation of weight between containers is between 1800 kg – 2300 kg.

Other containers are possible, 10 feet full or half height and 20 feet full height could be used.

Treatment and conditioning

The raw waste is collected from controlled areas from various places on the site. Some coarse sorting is made at each collection point before transported to central treatment.

The waste is normally packed in plastic bags or steel drums and then placed in the ISO container. A few containers include super compacted drums with steel waste.

The void varies but is estimated to 7,5 m^3 in a container.

8.1.2 Materials – chemical composition

The amounts of different materials in a S.12 container are given in Table 8-1. Data comes from /Meijer, 1987; Öberg, 1990; Chyssler, 2000/. The mix of different waste materials has changed from time to time depending if incineration is used, on different maintenance work or other reasons.

The weight of the raw waste material is normally 10 000 kg per package including the weight of the container /Johansson, 2000/. The weight on the waste material can vary from approximately 5000–15000 kg depending on different waste materials.

Table 8-1. Amount of different material in a typical package S.12.

Material	Weight (kg)	Area (m^2)	Weight %
Iron/steel	0-10000	0-508	0-100
Aluminium	0-200	0-30	0-2
Cellulose (including wood, paper, textiles, absorbed water)	0-5000		0-50
Other organic material (including plastics, rubber, cable)	0-3500		0-35
Other material (including insulation like mineral wool etc)	0-2500		0-25

* Upper limit calculated as per cent of the ratio between mass of material and 10 000 kg.

8.1.3 Radionuclide inventory

Before the waste is transported from Studsvik to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $6{,}2 \cdot 10^{10}$ Bq for Co-60 and between 0 and $5{,}1 \cdot 10^{11}$ Bq for Cs-137 (based on types B.12, F.12 and R.12). Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h. No information is available on normal doserates, but probably the doserates are like the normal dosrates for types B.12, F.12 and R.12. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

8.1.4 Waste production

The waste type is not yet licensed to be deposited in SFR-1. The number of packages produced until 1998-12-31 is 15, the annual production is estimated to 1, see appendix A.

8.2 Reference waste type description

8.2.1 Waste package and material

The number of packages that will be produced is estimated to 31 packages during the operation of Studsvik.

Table 8-2 shows the content of different materials and steel surface areas of the packaging in typical package from Studsvik.

The assumed composition of the waste in a reference waste package of S.12 is given in Table 8-3. The surface area on a components in the waste are estimated assuming planar plates with a thickness of 5 mm, and assuming a density of 7860 kg/m^3 for carbon and stainless steel and 2700 kg/m^3 for aluminium.

Table 8-2. Estimated reference packaging composition and surface area and thickness of components in an ISO container of S.12.

Component	Material	Weight	Surface area	Thickness
ISO container	Carbon steel	1900 kg	104 m^2	1,5 mm

Table 8-3. Estimated reference waste composition and surface area and thickness of components in one S.12.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	4500	229	5
Aluminium	100	15	5
Cellulose (including wood, paper, textiles, absorbed water)	500 (2000)		
Other organic material (including plastics, rubber, cable)	3000		
Other material (including insulation like mineral wool etc)	400		

The total amounts of different materials in all the packages of S.12 are summarised in Table 8-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 8-5. The waste volume is estimated from the weights of the waste components in Table 8-3 and approximate densities of the different material. Average void is estimated to 50 % in a package.

Void and waste volume is specified in Table 8-5.

Table 8-4. Reference composition and surface area of metallic components in 31 containers S.12.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	139 500	7 100	58 900	3 220	198 400	10 300
Aluminium	3 100	465			3 100	465
Cellulose	15 500				15 500	
Other organic material	93 000				93 000	
Other material	12 400				12400	

Table 8-5. Volumes in 1 and 31 reference waste packages of S.12.

	Volume in 1 package (m^3)	Volumes in 31 packages (m^3)
Waste	11,5	357
Void	7,5	232

8.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 8-6.

Table 8-6. Radionuclide composition of a reference waste package of the type S.12.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$4,3 \cdot 10^{9}$	Pu-239	$2,0 \cdot 10^{5}$
Ag-108m	$2,6 \cdot 10^{5}$	Pu-240	$4,1 \cdot 10^{5}$
Ba-133	$4,3 \cdot 10^{4}$	Pb-210	$1,2 \cdot 10^{-5}$
Be-10	$2,6 \cdot 10^{0}$	Ra-226	$1,2 \cdot 10^{-4}$
C-14	$4,3 \cdot 10^{6}$	Ac-227	$2,4 \cdot 10^{-3}$
Fe-55	$4,3 \cdot 10^{9}$	Th-229	$1,8 \cdot 10^{-4}$
H-3	$4,3 \cdot 10^{5}$	Th-230	$5,5 \cdot 10^{-2}$
Ho-166m	$1,7 \cdot 10^{4}$	Th-232	$6,1 \cdot 10^{-8}$
Mo-93	$2,1 \cdot 10^{4}$	Pa-231	$1,8 \cdot 10^{-2}$
Nb-93m	$4,3 \cdot 10^{6}$	U-232	$1,8 \cdot 10^{1}$
Nb-94	$4,3 \cdot 10^{4}$	U-233	$1,2 \cdot 10^{-2}$
Ni-59	$4,3 \cdot 10^{6}$	U-234	$6,1 \cdot 10^{2}$
Ni-63	$8,5 \cdot 10^{8}$	U-235	$1,2 \cdot 10^{1}$
Sb-125	$4,3 \cdot 10^{8}$	U-236	$1,8 \cdot 10^{2}$
Zr-93	$4,3 \cdot 10^{3}$	U-238	$2,4 \cdot 10^{2}$
		Np-237	$2,4 \cdot 10^{2}$
Correlated to Cs-137		Pu-238	$2,4 \cdot 10^{6}$
Cs-137	$8,1 \cdot 10^{8}$	Pu-241	$6,1 \cdot 10^{7}$
Cd-113m	$4,9 \cdot 10^{5}$	Pu-242	$1,8 \cdot 10^{3}$
Cl-36	$8,1 \cdot 10^{3}$	Am-241	$6,1 \cdot 10^{5}$
Cs-134	$8,1 \cdot 10^{8}$	Am-242m	$6,1 \cdot 10^{3}$
Cs-135	$4,0 \cdot 10^{3}$	Am-243	$1,8 \cdot 10^{4}$
Eu-152	$5,7 \cdot 10^{4}$	Cm-243	$1,2 \cdot 10^{4}$
Eu-154	$8,1 \cdot 10^{7}$	Cm-244	$1,8 \cdot 10^{6}$
Eu-155	$5,7 \cdot 10^{7}$	Cm-245	$1,8 \cdot 10^{2}$
I-129	$2,4 \cdot 10^{2}$	Cm-246	$4,9 \cdot 10^{1}$
Pd-107	$8,1 \cdot 10^{2}$	Pu-244	$4,3 \cdot 10^{-4}$
Pm-147	$7,3 \cdot 10^{8}$		
Ru-106	$4,0 \cdot 10^{6}$		
Se-79	$3,2 \cdot 10^{3}$		
Sm-151	$2,4 \cdot 10^{6}$		
Sn-126	$4,0 \cdot 10^{2}$		
Sr-90	$8,1 \cdot 10^{7}$		
Tc-99	$4,0 \cdot 10^{6}$		

A reference waste package of the type S.12 has a surface dose rate of 2 mSv/h and no surface contamination.

8.3 Uncertainties

- General uncertainties are described in chapter 1.3.

9 S.14

9.1 Waste type description

9.1.1 Waste package

The S.14 waste type consists of a standard ISO-container containing 200 l drums of steel with scrap metal and refuse generated at the Studsvik research site. The waste is placed in smaller drums, which is placed in the 200 l drum. Concrete is used between the two drums. Each container normally includes 36 drums. The material is classified as low level waste.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1
- The content of toxic material should fall within the limits set up earlier for SFR-1. That means in principle avoidance of toxic material. Small amounts of lead and PVC could follow this waste stream.

Packaging

The ISO container is made of steel with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The container is often referred to as '20 feet half height container'. The weight of steel is approximately 1900 kg and the surface area of the container is approximately 104 m^2. The floor of the container could be of plywood or steel. The plywood floor weighs approximately 310 kg. The variation of weight between containers is between 1800 kg – 2300 kg.

The drums are exactly like waste type S.21 (see appendix E) except the amount of radionuclides and doserates. For all details about composition, treatment etc see the appendices E and F. The steel weight of 36 drums is 900 kg.

Treatment and conditioning

The raw waste is after eventual fragmentation packed in the inner drum (100 l). Inner drums are then placed inside the outer drum (200 l). Free void between the two drums is filled with concrete. Normally 36 conditioned drums are placed in an ISO container, but it could differ from 33 to 36.

The void varies but is estimated to 6,4 m^3 in a container.

9.1.2 Materials – chemical composition

The amounts of different materials in a S.14 container are given in Table 9-1. Data comes from reference /Meijer, 1987; Aggeryd et al, 1994/. At present no information is available of normal variation of materials a S.14 package.

The weight of a container and waste is normally 10 000 kg /Johansson, 2000/ but can be up to 17 500 kg. The weight on the waste material can vary but weighs approximately 200 kg per drum.

Table 9-1. Amount of different materials in a typical package S.14.

Material	Weight (kg)	Surface area (m^2)	Weight %
Iron/steel	2664	133,2	81
Aluminium	180	25,2	6
Cellulose (including wood, paper, textiles, absorbed water)	284,4		9
Other organic material (including plastics, rubber, cable)	144		4

9.1.3 Radionuclide inventory

Before the waste is transported from Studsvik to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides for 1 drum are between 0 and $1{,}2 \cdot 10^9$ for Co-60 and between 0 and $1{,}6 \cdot 10^7$ for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h but normally it is between 0–0,2 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

9.1.4 Waste production

The waste type has been in production since 1980 and is still in production. The number of packages produced until 1998 is 22, the annual production varies a lot but as an average estimated to 3, see appendix A.

9.2 Reference waste type description

9.2.1 Waste package and material

The number of packages that will be produced is estimated to 73 packages during the operation of Studsvik.

Table 9-2 shows the content of different materials and steel surface areas of the packaging in typical package from Studsvik.

The assumed composition of the waste in a reference waste package of S.14 is given in Table 9-3.

Table 9-2. Estimated reference packaging composition and surface area and thickness of components in an ISO container of S.14.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
ISO container	Carbon steel	1900	104	1,5
Plywood	Cellulose	310		
36 inner and outer drums	Carbon steel	1080	256	1

Table 9-3. Estimated reference waste composition and surface area and thickness of components in one S.14.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	2664	133	5
Aluminium	180	25	5
Cellulose (including wood, paper, textiles, absorbed water)	284		
Other organic material (including plastics, rubber, cable)	144		

The total amounts of different materials in all the packages of S.14 are summarised in Table 9-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 9-5. The waste volume is estimated from the weights of the waste components in Table 9-3 and approximate densities of the different material. Average void is estimated to 47 % in a package.

Void and waste volume is specified in Table 9-5.

Table 9-4. Reference composition and surface area of metallic components in 73 containers S.14 (including 36 drums).

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	194 000	9 700	217 000	26 300	411 000	36 000
Aluminium	13 100	1 820			13 100	1 820
Cellulose	20 700		22 630		43 300	
Other organic material	10 500				10 500	

Table 9-5. Volumes in 1 and 73 reference waste packages of S.14 (including drums).

	Volume in 1 package (m^3)	Volumes in 73 packages (m^3)
Waste	12,7	927
Void	6,4	467

9.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 9-6. The transuranic elements have been calculated in a different way and it is not possible to calculate a reference waste type. An inventory for transuranic elements for all drums at the year 2030 is presented in appendix B.

Table 9-6. Radionuclide composition of a reference waste package of the type S.14.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$2,1\cdot10^{9}$	Pu-239	$1,0\cdot10^{5}$
Ag-108m	$1,3\cdot10^{5}$	Pu-240	$2,0\cdot10^{5}$
Ba-133	$2,1\cdot10^{4}$	Pb-210	$6,1\cdot10^{-6}$
Be-10	$1,3\cdot10^{0}$	Ra-226	$6,1\cdot10^{-5}$
C-14	$2,1\cdot10^{6}$	Ac-227	$1,2\cdot10^{-3}$
Fe-55	$2,1\cdot10^{9}$	Th-229	$9,2\cdot10^{-5}$
H-3	$2,1\cdot10^{5}$	Th-230	$2,8\cdot10^{-2}$
Ho-166m	$8,6\cdot10^{3}$	Th-232	$3,1\cdot10^{-8}$
Mo-93	$1,1\cdot10^{4}$	Pa-231	$9,2\cdot10^{-3}$
Nb-93m	$2,1\cdot10^{6}$	U-232	$9,2\cdot10^{0}$
Nb-94	$2,1\cdot10^{4}$	U-233	$6,1\cdot10^{-3}$
Ni-59	$2,1\cdot10^{6}$	U-234	$3,1\cdot10^{2}$
Ni-63	$4,3\cdot10^{8}$	U-235	$6,1\cdot10^{0}$
Sb-125	$2,1\cdot10^{8}$	U-236	$9,2\cdot10^{1}$
Zr-93	$2,1\cdot10^{3}$	U-238	$1,2\cdot10^{2}$
		Np-237	$1,2\cdot10^{2}$
Correlated to Cs-137		Pu-238	$1,2\cdot10^{6}$
Cs-137	$1,6\cdot10^{7}$	Pu-241	$3,1\cdot10^{7}$
Cd-113m	$9,6\cdot10^{3}$	Pu-242	$9,2\cdot10^{2}$
Cl-36	$1,6\cdot10^{2}$	Am-241	$3,1\cdot10^{5}$
Cs-134	$1,6\cdot10^{7}$	Am-242m	$3,1\cdot10^{3}$
Cs-135	$8,0\cdot10^{1}$	Am-243	$9,2\cdot10^{3}$
Eu-152	$1,1\cdot10^{3}$	Cm-243	$6,1\cdot10^{3}$
Eu-154	$1,6\cdot10^{6}$	Cm-244	$9,2\cdot10^{5}$
Eu-155	$1,1\cdot10^{6}$	Cm-245	$9,2\cdot10^{1}$
I-129	$4,8\cdot10^{0}$	Cm-246	$2,5\cdot10^{1}$
Pd-107	$1,6\cdot10^{1}$	Pu-244	$2,1\cdot10^{-4}$
Pm-147	$1,4\cdot10^{7}$		
Ru-106	$8,0\cdot10^{4}$		
Se-79	$6,4\cdot10^{1}$		
Sm-151	$4,8\cdot10^{4}$		
Sn-126	$8,0\cdot10^{0}$		
Sr-90	$1,6\cdot10^{6}$		
Tc-99	$8,0\cdot10^{4}$		

A reference waste package of the type S.14 has a surface dose rate of 2 mSv/h and no surface contamination.

9.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- Waste volume in individual packages depends on fragmentation and the possibility to compact in the inner of the two steel drums.

10 Other waste types

10.1 Waste type description

10.1.1 General

Since SFR-1 still is in operation there is always the possibility that new waste types are needed. It is not possible to define these types per se; this can only be done when more data is available. Still, there is a need to include this waste in the safety assessment of the SFR-1 repository. In order to make some sort of analysis one has to make some rather crude assumptions.

The assumptions made are:

- The waste consists of large components or scrap metal.
- The materials of the waste package is based on several large components and is set to approximately 10 % steel and 90% void.

The geometry is set to the same as an ISO container, i.e. with the length of 6,1 m, width of 2,4 m and height of 1,3 m. The actual packages can differ considerably from this, the geometry has no other meaning than to facilitate easy calculations.

- No waste container is assumed for this waste, the waste itself is assumed to be the container.
- The radionuclide inventory is equal to the volume the waste takes in the cavern, i.e. if there is 10 % of odd waste in the cavern, the radionuclides are 10 % of what is allowed.
- Surface dose rate is estimated to the limiting dose rate in the cavern, i.e. 2 mSv/h.

At present no types of odd waste have been disposed off in the BLA.

10.2 Reference waste type description

10.2.1 Waste package and material

The number of packages that will be produced is 64.

Table 10-1 shows the content of different materials and the surface areas of steel in the odd waste. The surface area on metal components in the waste are estimated by assuming planar plates with a thickness of 10 mm, the density is set to 7860 kg/m^3 for carbon and stainless steel.

Table 10-1. Estimated typical packaging composition and surface area and thickness of components of odd type.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Carbon steel	13300	509	10

The total amounts of different material in all of the packages of the odd waste are summarised in Table 10-2.

Void and waste volume is specified in Table 10-3.

Table 10-2. Reference composition and surface area of metallic components in 64 packages of odd waste.

Content	Waste packages weight (kg)	area (m^2)
Iron/steel	851200	32500

Table 10-3. Volumes in 1 and 64 typical waste packages of odd waste.

	Volume (m^3) 1 package	Volume (m^3) 64 packages
Waste	1,8	115
Void	17,3	1107

10.2.2 Radionuclide inventory

The reference inventory in one package at the time of production has not been calculated since waste type is hypothetical and hence there is no need for a reference package. A inventory for all boxes at the year 2030 is presented in appendix B.

A reference waste package of the odd waste type has a surface dose rate of 2 mSv/h and no surface contamination.

10.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- Up to this date no kind of odd waste has been disposed off in BLA, in future odd waste types could be disposed off.

11 References

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Appendix D

Waste types in BTF

1 General

1.1 Waste in BTF

In SFR, in the BTF – rock cavern for concrete tanks – short-lived waste from the nuclear power plants and Studsvik research site are disposed off. BTF includes two different rock caverns, 1BTF and 2BTF. The BTF caverns are approximately 160 m long, 14,8 m wide and have a height of 9,5 m.

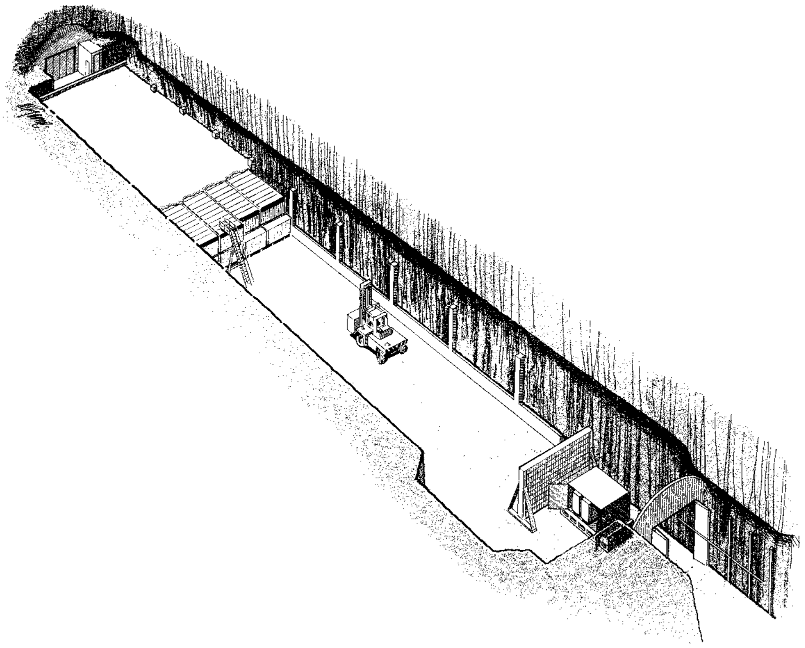

Figure 1-1. *The BTF rock caverns.*

The waste in 1BTF consist mainly of ash drums and concrete tanks containing ion-exchange resins and filter aids. In the 2BTF only concrete tanks containing ion-exchange resins and filter aids. Moreover, some big components of metal e.g. steam separators or rector vessel lids may be disposed of in the caverns.

A few waste packages of waste types that are designed for BMA, type O.01, C.01, R.01, R.10, R.23 are used in 1BTF to build supportive walls for ash drums. These waste types are discussed in appendix E.

The dose rates allowed on packages are maximum 10 mSv/h. The amount of radionuclides are fairly low, dominating nuclide are Co-60 and Cs-137. Some transuranic elements are also present in the waste streams to BTF. Other criteria for acceptance are:

- Construction, geometry, dimensions and weight must be suited to the handling system in SFR and the transportation system in general and in BLA in particular. The strength of the packages must be sufficient to withstand normal and unnormal handling.

- Each package must have an individual identity and the radionuclide content of gamma emitting nuclides shall be known.
- Surface contamination should not exceed 40 kBq/m^2 for gamma and beta emitting nuclides and 4 kBq/m^2 for alpha emitting nuclides.
- The internal dosrates and integrated dose must not affect the barrier properties in the repository.
- The chemical and physical properties and the structure of the waste should be known.
- Chemical aggressive or explosive material, pressurised gas and free liquid are not allowed.
- Gas production from the waste must not be to big.
- The waste shall have enough resistance towards corrosion that the integrity of the package is kept until sealing of the repository.
- Burnable waste must not be subject to self-ignition.
- Complexing agents should if possible be avoided.

All waste in 1BTF is normally packed in steel drums, concrete or, in a few cases, steel tanks. Waste disposed off in BTF-2 is packed in concrete tanks.

1.2 Definitions

Surface area is defined as the area subject to anaerobic corrosion and gas production after sealing of the repository.

1.3 Uncertainties

- The presented waste types describes the types that has been, is in or can be foreseen to be produced in Sweden. New waste types may be present in the future.
- Almost all data is based on literature values, smaller changes may not been properly documented.
- All future production is based on a relative simple prognosis model. This model, described in appendix A, was chosen since the uncertainties about processes etc are large.
- No regard has been taken to improvements in processes etc.
- A reference package has been chosen. Actual packages may differ considerably from this reference package, the uncertainty for the whole population of packages is judged to be smaller.
- Void presented in this report is based on best estimates, the estimates can be quite crude.
- Big components as heat exchangers etc could in the future be of interest to dispose off in BLA. See chapter 6 in this appendix.

2 B.07

2.1 Waste type description

2.1.1 Waste package

General

The B.07 waste type consists of a concrete tank containing de-watered ion-exchange resins. The raw waste material consists of ion-exchange resins, filter aids and sludge generated at the Barsebäck nuclear power plant. The material is classified as low level waste. All data comes from /Berntsson, 1991; Johansson, 2000; TRIUMF, 2000/.

The physical properties and chemical conditions can vary a lot, but the following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.

Packaging

The tank is a concrete container with the outer dimensions of 3,3 m · 1,3 m · 2,3 m, see Figure 2-1. The thickness of the concrete wall is 0,15 m. The concrete weight is approximately 10 300 kg and the weight of steel in the package is approximately 647 kg. The reinforcement bars have a thickness of 8 mm which means that the surface of steel is approximately 40 m^2. The tank is lined with a 2 mm thick butyl rubber on the inside. The lining weighs 50 kg. The total weight of package is approximately 11 000 kg. The variations between packages are minimal. No major changes in design have been made since the start of production of this package.

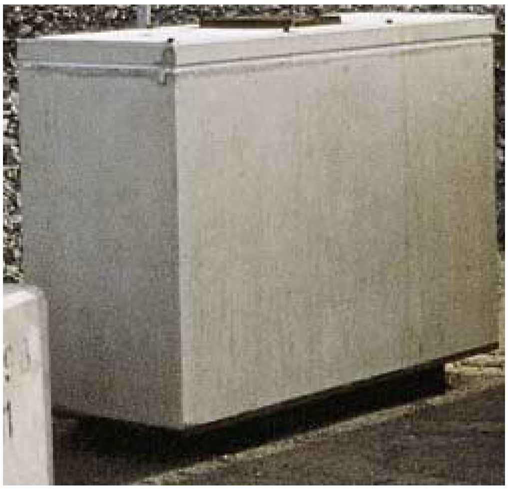

Figure 2-1. *A concrete tank.*

Treatment and conditioning

The ion-exchange resin containing metal hydroxides and other substances are pumped into the concrete tank. Then the resins are de-watered by suction through a filter system in the bottom of the tank. The filling and suction cycle is repeated two to three times in order to fill the container with waste. The weight of a tank including waste could be up to 15 000 kg.

In order to save space in the repository the operators tries to fill the containers as much as possible, but there will always be a void in the top of the tank. This void is fairly constant and is estimated to 0,5 m^3 per tank. Additional void is to be found in the waste itself. The porosity of the waste is also fairly constant and is estimated to 60 %, which gives a total void of approximately 3,8 m^3 in a tank.

2.1.2 Materials – chemical composition

The amounts of different materials in a B.07 tank are given in Table 2-1. The waste contains ion-exchange resins used for filtering metal hydroxides and other substances and other substances from the condensate cleaning system (system 332). The weight of the raw waste material can differ between 4000 and 5000 including water, normally it is 1400 kg of ion-exchange resin per package. In the waste there could also be sludges and other organic matter. The amount is between 0 and 200 kg but it is as an average approximately 60 kg sludge and 66 kg organic material.

Table 2-1. Amounts of different material in waste type B.07 (per package).

Material	Weight	Weight-%
Ion-exchange resin	1200-1600 kg	86-100 %
Sludge	0-100 kg	0-7 %
Other organic material	0-100 kg	0-7 %

2.1.3 Radionuclide inventory

Before the waste is transported from Barsebäck NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $8,7 \cdot 10^{10}$ Bq for Co-60 and between 0 and $9,3 \cdot 10^{9}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 3 mSv/h on the surface, but usually the dose rate is between 0–1 mSv/h. Contamination on surface should not exceed 40 kBq/m^2 for gamma and beta emitting nuclides and 4 kBq/m^2 for alpha emitting nuclides on the package. Usually there is no surface contamination.

2.1.4 Waste production

The waste type has been in production since 1983 and is still in production, a few of the total amount is produced before 1983. The number of packages produced until 1998-12-31 is 193, the annual production is estimated to 15, see appendix A.

2.2 Reference waste type description

2.2.1 Waste package and material

The number of packages that will be produced are calculated to 358 during the operational period of the Barsebäck NPP.

Table 2-2 shows the content of different materials and the surface areas of steel in the packaging in reference tank from Barsebäck NPP.

The assumed composition of the waste in a reference waste package of B.07 is given in Table 2-3.

Table 2-2. Typical packaging composition and surface area and thickness of components in a concrete tank.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel in reinforcement	647	40	8
Rubber lining	50		2
Concrete	10 300		150

Table 2-3. Estimated reference waste composition in one concrete tank.

Material	Weight	Weight-%
Ion-exchange resin	1400 kg	92 %
Sludge	60 kg	4 %
Other organic material	66 kg	4 %

The total amounts of different materials in all the packages of B.07 are summarised in Table 2-4.

Void and waste volume is specified in Table 2-5.

Table 2-4. Reference composition and surface area of metallic components in 358 B.07 concrete tanks.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		231 600	14 320	231 600	14 320
Concrete		3 687 000		3 687 000	
Sludge	21 480			21 480	
Organics	23 600	17 900		41 500	

Table 2-5. Volumes in 1 and 358 typical waste packages of B.07 concrete tanks.

	Volume (m^3) 1 package	Volume (m^3) 358 packages
Waste	2,2	787
Void	3,8	1360

2.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 2-6.

Table 2-6. Radionuclide composition of a reference waste package of the type B.07.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$2,8\cdot10^{10}$	Pu-239	$5,5\cdot10^{3}$
Ag-108m	$1,7\cdot10^{6}$	Pu-240	$1,1\cdot10^{4}$
Ba-133	$2,8\cdot10^{5}$	Pb-210	$3,3\cdot10^{-7}$
Be-10	$1,7\cdot10^{1}$	Ra-226	$3,3\cdot10^{-6}$
C-14	$2,8\cdot10^{7}$	Ac-227	$6,6\cdot10^{-5}$
Fe-55	$2,8\cdot10^{10}$	Th-229	$4,9\cdot10^{-6}$
H-3	$2,8\cdot10^{6}$	Th-230	$1,5\cdot10^{-3}$
Ho-166m	$1,1\cdot10^{5}$	Th-232	$1,6\cdot10^{-9}$
Mo-93	$1,4\cdot10^{5}$	Pa-231	$4,9\cdot10^{-4}$
Nb-93m	$2,8\cdot10^{7}$	U-232	$4,9\cdot10^{-1}$
Nb-94	$2,8\cdot10^{5}$	U-233	$3,3\cdot10^{-4}$
Ni-59	$2,8\cdot10^{7}$	U-234	$1,6\cdot10^{1}$
Ni-63	$5,5\cdot10^{9}$	U-235	$3,3\cdot10^{-1}$
Sb-125	$2,8\cdot10^{9}$	U-236	$4,9\cdot10^{0}$
Zr-93	$2,8\cdot10^{4}$	U-238	$6,6\cdot10^{0}$
		Np-237	$6,6\cdot10^{0}$
Correlated to Cs-137		Pu-238	$6,6\cdot10^{4}$
Cs-137	$1,7\cdot10^{9}$	Pu-241	$1,6\cdot10^{6}$
Cd-113m	$1,0\cdot10^{6}$	Pu-242	$4,9\cdot10^{1}$
Cl-36	$1,7\cdot10^{4}$	Am-241	$1,6\cdot10^{4}$
Cs-134	$1,7\cdot10^{9}$	Am-242m	$1,6\cdot10^{2}$
Cs-135	$8,6\cdot10^{3}$	Am-243	$4,9\cdot10^{2}$
Eu-152	$1,2\cdot10^{5}$	Cm-243	$3,3\cdot10^{2}$
Eu-154	$1,7\cdot10^{8}$	Cm-244	$4,9\cdot10^{4}$
Eu-155	$1,2\cdot10^{8}$	Cm-245	$4,9\cdot10^{0}$
I-129	$5,2\cdot10^{2}$	Cm-246	$1,3\cdot10^{0}$
Pd-107	$1,7\cdot10^{3}$	Pu-244	$1,2\cdot10^{-5}$
Pm-147	$1,5\cdot10^{9}$		
Ru-106	$8,6\cdot10^{6}$		
Se-79	$6,9\cdot10^{3}$		
Sm-151	$5,2\cdot10^{6}$		
Sn-126	$8,6\cdot10^{2}$		
Sr-90	$1,7\cdot10^{8}$		
Tc-99	$8,6\cdot10^{6}$		

A reference waste package of the type B.07 has a surface dose rate of 3 mSv/h and no surface contamination.

2.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- Void in concrete tank according to porosity is estimated to be in the range 60–75 %.

3 O.07

3.1 Waste type description

3.1.1 Waste package

General

The O.07 waste type consists of a concrete tank containing de-watered ion-exchange resins. The raw waste material consists of ion-exchange resins, filter aids and sludge generated at the Oskarshamn nuclear power plant. The material is classified as low level waste. All data comes from /Ingemansson, 1999; Johansson, 2000; TRIUMF, 2000/.

The physical properties and chemical conditions can vary a lot, but the following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.

Packaging

The tank is a concrete container with the outer dimensions of 3,3 m · 1,3 m · 2,3 m, see Figure 3-1. The thickness of the concrete wall is 0,15 m. The concrete weight is approximately 10 300 kg and the weight of steel in the package is approximately 647 kg. The reinforcement bars have a thickness of 8 mm which gives the surface of steel to 40 m^2. The tank is lined with a 2 mm thick butyl rubber on the inside. The lining weighs 50 kg. The total weight of package is approximately 11 000 kg. The variations between packages are minimal. No major changes in design have been made since the start of production of this package.

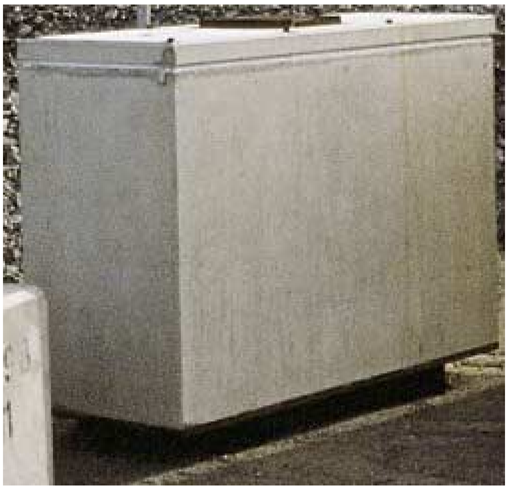

Figure 3-1. *A concrete tank.*

Treatment and conditioning

The ion-exchange resin containing metal hydroxides and other substances are pumped into the concrete tank. Then the resins are de-watered by suction through a filter system in the bottom of the tank. The filling and suction cycle is repeated two to three times in order to fill the container with waste. The weight of a tank including waste could be up to 15 000 kg.

In order to save space in the repository the operators tries to fill the containers as much as possible, but there will always be a void in the top of the tank. This void is fairly constant and is estimated to 0,5 m^3 per tank. Additional void is to be found in the waste itself. The porosity of the waste is also fairly constant and is estimated to 60 %, which gives a total void of approximately 3,8 m^3 in a tank.

3.1.2 Materials – chemical composition

The amounts of different materials in a O.07 tank are given in Table 3-1. The waste contains ion-exchange resins used for filtering metal hydroxides and other substances from the condensate cleaning system (system 332). The weight of the raw waste material can differ between 3400 and 4700 including water but it is normally 1000 kg of ion-exchange resin per package. In the waste there could also be sludges and other organic matter. The amount is between 0 and 200 kg but it is as an average approximately 60 kg sludge and 66 kg organic material. Some trace amounts of complexing agents from detergents etc could be present in this waste type.

Table 3-1. Amounts of different material in waste type O.07 (per package).

Material	Weight	Weight-%
Ion-exchange resin	850-1200 kg	81-100 %
Sludge	0-100kg	0-9 %
Other organic material	0-100 kg	0-9 %

3.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $4{,}9 \cdot 10^{11}$ Bq for Co-60 and between 0 and $6{,}1 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 10 mSv/h on the surface, but usually the dose rate is between 0 and 4 mSv/h. Contamination on surface should not exceed 40 kBq/m^2 for gamma and beta emitting nuclides and 4 kBq/m^2 for alpha emitting nuclides on the package. Usually there is no surface contamination.

3.1.4 Waste production

The waste type has been in production since before 1988 and is still in production. The number of packages produced until 1998-12-31 is 400, the annual production is estimated to 12, see appendix A.

3.2 Reference waste type description

3.2.1 Waste package and material

The number of packages that will be produced are calculated to 628 during the operational period of the Oskarshamn NPP.

Table 3-2 shows the content of different materials and the surface areas of steel in the packaging in reference tank from Oskarshamn NPP.

The assumed composition of the waste in a reference waste package of O.07 is given in Table 3-3.

Table 3-2. Typical packaging composition and surface area and thickness of components in a concrete tank.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel in reinforcement	647	40	8
Rubber lining	50		2
Concrete	10 300		150

Table 3-3. Estimated reference waste composition in one concrete tank.

Material	Weight	Weight-%
Ion-exchange resin	1 000 kg	89 %
Sludge	60 kg	5 %
Other organic material	66 kg	6 %

The total amount of different materials in all of the packages of O.07 are summarised in Table 3-4.

Void and waste volume is specified in Table 3-5.

Table 3-4. Reference composition and surface area of metallic components in 628 O.07 concrete tanks.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		406 300	25 100	406 300	25 100
Concrete		6 468 000		6 468 000	
Sludge	37 700			37 700	
Organics	41 400	31 400		72 800	

Table 3-5. Volumes in 1 and 628 typical O.07 concrete tanks.

	Volume (m^3) 1 package	Volume (m^3) 628 packages
Waste	2,2	1380
Void	3,8	2390

3.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 3-6.

Table 3-6. radionuclide composition of a reference waste package of the type O.07.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$5,0\cdot10^{10}$	Sr-90	$1,1\cdot10^{9}$
Ag-108m	$3,0\cdot10^{6}$	Tc-99	$5,3\cdot10^{7}$
Ba-133	$5,0\cdot10^{5}$	Pu-239	$2,6\cdot10^{5}$
Be-10	$3,0\cdot10^{1}$	Pu-240	$5,2\cdot10^{5}$
C-14	$5,0\cdot10^{7}$	Pb-210	$1,5\cdot10^{-5}$
Fe-55	$5,0\cdot10^{10}$	Ra-226	$1,5\cdot10^{-4}$
H-3	$5,0\cdot10^{6}$	Ac-227	$3,1\cdot10^{-3}$
Ho-166m	$2,0\cdot10^{5}$	Th-229	$2,3\cdot10^{-4}$
Mo-93	$2,5\cdot10^{5}$	Th-230	$7,0\cdot10^{-2}$
Nb-93m	$5,0\cdot10^{7}$	Th-232	$7,7\cdot10^{-8}$
Nb-94	$5,0\cdot10^{5}$	Pa-231	$2,3\cdot10^{-2}$
Ni-59	$5,0\cdot10^{7}$	U-232	$2,3\cdot10^{1}$
Ni-63	$1,0\cdot10^{10}$	U-233	$1,5\cdot10^{-2}$
Sb-125	$5,0\cdot10^{9}$	U-234	$7,7\cdot10^{2}$
Zr-93	$5,0\cdot10^{4}$	U-235	$1,5\cdot10^{1}$
		U-236	$2,3\cdot10^{2}$
Correlated to Cs-137		U-238	$3,1\cdot10^{2}$
Cs-137	$1,1\cdot10^{10}$	Np-237	$3,1\cdot10^{2}$
Cd-113m	$6,4\cdot10^{6}$	Pu-238	$3,1\cdot10^{6}$
Cl-36	$1,1\cdot10^{5}$	Pu-241	$7,7\cdot10^{7}$
Cs-134	$1,1\cdot10^{10}$	Pu-242	$2,3\cdot10^{3}$
Cs-135	$5,3\cdot10^{4}$	Am-241	$7,7\cdot10^{5}$
Eu-152	$7,5\cdot10^{5}$	Am-242m	$7,7\cdot10^{3}$
Eu-154	$1,1\cdot10^{9}$	Am-243	$2,3\cdot10^{4}$
Eu-155	$7,5\cdot10^{8}$	Cm-243	$1,5\cdot10^{4}$
I-129	$3,2\cdot10^{3}$	Cm-244	$2,3\cdot10^{6}$
Pd-107	$1,1\cdot10^{4}$	Cm-245	$2,3\cdot10^{2}$
Pm-147	$9,6\cdot10^{9}$	Cm-246	$6,2\cdot10^{1}$
Ru-106	$5,3\cdot10^{7}$	Pu-244	$5,4\cdot10^{-4}$
Se-79	$4,3\cdot10^{4}$		
Sm-151	$3,2\cdot10^{7}$		
Sn-126	$5,3\cdot10^{3}$		

A reference waste package of the type O.07 has a surface dose rate of 3 mSv/h and no surface contamination.

3.3 Uncertainties

- Void in concrete tank according to porosity is estimated to be in the range 60–75 %.

4 S.13

4.1 Waste type description

4.1.1 Waste package

General

The S.13 waste type consists of a ordinary 200 litre steel drums with ashes from the Studsvik incineration facility. The interior of the 200 litre drum consists of a 100 litre drum and concrete filling between the two drums. The waste material consists of ashes which is a residue after incineration of low level waste as textiles, plastics and wood. The waste could also contain some fragments of scrap metals. The raw waste comes from the operations in Studsvik but also from all of the Swedish nuclear power plants. Some raw waste comes from medical and non-nuclear industrial sources. The material is classified as low level waste /Andersson and Aggeryd, 1990; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The drum is a standard 200 litre (more precise 218 l) steel drum with the outer dimensions height 0,84 m and diameter 0,57 m. The thickness of the walls are 1 mm and it weighs 20 kg. The inner drum is a 100 litre (precise 113 l.) drum with the height 0,70 m and the diameter 0,46 m. The thickness of the walls is 1 mm and it weighs 10 kg. The space between the drums are filled with concrete, the content of cement in the concrete is 20 % by weight. A picture of a 200 l steel drum can be seen in Figure 4-1.

The variations between packages are minimal. No major changes in design has been made since the start of production of this package. In the beginning of production of this waste type second-hand drums were used as outer package, which has resulted in small differences in the dimensions of the packages. The variations are a few centimetres on height and diameter. Nowadays only new drums are used in the process.

Figure 4-1. *View of a S.13 outer drum 218 l.*

Treatment and conditioning

The Waste material is packed in the inner drum after incineration. The inner drum is then placed inside the outer drum, which is already fitted with the concrete lining. Wet concrete is then poured on top of the inner drum as a lid.

Average void is estimated to 5 % in a package including inner and outer steel drums.

4.1.2 Materials – chemical composition

The amounts of different materials in a S.13 drum are given in Table 4-1. Even though the waste is ashes the composition can change from time to time depending on what kind of origin and from where the waste are coming from. The content of waste in an individual package can vary compared to a average package. The amount of aluminium and other metals have been analysed in a batch sample of ash with different size of particles /Lidberg-Berg and Chyssler, 2000/.

The weight of ash in the waste matrix is normally 70 kg per conditioned drum. Weight of the total package varies between 300 and 450 kg. About 6,5 kg of these average 70 kg ashes is approximately aluminium according to the analysis. The variations are huge depending on origin of the raw waste.

Table 4-1. Amounts of different material in waste type S.13 (per package).

Material	Weight	Surface area	Weight-%
Ashes	60-100 kg		19-30 %
Aluminium	0-10 kg	0-3,6 m^2	0-3 %
Concrete	230-250 kg		70-75 %
Steel	30-40kg	7,1-12,7m^2	9-14 %

4.1.3 Radionuclide inventory

Before the waste is transported from Studsvik to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amount of these nuclides are between 0 and $9{,}5 \cdot 10^8$ Bq for Co-60 and between 0 and $3{,}5 \cdot 10^8$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 2 mSv/h on the surface, but usually the dose rate is between 0 and 1 mSv/h. Contamination on surface should not exceed 40 kBq/m^2 for gamma and beta emitting nuclides and 4 kBq/m^2 for alpha emitting nuclides on the package. Usually there is no surface contamination.

4.1.4 Waste production

The waste type has been in production since 1980 and is still in production. The number of packages produced until 1998-12-31 is 4589, the annual production is estimated to 190, see appendix A.

4.2 Reference waste type description

4.2.1 Waste package and material

The number of packages that will be produced are calculated to 6479 packages during the operational period of Studsvik.

Table 4-2 shows the content of different materials and the surface areas of steel in the packaging in reference drum from Studsvik.

The assumed composition of the waste in a reference waste package of S.13 is given in Table 4-3. The surface area on the aluminium fraction in the waste are calculated as the area for spheres with a diameter of 4 mm, and a density of 2700 kg/m^3.

Table 4-2. Estimated typical packaging composition and surface area and thickness of components in waste type S.13.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Inner steel drum	Carbon steel	10	2,7	1
Outer steel drum	Carbon steel	20	4,4	1
	Concrete	240*		

* A review of materials in waste type S.13 was made after the values in SAFE project calculations was chosen. The review has led to revised value for concrete. The value used in the calculations for concrete are 29 kg cement/package. Content in above listed value is 48 kg cement ($0{,}20 \cdot 240 = 48$ kg).

Table 4-3. Estimated reference waste composition in one drum.

Material	Weight	Surface area
Ashes	63,5 kg	
Aluminium	6,5 kg	3,6 m^2

The total amount of different materials in all of the packages of S.13 are summarised in Table 4-4.

Void and waste volume is specified in Table 4-5.

Table 4-4. Reference composition and surface area of metallic components in 6479 S.13 drums of ashes.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel			194 400	46 000	194 400	46 000
Ashes	411 400				411 400	
Aluminium	42 100	23 300			42 100	23 300
Concrete	1550 000				1550 000	

Table 4-5. Volumes in 1 and 6479 typical waste packages of S.13 drums of ashes.

	Volume (m^3) 1 package	Volume (m^3) 6479 packages
Waste	0,107	693
Void	0,006	39

4.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 4-6.

Table 4-6. radionuclide composition of a reference waste package of the type S.13.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$5{,}2\cdot10^{7}$	Sr-90	$3{,}7\cdot10^{5}$
Ag-108m	$3{,}1\cdot10^{3}$	Tc-99	$1{,}8\cdot10^{4}$
Ba-133	$5{,}2\cdot10^{2}$	Pu-239	$9{,}3\cdot10^{3}$
Be-10	$3{,}1\cdot10^{-2}$	Pu-240	$1{,}9\cdot10^{4}$
C-14	$5{,}2\cdot10^{4}$	Pb-210	$5{,}6\cdot10^{-7}$
Fe-55	$5{,}2\cdot10^{7}$	Ra-226	$5{,}6\cdot10^{-6}$
H-3	$5{,}2\cdot10^{3}$	Ac-227	$1{,}1\cdot10^{-4}$
Ho-166m	$2{,}1\cdot10^{2}$	Th-229	$8{,}3\cdot10^{-6}$
Mo-93	$2{,}6\cdot10^{2}$	Th-230	$2{,}5\cdot10^{-3}$
Nb-93m	$5{,}2\cdot10^{4}$	Th-232	$2{,}8\cdot10^{-9}$
Nb-94	$5{,}2\cdot10^{2}$	Pa-231	$8{,}3\cdot10^{-4}$
Ni-59	$5{,}2\cdot10^{4}$	U-232	$8{,}3\cdot10^{-1}$
Ni-63	$1{,}0\cdot10^{7}$	U-233	$5{,}6\cdot10^{-4}$
Sb-125	$5{,}2\cdot10^{6}$	U-234	$2{,}8\cdot10^{1}$
Zr-93	$5{,}2\cdot10^{1}$	U-235	$5{,}6\cdot10^{-1}$
		U-236	$8{,}3\cdot10^{0}$
Correlated to Cs-137		U-238	$1{,}1\cdot10^{1}$
Cs-137	$3{,}7\cdot10^{6}$	Np-237	$1{,}1\cdot10^{1}$
Cd-113m	$2{,}2\cdot10^{3}$	Pu-238	$1{,}1\cdot10^{5}$
Cl-36	$3{,}7\cdot10^{1}$	Pu-241	$2{,}8\cdot10^{6}$
Cs-134	$3{,}7\cdot10^{6}$	Pu-242	$8{,}3\cdot10^{1}$
Cs-135	$1{,}8\cdot10^{1}$	Am-241	$2{,}8\cdot10^{4}$
Eu-152	$2{,}6\cdot10^{2}$	Am-242m	$2{,}8\cdot10^{2}$
Eu-154	$3{,}7\cdot10^{5}$	Am-243	$8{,}3\cdot10^{2}$
Eu-155	$2{,}6\cdot10^{5}$	Cm-243	$5{,}6\cdot10^{2}$
I-129	$1{,}1\cdot10^{0}$	Cm-244	$8{,}3\cdot10^{4}$
Pd-107	$3{,}7\cdot10^{0}$	Cm-245	$8{,}3\cdot10^{0}$
Pm-147	$3{,}3\cdot10^{6}$	Cm-246	$2{,}2\cdot10^{0}$
Ru-106	$1{,}8\cdot10^{4}$	Pu-244	$1{,}9\cdot10^{-5}$
Se-79	$1{,}5\cdot10^{1}$		
Sm-151	$1{,}1\cdot10^{4}$		
Sn-126	$1{,}8\cdot10^{0}$		

A reference waste package of the type S.13 has a surface dose rate of 2 mSv/h and no surface contamination.

4.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- Waste volume in individual packages depends on size of fragments of the residual ashes.

5 S.19

5.1 Waste type description

5.1.1 Waste package

The S.19 waste type consists of steel boxes with graphite waste. The waste origins from the graphite reflector shield in the small research rector R1 that was situated under the royal Institute of Technology in Stockholm. The reactor was decommissioned during the 1980's. The waste material consists of blocks of graphite and in one box there are some scrap metal. Small amounts of aluminium is present in the waste. The material is classified as low level waste /Larsson, 1998; Johansson, 2000/.

Following general restrictions are applicable on this waste:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.
- Limited amounts of C-14.

Packaging

The steel box is a standard type box called 'Berglöf 600 T', with dimensions 1,20 m · 0,80 m · 0,80 m. The weight including lid is 145 kg. The walls of the package are 3–5 mm thick. A picture of the 'Berglöf' box can be seen in Figure 5-1.

The 'Berglöf' box is a standard box designed to fit in an ordinary ISO-containers. The variations in construction are minimal.

Figure 5-1. *Schematic view of a 'Berglöf' box used for waste type S.19.*

Treatment and conditioning

During the decommissioning of the R1-reactor the graphite was placed directly in the steel boxes.

Average void differs but since the waste consists of graphite blocks the void is small. An estimate is about 5 % in a package.

5.1.2 Materials – chemical composition

The amounts of different materials in a S.19 box are given in Table 5-1. Since the waste contains a graphite reflector the waste is extremely well defined. No more production of this waste type is expected since graphite is not used in the Swedish reactors.

In one of the boxes there are also metal scrap.

In total there are 95 steel boxes of this waste type, one of them has been filled with scrap metal in order to save space in the repository.

Table 5-1. Amount of different material in a typical package S.19.

Material	Weight	Surface area	Weight-%
Graphite	445-790 kg		62-100 %
Steel	0-275 kg	0-3,5 m^2	0-38 %

5.1.3 Radionuclide inventory

Measurements of the graphite shows presence of C-14, Eu-152, Eu-154 and some Co-60. Measures on Co-60 are below detection limit, approximately 3,3 kBq/kg. Calculation shows that the C-14 and Eu-isotopes are between 90 GBq and 100 GBq (C-14), 23 MBq and 3 GBq (Eu-152) and 1,1 MBq and 275 MBq (Eu-154). In the waste inventory for the SAFE project the amount of C-14 has been exaggerated compared to the measurements as a very conservative assumption.

Dose rate limit for this package is 10 mSv/h according to limits in rock cavern BTF. Dose rates on actual packages vary from 0,1–3 mSv/h. Contamination on surface should not exceed 40 kBq/m^2 for gamma and beta emitting nuclides and 4 kBq/m^2 for alpha emitting nuclides on the package.

5.1.4 Waste production

The number of packages produced until 1998-12-31 is 95, see appendix A. There will be no more production of this waste type.

5.2 Reference waste type description

5.2.1 Waste package and material

The number of packages that will be produced is 95.

Table 5-2 shows the content of different materials and the surface areas of steel in the packaging in reference box of graphite waste.

The assumed composition of the waste in a reference waste package of S.19 is given in Table 5-3. The surface area on metal components in the waste are estimated by assuming planar plates with a thickness of 5 mm, the density is set to 7860 kg/m^3 for carbon and stainless steel. The steel that is present as waste in one box is averaged over the whole population.

Table 5-2. Estimated typical packaging composition and surface area and thickness of components waste type S.13.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel box	Carbon steel	145	10,2	3

Table 5-3. Estimated reference waste composition and surface area and thickness of components in one steel box.

Material	Weight	Surface area
Graphite	550	
Iron/steel	2,9	0,1

The total amount of different material in all of the packages of the S.19 type are summarised in Table 5-4.

Void and waste volume is specified in Table 5-5.

Table 5-4. Reference composition and surface area of metallic components in 95 steel boxes .

Content	Waste		Packaging		Waste packages	
	Weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	275	0,1	13 775	973	14 050	973
Graphite	52 000				52 000	

Table 5-5. Volumes in 1 and 95 typical waste packages of S.19.

	Volume (m^3) 1 package	Volume (m^3) 95 packages
Waste	0,542	51,5
Void	0,028	2,7

5.2.2 Radionuclide inventory

The reference inventory in one package at the time of production has not been calculated since there are no more production of the waste type and hence there is no need for a reference inventory. A inventory for all boxes at the year 2030 is presented in appendix B.

A reference waste package of the type S.19 has a surface dose rate of 3 mSv/h and no surface contamination.

5.3 Uncertainties

- Content of C-14 is analysed from small amounts of weight in test samples. If these samples are representative for all graphite is uncertain.
- There is a suspicion that Cl-36 is present in the waste. Tests are being made during 2001.

6 Other waste types

6.1 Waste type description

6.1.1 General

Since SFR-1 still is in operation there is always the possibility that new waste types are needed. It is not possible to define these types per se; this can only be done when more data is available. Still, there is a need to include this waste in the safety assessment of the SFR-1 repository. In order to make some sort of analysis one has to make some rather crude assumptions.

The assumptions made are:

- The waste consists of large components or scrap metal.
- The materials of the waste package is based on several large components and is set to approximately 10 % steel, 45 % concrete and 45 % void.
- The geometry is set to the same as the concrete tanks, i.e. 3,3 m · 1,3 m · 2,3 m. The actual packages can differ considerably from this, the geometry has no other meaning than facilitate easy calculations.
- No waste container is assumed for this waste, the waste itself is assumed to be the container.
- The radionuclide inventory is equal to the volume the waste takes in the cavern, i.e. if there is 10 % of odd waste in the cavern, the radionuclides are 10 % of what is allowed.
- Surface dose rate is estimated to the limiting dose rate in the cavern, i.e. 10 mSv/h.

At present only two types of odd waste have been disposed off in the BTF. Type F.99:2 which is steam separators in steel boxes filled with concrete and R.99:1, which is the old reactor vessel lid from the Ringhals 1 reactor (also filled with concrete. We have chosen not to use data from these types since the uncertainties regarding future waste are so big.

6.2 Reference waste type description

6.2.1 Waste package and material

The number of packages that will be produced is 415.

Table 6-1 shows the content of different materials and the surface areas of steel in the odd waste. The surface area on metal components in the waste are estimated by assuming planar plates with a thickness of 10 mm, the density is set to 7860 kg/m^3 for carbon and stainless steel.

Table 6-1. Estimated typical packaging composition and surface area and thickness of components of odd waste type.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Carbon steel	7 000	179	10
Concrete	10 000		

The total amount of different material in all of the packages of the odd waste are summarised in Table 6-2.

Void and waste volume is specified in Table 6-3.

Table 6-2. Reference composition and surface area of metallic components in 415 packages of odd waste.

Content	Waste packages weight (kg)	Waste packages area (m^2)
Iron/steel	2 905 000	74 487
Concrete	4 150 000	

Table 6-3. Volumes in 1 and 415 typical waste packages of odd waste.

	Volume (m^3) 1 package	Volume (m^3) 415 packages
Waste	5,45	2262
Void	4,55	1888

6.2.2 Radionuclide inventory

The reference inventory in one package at the time of production has not been calculated since waste type is hypothetical and hence there is no need for a reference inventory. A inventory for all boxes at the year 2030 is presented in appendix B.

A reference waste package of the odd waste type has a surface dose rate of 10 mSv/h and no surface contamination.

6.3 Uncertainties

- Up to this date only a few kinds of odd waste has been disposed off in BTF, in future odd waste types could be disposed off.

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Appendix E

Waste types in BMA

1 General

1.1 Waste in BMA

In SFR, in the BMA – rock cavern for intermediate level waste – short-lived wastes from the nuclear power plants and the Studsvik research site are disposed off. The BMA cavern is approximately 160 m long, 19,5 m wide and has a height of 16,5 m. Inside the cavern a concrete construction has been raised. The construction consists of 13 big and 2 smaller compartments. The big ones is 10 m · 15 m · 8 m and the small ones 4 m · 7,2 m · 4,8 m. The waste, moulds and drums, are placed in the compartments be remote controlled equipment. When a compartment is filled a lid is built upon the waste. There is also a possibility to back-fill the void between the waste packages in a compartment. The technical barriers are basically the concrete structure that will minimise flow through the waste and lead the ground-water flow around the construction.

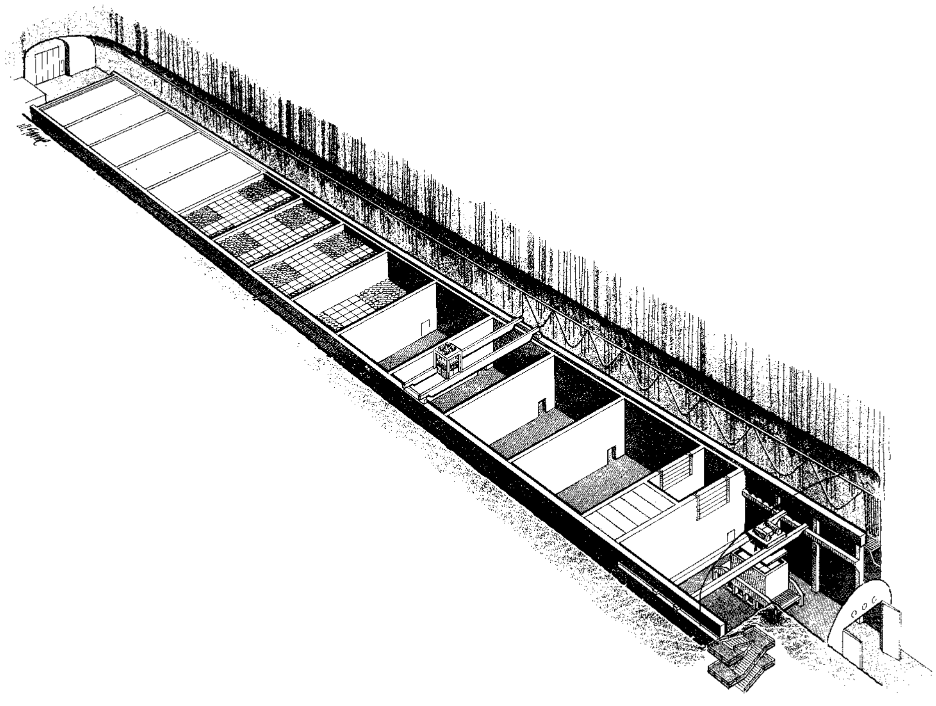

Figure 1-1. *BMA.*

The waste that is intended in BMA comes from many different waste streams but the most important one is ion-exchange resins from the nuclear power plants. Other waste like metal components of different origin and contaminated ordinary garbage is also disposed off in BMA.

The dose rates allowed on packages are maximum 100 mSv/h. The amount of radionuclides are fairly low, BMA has been designed to handle approximately 6 % of the radionuclides in SFR-1. Dominating nuclide are Co-60 and Cs-137.

Other criteria for acceptance are:

- Construction, geometry, dimensions and weight must be suited to the handling system in SFR and the transportation system in general and in BLA in particular. The strength of the packages must be sufficient to withstand normal and unnormal handling.
- Each package must have an individual identity and the radionuclide content of gamma emitting nuclides shall be known.
- Surface contamination should not exceed 40 kBq/m^2 for gamma and beta emitting nuclides and 4 kBq/m^2 for alpha emitting nuclides.
- The internal dosrates and integrated dose must not affect the barrier properties in the repository.
- The chemical and physical properties and the structure of the waste should be known.
- Chemical aggressive or explosive material, pressurised gas and free liquid are not allowed.
- Gas production from the waste must not be to big.
- The waste shall have enough resistance towards corrosion that the integrity of the package is kept until sealing of the repository.
- Burnable waste must not be subject to self-ignition.
- Complexing agents should if possible be avoided.

All waste in BMA is normally packed in concrete or steel moulds or steel drums.

1.2 Definitions

Surface area is defined as the area subject to anaerobic corrosion and gas production after sealing of the repository.

1.3 Uncertainties

- The presented waste types describes the types that has been, is in or can be foreseen to be produced in Sweden. New waste types may be present in the future.
- Almost all data is based on literature values, smaller changes may not been properly documented.
- All future production is based on a relative simple prognosis model. This model, described in appendix A, was chosen since the uncertainties about processes etc are large.
- No regard has been taken to improvements in processes etc.

- A reference package has been chosen based on best estimates. Actual packages may differ considerably from this reference package, the uncertainty for the whole population of packages is judged to be smaller.

- Big components as heat exchangers etc could in the future be of interest to dispose off in BMA. See chapter 18 in this appendix.

- Void presented in this report is based on best estimates, the estimates can be quite crude.

2 B.05

2.1 Waste type description

2.1.1 Waste package

General

The B.05 waste type consists of a standard 200-litre drum containing ion-exchange resins in a bitumen matrix. The raw waste material consists of ion-exchange resins and sludges generated at the Barsebäck nuclear power plant. The material is classified as intermediate level waste. All data comes from /Berntsson, 1991; Johansson, 2000; TRIUMF, 2000/.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.

This waste type is more or less identical to the B.06-type except the radionuclide content.

Packaging

The steel drum is made of stainless steel with diameter 0,595 m and 0,882 m in height. The thickness of the material is 1,2 mm. The drum weighs approximately 23 kg and the surface area is approximately 3 m^2. To facilitate the handling in SFR the drums are placed four by four on a steel plate with the dimension 1,2 m ·1,2 m and the thickness of 0,004 m. The weight of the steel plate is 49 kg with surface area of 2,9 m^2. The variations between packages are minimal. No major changes in design have been made since the start of production of this package except that since 1985 the drums are made of stainless steel. The weight in total of a package including waste and is approximately 200 kg. The maximum allowed weight of a waste package is 500 kg.

Treatment and conditioning

The ion exchange resin containing metal hydroxides and other substances are mixed with bitumen in a custom-made facility in the Barsebäck NPP. The flow in the bitumenisation process is measured with electrical conductivity. A small amount of Na_2SO_4 is mixed with the product to give correct measurements of the conductivity. Emulgator is added in order to make the product more homogene. After filling, a steel lid is placed upon the drum. The drums are placed on the steel plate when they are sent to SFR.

The void varies but is estimated to 0,03 m^3 in a drum (not including expansion box).

2.1.2 Materials – chemical composition

The amounts of different materials in a B.05 drum are given in Table 2-1. The waste matrix contains metal hydroxides from the clean-up system for the reactor and evaporation residues from back flush water from the fuel storage pools. The weight of the raw waste material is normally 50 kg ion exchange resin per package but varies, see Table 2-1.

The matrix is made of bitumen. The specific brand of bitumen has changed during the many years of production of this waste type but it is always of the distilled sort. The brands used are: Mexphalate until 1982, Nynäs industrial bitumen IB 45 between 1983–1995 and Nynäs industrial bitumen IB 55 used from 1995. The amounts of added chemicals are:

Na_2SO_4	0,2–0,5 kg/drum
Emulgator	0,4–1,1 kg/drum

Table 2-1. Amounts of different material in waste type B.05 (per package).

Material	Weight	Weight-%
Ion-exchange resin	30-55 kg	16-43 %
Bitumen	129-155 kg	57-84 %

2.1.3 Radionuclide inventory

Before the waste is transported from Barsebäck NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $5,1 \cdot 10^{11}$ Bq for Co-60 and between 0 and $1,1 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 100 mSv/h but normally it is between 0–10 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

2.1.4 Waste production

The waste type has been in production since 1985 and is still in production. The number of packages produced until 1998-12-31 is 4208, the annual production is estimated to 2, see appendix A.

2.2 Reference waste type description

2.2.1 Waste package and material

The number of packages that will be produced is calculated to 4230 during the operation of Barsebäck.

Table 2-2 shows the content of different materials and the surface areas of the packaging in B.05 package from Barsebäck. Since the steel plate and expansion box is shared between four drums ¼ of the plate and box is included in a package of B.05.

The assumed composition of the waste in a reference waste package of B.05 is given in Table 2-3.

Table 2-2. Estimated reference packaging composition and surface area and thickness of components in each steel drum and one ¼ of a steel plate of B.05.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel drum	Stainless steel	23	3	1,2
Steel plate	Carbon steel	12,25	0,7	4
Expansion box	Carbon steel	5	0,2	6

Table 2-3. Estimated reference waste composition in one steel drum of B.05.

Material	Weight
Ion-exchange resin	50 kg
Bitumen	150 kg
Chemicals(Na-sulphate)	0,5 kg

The total amounts of different materials in all the packages of B.05 are summarised in Table 2-4.

Void and waste volume is specified in Table 2-5.

Average void is estimated to 0,03 m^3 in a steel drum.

Table 2-4. Reference composition and surface area of metallic components in 4230 steel drums including ¼ steel plate per drum of B.05.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	Area (m^2)	weight (kg)	area (m^2)
Iron/steel		149 100	15 700	149 100	15 700
Bitumen	634 500			634 500	
Ion-exchange resin	211 500			211 500	

Table 2-5. Volumes in 1 and 4230 reference waste packages of steel drums including ¼ steel plate per drum of B.05.

	Volume (m^3) 1 package	Volume (m^3) 4230 packages
Waste	0,2	85
Void	0,03	127

2.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 2-6.

Table 2-6. Radionuclide composition of a reference waste package of the type B.05.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$8{,}7\cdot10^{9}$	Pu-239	$1{,}7\cdot10^{3}$
Ag-108m	$5{,}2\cdot10^{5}$	Pu-240	$3{,}5\cdot10^{3}$
Ba-133	$8{,}7\cdot10^{4}$	Pb-210	$1{,}0\cdot10^{-7}$
Be-10	$5{,}2\cdot10^{0}$	Ra-226	$1{,}0\cdot10^{-6}$
C-14	$8{,}7\cdot10^{6}$	Ac-227	$2{,}1\cdot10^{-5}$
Fe-55	$8{,}7\cdot10^{9}$	Th-229	$1{,}6\cdot10^{-6}$
H-3	$8{,}7\cdot10^{5}$	Th-230	$4{,}7\cdot10^{-4}$
Ho-166m	$3{,}5\cdot10^{4}$	Th-232	$5{,}2\cdot10^{-1}0$
Mo-93	$4{,}4\cdot10^{4}$	Pa-231	$1{,}6\cdot10^{-4}$
Nb-93m	$8{,}7\cdot10^{6}$	U-232	$1{,}6\cdot10^{-1}$
Nb-94	$8{,}7\cdot10^{4}$	U-233	$1{,}0\cdot10^{-4}$
Ni-59	$8{,}7\cdot10^{6}$	U-234	$5{,}2\cdot10^{0}$
Ni-63	$1{,}7\cdot10^{9}$	U-235	$1{,}0\cdot10^{-1}$
Sb-125	$8{,}7\cdot10^{8}$	U-236	$1{,}6\cdot10^{0}$
Zr-93	$8{,}7\cdot10^{3}$	U-238	$2{,}1\cdot10^{0}$
		Np-237	$2{,}1\cdot10^{0}$
Correlated to Cs-137		Pu-238	$2{,}1\cdot10^{4}$
Cs-137	$7{,}2\cdot10^{8}$	Pu-241	$5{,}2\cdot10^{5}$
Cd-113m	$4{,}3\cdot10^{5}$	Pu-242	$1{,}6\cdot10^{1}$
Cl-36	$7{,}2\cdot10^{3}$	Am-241	$5{,}2\cdot10^{3}$
Cs-134	$7{,}2\cdot10^{8}$	Am-242m	$5{,}2\cdot10^{1}$
Cs-135	$3{,}6\cdot10^{3}$	Am-243	$1{,}6\cdot10^{2}$
Eu-152	$5{,}0\cdot10^{4}$	Cm-243	$1{,}0\cdot10^{2}$
Eu-154	$7{,}2\cdot10^{7}$	Cm-244	$1{,}6\cdot10^{4}$
Eu-155	$5{,}0\cdot10^{7}$	Cm-245	$1{,}6\cdot10^{0}$
I-129	$2{,}2\cdot10^{2}$	Cm-246	$4{,}2\cdot10^{-1}$
Pd-107	$7{,}2\cdot10^{2}$	Pu-244	$3{,}6\cdot10^{-6}$
Pm-147	$6{,}5\cdot10^{8}$		
Ru-106	$3{,}6\cdot10^{6}$		
Se-79	$2{,}9\cdot10^{3}$		
Sm-151	$2{,}2\cdot10^{6}$		
Sn-126	$3{,}6\cdot10^{2}$		
Sr-90	$7{,}2\cdot10^{7}$		
Tc-99	$3{,}6\cdot10^{6}$		

A reference waste package of the type B.05 has a surface dose rate of 100 mSv/h and no surface contamination.

2.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- The production of type B.05 was closed down in the end of 2000. Since the replacing type is not decided yet the B.05 is used in the calculations.

3 F.05

3.1 Waste type description

3.1.1 Waste package

General

The F.05 waste type consists of a standard 200-litre drum containing ion-exchange resins in a bitumen matrix. The raw waste material consists of ion-exchange resins generated at the Forsmark nuclear power plant. The material is classified as intermediate level waste. All data comes from /Lindberg and Malmkvist, 1991a,b; Johansson, 2000; TRIUMF, 2000/.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.

Packaging

The steel drum is made of stainless steel with diameter 0,595 m and 0,882 m in height. The wall thickness is 1,2 mm. The drum weighs approximately 25 kg and surface area is approximately 2,5 m^2. To facilitate the handling in SFR the drums are placed four by four on a steel plate with the dimension 1,2 m ·1,2 m and the thickness of 4 mm. The weight of the steel plate is 66,5 kg with surface area of 3,9 m^2. The variations between packages are minimal. No major changes in design have been made since the start of production of this package.

The weight in total of a package including waste and is approximately 250 kg but varies between 115 and 350 kg. The maximum allowed weight of a waste package is 500 kg.

Treatment and conditioning

The ion-exchange resins containing metal hydroxides and other substances are mixed with bitumen in a custom-made facility in the Forsmark NPP. After filling, the drums are topped up with a small amount of bitumen and then a steel lid is placed upon the drum. The drums are placed on the steel plate when the drums are sent to SFR.

The void varies but is estimated to 0,03 m^3 in a drum.

3.1.2 Materials – chemical composition

The amounts of different materials in a F.05 drum are given in Table 3-1. The waste contains metal hydroxides from condensate cleaning up system (system 332), system drainage (342) and small amounts from fuel pool cleaning system (324). Some trace amounts of complexing agents from cleaning products could follow this waste stream. The weight of the raw waste material is normally 130 kg ion-exchange resin per package but varies, see Table 3-1.

The matrix is made of bitumen. The brand used is Nynäs industrial bitumen according to /Lindberg and Malmkvist, 1991a,b/.

Table 3-1. Amounts of different material in waste type F.05 (per package).

Material	Weight	Weight-%
Ion-exchange resin	130 kg	58 %
Bitumen	95 kg	42 %

No interval for different material is specified in the literature.

3.1.3 Radionuclide inventory

Before the waste is transported from Forsmark NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $3{\cdot}10^{10}$ Bq for Co-60 and between 0 and $2{\cdot}10^{9}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 100 mSv/h but normally it is between 0–2 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

3.1.4 Waste production

The waste type has been in production from 1982 to 1990. The number of packages produced until 1998-12-31 is 1718. See appendix A.

3.2 Reference waste type description

3.2.1 Waste package and material

The number of packages that will be produced is calculated to 1718 during the operation of Forsmark.

Table 3-2 shows the content of different materials and the surface areas of the packaging in F.05 package from Forsmark. Since the steel plate is shared between four drums ¼ of the plate and box is included in a package of F.05.

The assumed composition of the waste in a reference waste package of F.05 is given in Table 3-3.

Table 3-2. Estimated reference packaging composition and surface area and thickness of components in each steel drum and one ¼ of a steel plate of F.05.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel drum	Stainless steel	25	2,5	1,25
Steel plate	Stainless steel	16,6	0,98	4

Table 3-3. Estimated reference waste composition in one steel drum of F.05.

Material	Weight
Ion-exchange resin	130 kg
Bitumen	95 kg

The total amounts of different materials in all the packages of F.05 are summarised in Table 3-4.

Void and waste volume is specified in Table 3-5.

Average void is estimated to 0,02 m^3 in a steel drum.

Table 3-4. Reference composition and surface area of metallic components in 1718 steel drums including ¼ steel plate per drum of F.05.

Content	Waste	Packaging		Waste packages	
	Weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		71 500	5 980	71 500	5 980
Bitumen	223 300			223 300	
Ion-exchange resin	163 200			163 200	

Table 3-5. Volumes in 1 and 1718 reference waste packages of steel drums including ¼ steel plate per drum of F.05.

	Volume (m^3) 1 package	Volume (m^3) 1718 packages
Waste	0,195	335
Void	0,02	34

3.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 3-6. The transuranic elements have been calculated in a different way and it is not possible to calculate a reference waste type. An inventory for transuranic elements for all drums at the year 2030 is presented in appendix B.

Table 3-6. Radionuclide composition of a reference waste package of the type F.05.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Cs-137	
Co-60	$4{,}0\cdot10^{9}$	Cs-137	$4{,}4\cdot10^{7}$
Ag-108m	$2{,}4\cdot10^{5}$	Cd-113m	$2{,}6\cdot10^{4}$
Ba-133	$4{,}0\cdot10^{4}$	Cl-36	$4{,}4\cdot10^{2}$
Be-10	$2{,}4\cdot10^{0}$	Cs-134	$4{,}4\cdot10^{7}$
C-14	$4{,}0\cdot10^{6}$	Cs-135	$2{,}2\cdot10^{2}$
Fe-55	$4{,}0\cdot10^{9}$	Eu-152	$3{,}1\cdot10^{3}$
H-3	$4{,}0\cdot10^{5}$	Eu-154	$4{,}4\cdot10^{6}$
Ho-166m	$1{,}6\cdot10^{4}$	Eu-155	$3{,}1\cdot10^{6}$
Mo-93	$2{,}0\cdot10^{4}$	I-129	$1{,}3\cdot10^{1}$
Nb-93m	$4{,}0\cdot10^{6}$	Pd-107	$4{,}4\cdot10^{1}$
Nb-94	$4{,}0\cdot10^{4}$	Pm-147	$3{,}9\cdot10^{7}$
Ni-59	$4{,}0\cdot10^{6}$	Ru-106	$2{,}2\cdot10^{5}$
Ni-63	$7{,}9\cdot10^{8}$	Se-79	$1{,}7\cdot10^{2}$
Sb-125	$4{,}0\cdot10^{8}$	Sm-151	$1{,}3\cdot10^{5}$
Zr-93	$4{,}0\cdot10^{3}$	Sn-126	$2{,}2\cdot10^{1}$
		Sr-90	$4{,}4\cdot10^{6}$
		Tc-99	$2{,}2\cdot10^{5}$

A reference waste package of the type F.05 has a surface dose rate of 30 mSv/h and no surface contamination.

3.3 Uncertainties

- General uncertainties are described in chapter 1.3.

4 F.15

4.1 Waste type description

4.1.1 Waste package

General

The F.15 waste type consists of 1,73 m^3 steel moulds containing ion-exchange resins in a concrete matrix. The raw waste material consists of ion-exchange resins, filter aids and evaporator residues generated at the Forsmark nuclear power plant. The material is classified as intermediate level waste. All data comes from /Lindberg and Malmkvist, 1991c; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of steel with the dimensions 1,2 m ·1,2 m ·1,2 m. The wall is 5 mm thick, the bottom is 6 mm thick. The mould weighs approximately 425 kg and the surface area is approximately 20 m^2. The variations between moulds are minimal. No major change in design has been made since the start of production of this package.

The weight in total of a package including waste and is approximately 2400 kg but differs between 2300–3100 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is heated and then mixed with water and cement additives. The slurry is then pumped into the mould and cement is added. When the cement is added the stirrer is started and the waste matrix is mixed. The matrix is then allowed to harden. A steel lid is placed upon the mould.

4.1.2 Materials – chemical composition

The amounts of different materials in a F.15 mould are given in Table 4-1. The waste is well defined and consists of ion-exchange resins, evaporator residues and filter-aid with radionuclides.

The waste includes powder resins and filter-aids from cleaning of condensate (system 332), system drainage (system 342/1), cleaning of floor drainage (system 342/2) and bead resins from, system drainage (system 342/1) and evaporator residues from system 342/5. Some resins from other systems can be present if the radionuclide content is low enough.

The weight of the raw waste material is normally 536 kg of waste per package but varies, see Table 4-1.

The matrix is made of cement, standard Portland type. Silix GP and Sika AER are used as additives.

Table 4-1. Amounts of different material in waste type F.15 (per package)

Material	Weight	Weight-%
Ion-exchange resin	355-550 kg	24,8-41,7 %
Evaporator residues	0-200 kg	0-15,1 %
Cement*	770-875 kg	50,7-71,1 %

* Including water 0,4 kg/kg cement.

4.1.3 Radionuclide inventory

Before the waste is transported from Forsmark NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $5 \cdot 10^9$ Bq for Co-60 and between 0 and $5 \cdot 10^9$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 100 mSv/h on the surface. Normally the dose rate at 1 meter is 0–0,1 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package. The waste packages are usually free of contamination.

4.1.4 Waste production

The waste type was in production between 1981 and 1988. The numbers of packages produced until 1994-12-31 is 11, no more packages are foreseen, see appendix A.

4.2 Reference waste type description

4.2.1 Waste package and material

The number of packages that will be produced is calculated to 11 packages during the operation of Forsmark.

Table 4-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of F.15 is given in Table 4-3.

Table 4-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of F.15.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel box	Stainless steel	400	17	5
Stirrer	Stainless steel	25	3	2

Table 4-3. Estimated reference waste composition and surface area and thickness of components in one of F.15.

Material	Weight
Ion-exchange resin	375 kg
Evaporator concentrates	161 kg
Cement*	805 kg

* Including 0,4 kg water/kg cement.

The total amounts of different materials in all the packages of F.15 are summarised in Table 4-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 4-5. The waste volume is estimated from the weights of the waste components in Table 4-3 and approximate densities of the different material. Average void is estimated to 10 % in a package.

Void and waste volume is specified in Table 4-5.

Table 4-4. Reference composition and surface area of metallic components in 11 concrete moulds in F.15.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		4 670	220	4 670	220
Ion-exchange resin	4 125			4 125	
Evaporator concentrate	1 770			1 770	
Cement*	8 900			8 900	

* Including 0,4 kg water/kg cement.

Table 4-5. Volumes in 1 and 11 reference waste packages of F.15.

	Volume (m^3) 1 package	Volume (m^3) 11 packages
Waste	1,53	17
Void	0,17	1,9

4.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 4-6. The transuranic elements have been calculated in a different way and it is not possible to calculate a reference waste type. An inventory for transuranic elements for all drums at the year 2030 is presented in appendix B.

Table 4-6. Radionuclide composition of a reference waste package of the type F.15.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Cs-137	
Co-60	$3{,}4 \cdot 10^9$	Cs-137	$2{,}2 \cdot 10^9$
Ag-108m	$2{,}1 \cdot 10^5$	Cd-113m	$1{,}3 \cdot 10^6$
Ba-133	$3{,}4 \cdot 10^4$	Cl-36	$2{,}2 \cdot 10^4$
Be-10	$2{,}1 \cdot 10^0$	Cs-134	$2{,}2 \cdot 10^9$
C-14	$3{,}4 \cdot 10^6$	Cs-135	$1{,}1 \cdot 10^4$
Fe-55	$3{,}4 \cdot 10^9$	Eu-152	$1{,}6 \cdot 10^5$
H-3	$3{,}4 \cdot 10^5$	Eu-154	$2{,}2 \cdot 10^8$
Ho-166m	$1{,}4 \cdot 10^4$	Eu-155	$1{,}6 \cdot 10^8$
Mo-93	$1{,}7 \cdot 10^4$	I-129	$6{,}7 \cdot 10^2$
Nb-93m	$3{,}4 \cdot 10^6$	Pd-107	$2{,}2 \cdot 10^3$
Nb-94	$3{,}4 \cdot 10^4$	Pm-147	$2{,}0 \cdot 10^9$
Ni-59	$3{,}4 \cdot 10^6$	Ru-106	$1{,}1 \cdot 10^7$
Ni-63	$6{,}9 \cdot 10^8$	Se-79	$8{,}9 \cdot 10^3$
Sb-125	$3{,}4 \cdot 10^8$	Sm-151	$6{,}7 \cdot 10^6$
Zr-93	$3{,}4 \cdot 10^3$	Sn-126	$1{,}1 \cdot 10^3$
		Sr-90	$2{,}2 \cdot 10^8$
		Tc-99	$1{,}1 \cdot 10^7$

A reference waste package of the type F.15 has a surface dose rate of 30 mSv/h and no surface contamination.

4.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- Evaporator concentrate could also contain fragments of metals, plastics, oil, paint and different salts.

5 F.17

5.1 Waste type description

5.1.1 Waste package

General

The F.17 waste type consists of 1,73 m^3 steel moulds containing ion-exchange resins in a bitumen matrix. The raw waste material consists of ion-exchange resins, filter aids and evaporator concentrates generated at the Forsmark nuclear power plant. The material is classified as intermediate level waste. All data comes from /Lindberg and Malmkvist, 1999; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.

Packaging

The mould is a cubic box made of steel with the dimensions 1,2 m · 1,2 m ·1,2 m. The wall is 5 mm thick, the bottom is 6 mm thick. The mould weighs approximately 400 kg and the surface area is approximately 10 m^2. The variations between moulds are minimal. No major change in design has been made since the start of production of this package.

The weight in total of a package including waste and is approximately 2080 kg but differs between 1900–2250 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The ion-exchange resins are dried in 150°C in a conical dryer and are then homogenised with bitumen in a conical mixer. The mixed waste is then poured in a steel mould. Each batch is maximum 500 litres. The mix is then allowed to cool for at least 17 h before a thin layer (~1 cm) of pure bitumen is poured upon the waste matrix. The waste package is thereafter lidded with a steel lid.

The void varies but is estimated to 10 % in a package.

5.1.2 Materials – chemical composition

The amounts of different materials in a F.17 mould are given in Table 5-1. The waste is well defined and consists of ion-exchange resins, filter aids and evaporator concentrates with radionuclides from system 342. The weight of the raw waste material is normally 770 kg waste per package but varies, see Table 5-1. Until 1992 the waste type F.17 contained filter aids based on cellulose, each package until this year is estimated to have an average of 3,6 kg cellulose per package. In total there is 195 packages with this amount of cellulose /Carlsson, 2001/.

The matrix is made of bitumen. The specific brand of bitumen has changed during the years of production of this waste type but it is always the distilled kind. The brands used are Nynäs industrial bitumen IB 45 or IB 55.

Table 5-1. Amounts of different material in waste type F.17 (per package).

Material	Weight	Weight-%
Ion-exchange resin	0-1100 kg	0-65 %
Evaporator concentrate	0-1100 kg	0-65 %
Bitumen	600-680 kg	35-40 %

5.1.3 Radionuclide inventory

Before the waste is transported from Forsmark NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $5\cdot10^{11}$ Bq for Co-60 and between 0 and $2\cdot10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 100 mSv/h. Normal doserate at 1 m is between 0,1–4,5 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package. The waste packages are usually free of contamination.

5.1.4 Waste production

The waste type has been in production since 1989 and is still in production. The number of packages produced until 1998-12-31 is 351, annual production is estimated to 22 packages per year, see appendix A.

5.2 Reference waste type description

5.2.1 Waste package and material

The number of packages that will be produced is calculated to 879 packages during the operation of Forsmark.

Table 5-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of F.17 is given in Table 5-3.

Table 5-2. Estimated reference packaging composition and surface area and thickness of components in steel mould of F.17.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel mould	Stainless steel	400	10	5

Table 5-3. Estimated reference waste composition and surface area and thickness of components in one of F.17.

Material	Weight
Ion-exchange resin	650 kg
Evaporator concentrates	120 kg
Bitumen	820 kg

The total amounts of different materials in all the packages of F.17 are summarised in Table 5-4.

Average void is estimated 10 % in a steel mould. Void and waste volume is specified in Table 5-5.

Table 5-4. Reference composition and surface area of metallic components in 879 steel moulds of F.17.

Content	Waste weight (kg)	Packaging weight (kg)	Packaging area (m^2)	Waste packages weight (kg)	Waste packages area (m^2)
Iron/steel		351 600	8 790	351 600	8 790
Ion-exchange resin	571 300			571 300	
Evaporator concentrate	105 500			105 500	
Bitumen	720 800			720 800	

Table 5-5. Volumes in 1 and 879 reference waste packages of F.17.

	Volume (m^3) 1 package	Volume (m^3) 879 packages
Waste	1,615	1420
Void	0,085	75

5.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 5-6.

Table 5-6. Radionuclide composition of a reference waste package of the type F.17.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$9{,}2 \cdot 10^{10}$	Pu-239	$2{,}0 \cdot 10^{5}$
Ag-108m	$5{,}5 \cdot 10^{6}$	Pu-240	$4{,}0 \cdot 10^{5}$
Ba-133	$9{,}2 \cdot 10^{5}$	Pb-210	$1{,}2 \cdot 10^{-5}$
Be-10	$5{,}5 \cdot 10^{1}$	Ra-226	$1{,}2 \cdot 10^{-4}$
C-14	$9{,}2 \cdot 10^{7}$	Ac-227	$2{,}4 \cdot 10^{-3}$
Fe-55	$9{,}2 \cdot 10^{10}$	Th-229	$1{,}8 \cdot 10^{-4}$
H-3	$9{,}2 \cdot 10^{6}$	Th-230	$5{,}5 \cdot 10^{-2}$
Ho-166m	$3{,}7 \cdot 10^{5}$	Th-232	$6{,}1 \cdot 10^{-8}$
Mo-93	$4{,}6 \cdot 10^{5}$	Pa-231	$1{,}8 \cdot 10^{-2}$
Nb-93m	$9{,}2 \cdot 10^{7}$	U-232	$1{,}8 \cdot 10^{1}$
Nb-94	$9{,}2 \cdot 10^{5}$	U-233	$1{,}2 \cdot 10^{-2}$
Ni-59	$9{,}2 \cdot 10^{7}$	U-234	$6{,}1 \cdot 10^{2}$
Ni-63	$1{,}8 \cdot 10^{10}$	U-235	$1{,}2 \cdot 10^{1}$
Sb-125	$9{,}2 \cdot 10^{9}$	U-236	$1{,}8 \cdot 10^{2}$
Zr-93	$9{,}2 \cdot 10^{4}$	U-238	$2{,}4 \cdot 10^{2}$
		Np-237	$2{,}4 \cdot 10^{2}$
Correlated to Cs-137		Pu-238	$2{,}4 \cdot 10^{6}$
Cs-137	$1{,}7 \cdot 10^{10}$	Pu-241	$6{,}1 \cdot 10^{7}$
Cd-113m	$1{,}0 \cdot 10^{7}$	Pu-242	$1{,}8 \cdot 10^{3}$
Cl-36	$1{,}7 \cdot 10^{5}$	Am-241	$6{,}1 \cdot 10^{5}$
Cs-134	$1{,}7 \cdot 10^{10}$	Am-242m	$6{,}1 \cdot 10^{3}$
Cs-135	$8{,}3 \cdot 10^{4}$	Am-243	$1{,}8 \cdot 10^{4}$
Eu-152	$1{,}2 \cdot 10^{6}$	Cm-243	$1{,}2 \cdot 10^{4}$
Eu-154	$1{,}7 \cdot 10^{9}$	Cm-244	$1{,}8 \cdot 10^{6}$
Eu-155	$1{,}2 \cdot 10^{9}$	Cm-245	$1{,}8 \cdot 10^{2}$
I-129	$5{,}0 \cdot 10^{3}$	Cm-246	$4{,}8 \cdot 10^{1}$
Pd-107	$1{,}7 \cdot 10^{4}$	Pu-244	$4{,}2 \cdot 10^{-4}$
Pm-147	$1{,}5 \cdot 10^{10}$		
Ru-106	$8{,}3 \cdot 10^{7}$		
Se-79	$6{,}6 \cdot 10^{4}$		
Sm-151	$5{,}0 \cdot 10^{7}$		
Sn-126	$8{,}3 \cdot 10^{3}$		
Sr-90	$1{,}7 \cdot 10^{9}$		
Tc-99	$8{,}3 \cdot 10^{7}$		

A reference waste package of the type F.17 has a surface dose rate of 100 mSv/h and no surface contamination.

5.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- Evaporator concentrate could also contain fragments of metals, plastics, oil, paint and different salts.
- Data on cellulose in filter aids until 1992 is probably overestimated.

6 F.23

6.1 Waste type description

6.1.1 Waste package

General

The F.23 waste type consists of 1,73 m^3 concrete or steel moulds with scrap metal and refuse in a concrete matrix. The raw waste material consists of mainly iron/steel, cellulose and other organics generated at the Forsmark nuclear power plant. The material is classified as intermediate level waste. All data comes from /Forsmark, 2000; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The steel mould has the dimension 1,2 m · 1,2 m · 1,2 m. The weight is 445 kg and the total metal surface area of package is 14,5 m^2. The wall of the package is 5 mm thick, the bottom is 6 mm thick. The mould also has two lids and some reinforcements. The variations between moulds are minimal. Total weight of package including waste is approximately 2100 kg but differs between 1470–4270 kg.

The concrete mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are 10 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The mould weighs approximately 1600 kg. The variations between moulds are minimal. Total weight of package including waste is approximately 2400 kg but differs between 2200–4100 kg.

In some special cases a concrete mould with 25 cm thick walls can be used.

The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

Waste from the power plant is sorted in compactible and non-compactible. Non-compactible is put directly in a mould and the mould is then filled with concrete. Compactible waste is put in the mould and compacted. A 'middle-lid' is placed in the mould to prevent re-expansion of the waste. This operation is repeated until the mould is full. Then the mould is filled with concrete.

Pouring concrete on top of the package makes a lid.

6.1.2 Materials – chemical composition

The amounts of different materials in a F.23 mould are given in Table 6-1. The waste is fairly well defined and consists mainly of scrap metal and refuses as filters, wood, cloth, plastics and cables. The weight of the raw waste material is normally 770 kg waste per package but varies, see Table 6-1a and b.

The matrix is made of concrete. The brand used is of the standard Portland.

Table 6-1a. Amounts of different material in waste type F.23 steel mould (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Sludges	18		0,8
Cellulose	150		7,0
Other organic material	450		21,1
Iron/steel	150	7,6	7,0
Aluminium	5	0,5	0,2
Concrete**	1356		63,7

* Variation of amounts of material is not available in referred documents.
** Including 0,13 kg water/kg concrete.

Table 6-1b. Amounts of different material in waste type F.23 10-cm concrete mould (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Sludges	0		0
Cellulose	29		3,6
Other organic material	186		23,0
Iron/steel	30	1,5	3,7
Aluminium	0	0	0
Concrete**	565		69,8

* Variation of amounts of material is not available in referred documents.
** Including 0,13 kg water/kg concrete.

6.1.3 Radionuclide inventory

Before the waste is transported from Forsmark to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $9 \cdot 10^{10}$ Bq for Co-60 and between 0 and $3 \cdot 10^{10}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 100 mSv/h but normally it is between 0,01–8 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

6.1.4 Waste production

The waste type has been in production since 1986 and is still in production. The number of packages produced until 1998-12-31 is 108; annual production is estimated to 9 packages per year, see appendix A.

6.2 Reference waste type description

6.2.1 Waste package and material

The steel mould is used as reference waste package. The number of packages that will be produced is calculated to 324 packages during the operation of Forsmark, whereof 270 steel moulds and 54 concrete moulds.

Table 6-2a and b shows the content of different materials and the steel surface areas of the packaging in the reference packages.

The assumed composition of the waste in the reference waste packages of F.23 is given in Table 6-3a and b.

Table 6-2a. Estimated reference packaging composition, surface area and thickness of components in steel mould of F.23.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel box	Steel	400	10	5
Lid	Steel	48	5,8	3
Reinforcement	Steel	14	0,5	14

Table 6-2b. Estimated reference packaging composition, surface area and thickness of components in concrete mould of F.23.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		10
Lid	Steel	13	1,8	2
Reinforcement	Steel	261	10	12

Table 6-3a. Estimated reference waste composition and surface area and thickness of components in one steel mould F.23.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Sludge	18		
Cellulose	150		
Other organic material	450		
Iron/steel	150	7,8	5
Aluminium	5	0,7	5
Concrete*	1356		

* Including 0,13 kg water/kg concrete.

Table 6-3b. Estimated reference waste composition and surface area and thickness of components in one concrete mould F.23.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Sludge	0		
Cellulose	29		
Other organic material	186		
Iron/steel	30	1,5	5
Aluminium	0	0	5
Concrete*	565		

The total amounts of different materials in all the packages of F.23 steel and concrete moulds are summarised in Table 6-4a and b.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 6-5. The waste volume is estimated from the weights of the waste components in Table 6-3a and b and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 6-5.

Table 6-4a. Reference composition and surface area of components in 270 steel moulds F.23.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	40 500	2 100	125 000	4 400	165 500	6 500
Sludges	4 860				4 860	
Cellulose	40 500				40 500	
Other organic material	125 000				121 500	
Aluminium	1 350	190			1 350	190
Concrete*	366 000				366 000	

* Including 0,13 kg water/kg concrete.

Table 6-4 b. Reference composition and surface area of components in 54 concrete moulds F.23.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	1 620	80	15 800	640	17 400	720
Sludges	0				0	
Cellulose	1 570				1 570	
Other organic material	10 000				10 000	
Aluminium	0	0			0	
Concrete*	30 500		72 400		102 900	

* Including 0,13 kg water/kg concrete.

Table 6-5. Volumes in 1 and 324 reference waste packages of F.23.

	Volume (m^3) 1 package	Volume (m^3) 324 packages
Waste	1,615	523
Void	0,085	28

6.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 6-6.

Table 6-6. Radionuclide composition of a reference waste package of the type F.23.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1,1\cdot10^{10}$	Pu-239	$6,5\cdot10^{3}$
Ag-108m	$6,7\cdot10^{5}$	Pu-240	$1,3\cdot10^{4}$
Ba-133	$1,1\cdot10^{5}$	Pb-210	$3,9\cdot10^{-7}$
Be-10	$6,7\cdot10^{0}$	Ra-226	$3,9\cdot10^{-6}$
C-14	$1,1\cdot10^{7}$	Ac-227	$7,9\cdot10^{-5}$
Fe-55	$1,1\cdot10^{10}$	Th-229	$5,9\cdot10^{-6}$
H-3	$1,1\cdot10^{6}$	Th-230	$1,8\cdot10^{-3}$
Ho-166m	$4,5\cdot10^{4}$	Th-232	$2,0\cdot10^{-9}$
Mo-93	$5,6\cdot10^{4}$	Pa-231	$5,9\cdot10^{-4}$
Nb-93m	$1,1\cdot10^{7}$	U-232	$5,9\cdot10^{-1}$
Nb-94	$1,1\cdot10^{5}$	U-233	$3,9\cdot10^{-4}$
Ni-59	$1,1\cdot10^{7}$	U-234	$2,0\cdot10^{1}$
Ni-63	$2,2\cdot10^{9}$	U-235	$3,9\cdot10^{-1}$
Sb-125	$1,1\cdot10^{9}$	U-236	$5,9\cdot10^{0}$
Zr-93	$1,1\cdot10^{4}$	U-238	$7,9\cdot10^{0}$
		Np-237	$7,9\cdot10^{0}$
Correlated to Cs-137		Pu-238	$7,9\cdot10^{4}$
Cs-137	$4,8\cdot10^{7}$	Pu-241	$2,0\cdot10^{6}$
Cd-113m	$2,9\cdot10^{4}$	Pu-242	$5,9\cdot10^{1}$
Cl-36	$4,8\cdot10^{2}$	Am-241	$2,0\cdot10^{4}$
Cs-134	$4,8\cdot10^{7}$	Am-242m	$2,0\cdot10^{2}$
Cs-135	$2,4\cdot10^{2}$	Am-243	$5,9\cdot10^{2}$
Eu-152	$3,4\cdot10^{3}$	Cm-243	$3,9\cdot10^{2}$
Eu-154	$4,8\cdot10^{6}$	Cm-244	$5,9\cdot10^{4}$
Eu-155	$3,4\cdot10^{6}$	Cm-245	$5,9\cdot10^{0}$
I-129	$1,4\cdot10^{1}$	Cm-246	$1,6\cdot10^{0}$
Pd-107	$4,8\cdot10^{1}$	Pu-244	$1,4\cdot10^{-5}$
Pm-147	$4,3\cdot10^{7}$		
Ru-106	$2,4\cdot10^{5}$		
Se-79	$1,9\cdot10^{2}$		
Sm-151	$1,4\cdot10^{5}$		
Sn-126	$2,4\cdot10^{1}$		
Sr-90	$4,8\cdot10^{6}$		
Tc-99	$2,4\cdot10^{5}$		

A reference waste package of the type F.23 has a surface dose rate of 100 mSv/h and no surface contamination.

6.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- All future production of F.23 is assumed to be in steel moulds. Some packages may be of the concrete kind.

7 O.01

7.1 Waste type description

7.1.1 Waste package

General

The O.01 waste type consists of 1,73 m^3 concrete moulds containing ion-exchange resins and inert filter-aid in a concrete matrix. The raw waste material consists of ion-exchange resins and filter aids generated at the Oskarshamn nuclear power plant. The material is classified as intermediate level waste /Ingemansson, 1999; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are normally 10 cm thick but can in some exceptional cases be 25 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg and the 25-cm one weighs about 3200 kg. A stirrer made of carbon steel is included in the waste package. It weighs 16 kg and has a estimated surface of 1 m^2. To avoid cracking of the mould, due to expansion of the concrete matrix, a lining of compactible material (polyethene) is put inside of the mould, the lining has a thickness of 20 mm and a total weight of 10 kg. Lining is only placed in the 10-cm mould. The variations between moulds are minimal.

Some changes in the design have been made since the start of production of this package. 1975–78 the reinforcement was gradually improved and in 1981 a new design of reinforcement was introduced. In 1979 the moulds was fitted with a expansion cassette of polyurethane and wood, this was used until 1988 when the polyethene cassette was introduced. In 1986 a new brand of concrete to make the lid was introduced, instead of Sabema A, the Betokem EXM-4 was used. Today no chemical cement additives is used, earlier Silix GP was used.

The weight of a package including waste is approximately 3200 kg but differs between 3300–3600 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 30 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The lid is at least 10 cm thick. The concrete is allowed 24 hours to harden before the waste is transported to intermediate storage.

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 30 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to intermediate storage. The lid is at least 10 cm thick.

7.1.2 Materials – chemical composition

The amounts of different materials in a O.01 mould are given in Table 7-1. The waste is well defined and consists of ion exchange resins and filter-aid with radionuclides from systems for cleaning reactor water (system 331), treatment of liquid waste (system 342), decontamination (system 347) and cleaning of fuel ponds (system 324). Systems 331, 347 and 342 uses bead resin, system 342 uses powder resin. The weight of the raw waste material is normally 130 kg ion exchange resin per package but varies, see Table 7-1.

The matrix is made of cement. The specific brand of cement has changed during the years of production of this waste type. The brands used are:
Sabema A-bruk 1970–1986,
LH cement 1970–1981,
Massiv cement 1981–1986,
Anläggningscement 1986–1999,
Höghållfasthetscement from 1999–
Betokem EXM used from 1986–.

Table 7-1. Amounts of different material in waste type O.01 (per package).

Material	Weight	Weight-%
Ion-exchange resin	90-150 kg	5,7-10,0 %
Cement*	1350-1500 kg	90,0-94,3 %

* Including water 0,4 kg/kg cement.

7.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $6 \cdot 10^{11}$ Bq for Co-60 and between 0 and $9 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 30 mSv/h but normally it is between 0,01–11 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

7.1.4 Waste production

The waste type has been in production since 1970 and can still produced, but no further production is foreseen. The number of packages produced until 1998-12-31 is 710, see appendix A.

7.2 Reference waste type description

7.2.1 Waste package and material

The number of packages that will be produced is calculated to 710 packages during the operation of Oskarshamn.

Table 7-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of O.01 is given in Table 7-3.

Table 7-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of O.01.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete mould	Concrete	1340		100
Reinforcement	Steel	261	10	12
Steel lid	Steel	13	1,8	2
Stirrer	Steel	16	1	5
Other organics	Polyethene	10		

Table 7-3. Estimated reference waste composition and surface area and thickness of components in one of O.01.

Material	Weight
Ion-exchange resin	130 kg
Cement*	1540 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of O.01 are summarised in Table 7-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 7-5. The waste volume is estimated from the weights of the waste components in Table 7-3 and approximate densities of the different material. Average void is estimated to 15 % in a package.

Void and waste volume is specified in Table 7-5.

Table 7-4. Reference composition and surface area of metallic components in 710 concrete moulds in O.01.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		205 900	9 090	205 900	9 090
Ion-exchange resin	92 300			92 300	
Other organics	7 100			7 100	
Cement*	1 093 000	951 000		2 044 000	

* Including water 0,4 kg/kg cement for the waste, in package the value is noted as concrete.

Table 7-5. Volumes in 1 and 710 reference waste packages of O.01.

	Volume (m^3) 1 package	Volume (m^3) 938 packages
Waste	0,85	604
Void	0,15	106

7.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 7-6. The transuranic elements have been calculated in a different way and it is not possible to calculate a reference waste type. An inventory for transuranic elements for all drums at the year 2030 is presented in appendix B.

Table 7-6. Radionuclide composition of a reference waste package of the type O.01.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Cs-137	
Co-60	$4,2\cdot10^{10}$	Cs-137	$1,2\cdot10^{10}$
Ag-108m	$2,5\cdot10^{6}$	Cd-113m	$7,1\cdot10^{6}$
Ba-133	$4,2\cdot10^{5}$	Cl-36	$1,2\cdot10^{5}$
Be-10	$2,5\cdot10^{1}$	Cs-134	$1,2\cdot10^{10}$
C-14	$4,2\cdot10^{7}$	Cs-135	$6,0\cdot10^{4}$
Fe-55	$4,2\cdot10^{10}$	Eu-152	$8,3\cdot10^{5}$
H-3	$4,2\cdot10^{6}$	Eu-154	$1,2\cdot10^{9}$
Ho-166m	$1,7\cdot10^{5}$	Eu-155	$8,3\cdot10^{8}$
Mo-93	$2,1\cdot10^{5}$	I-129	$3,6\cdot10^{3}$
Nb-93m	$4,2\cdot10^{7}$	Pd-107	$1,2\cdot10^{4}$
Nb-94	$4,2\cdot10^{5}$	Pm-147	$1,1\cdot10^{10}$
Ni-59	$4,2\cdot10^{7}$	Ru-106	$6,0\cdot10^{7}$
Ni-63	$8,3\cdot10^{9}$	Se-79	$4,8\cdot10^{4}$
Sb-125	$4,2\cdot10^{9}$	Sm-151	$3,6\cdot10^{7}$
Zr-93	$4,2\cdot10^{4}$	Sn-126	$6,0\cdot10^{3}$
		Sr-90	$1,2\cdot10^{9}$
		Tc-99	$6,0\cdot10^{7}$

A reference waste package of the type O.01 has a surface dose rate of 30 mSv/h and no surface contamination.

7.3 Uncertainties

- No production of O.01 is planned but production is possible.
- General uncertainties are described in chapter 1.3.

8 C.01

8.1 Waste type description

8.1.1 Waste package

General

The C.01 waste type consists of 1,73 m^3 concrete moulds containing ion-exchange resins and inert filter-aid in a concrete matrix. The raw waste material consists of ion-exchange resins and filter aids generated at the CLAB facility in Oskarshamn. The material is classified as intermediate level waste /Ingemansson, 1999; Johansson, 2000; TRIUMF, 2000/.

The C.01 waste type is identical with O.01 with some small exceptions. The type is in everyday use called O.01.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are normally 10 cm thick but can in some exceptional cases be 25 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg and the 25-cm one weighs about 3200 kg. A stirrer made of carbon steel is included in the waste package. It weighs 16 kg and has a estimated surface of 1 m^2. To avoid cracking of the mould, due to expansion of the concrete matrix, a lining of compactible material (polyethene) is put inside of the mould, the lining has a thickness of 20 mm and a total weight of 10 kg. Lining is only placed in the 10-cm mould. The variations between moulds are minimal.

Some changes in the design have been made since the start of production of this package. 1975–78 the reinforcement was gradually improved and in 1981 a new design of reinforcement was introduced. In 1979 the moulds was fitted with a expansion cassette of polyurethane and wood, this was used until 1988 when the polyethene cassette was introduced. In 1986 a new brand of concrete to make the lid was introduced, instead of Sabema A, the Betokem EXM-4 was used. Today no chemical cement additives is used, earlier Silix GP was used.

The weight of a package including waste is approximately 3200 kg but differs between 3300–3600 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 30 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The lid is at least 10 cm thick. The concrete is allowed 24 hours to harden before the waste is transported to intermediate storage. Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 30 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to intermediate storage. The lid is at least 10 cm thick.

8.1.2 Materials – chemical composition

The amounts of different materials in a C.01 mould are given in Table 8-1. The waste is well defined and consists of ion exchange resins and filter-aid with radionuclides from systems for cleaning reactor water (system 331), treatment of liquid waste (system 342), decontamination (system 347) and cleaning of fuel ponds (system 324). Systems 331, 347 and 342 uses bead resin, system 342 uses powder resin. The weight of the raw waste material is normally 130 kg ion exchange resin per package but varies, see Table 8-1.

The matrix is made of cement. The specific brand of cement has changed during the years of production of this waste type. The brands used are:
Sabema A-bruk –1986,
Massiv cement –1986,
Anläggningscement 1986–1999,
Höghållfasthetscement from 1999–
Betokem EXM used from 1986–.

Table 8-1. Amounts of different material in waste type O.01 (per package).

Material	Weight	Weight-%
Ion-exchange resin	90-150 kg	5,7-10,0 %
Cement*	1350-1500 kg	90,0-94,3 %

* Including water 0,4 kg/kg cement.

8.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn NPP/CLAB to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $6 \cdot 10^{11}$ Bq for Co-60 and between 0 and $9 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 30 mSv/h but normally it is between 0,01–30 mSv/h on the surface. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

8.1.4 Waste production

The waste type has been in production since 1970 and can still produced, but no further production is foreseen. The number of packages produced until 1998-12-31 is 61, see appendix A.

8.2 Reference waste type description

8.2.1 Waste package and material

The number of packages that will be produced is calculated to 61 packages during the operation of CLAB.

Table 8-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of C.01 is given in Table 8-3.

Table 8-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of C.01.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete mould	Concrete	1340		100
Reinforcement	Steel	261	10	12
Steel lid	Steel	13	1,8	2
Stirrer	Steel	16	1	5
Other organics	Polyethene	10		

Table 8-3. Estimated reference waste composition and surface area and thickness of components in one of C.01.

Material	Weight
Ion-exchange resin	130 kg
Cement*	1540 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of C.01 are summarised in Table 8-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 8-5. The waste volume is estimated from the weights of the waste components in Table 8-3 and approximate densities of the different material. Average void is estimated to 15 % in a package.

Void and waste volume is specified in Table 8-5.

Table 8-4. Reference composition and surface area of metallic components in 61 concrete moulds in C.01.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		17 700	780	17 700	780
Ion-exchange resin	7 930			7 930	
Other organics	610			610	
Cement*	93 940	81 700		175 000 800	

* Including water 0,4 kg/kg cement for the waste, in package the value is noted as concrete.

Table 8-5. Volumes in 1 and 61 reference waste packages of C.01.

	Volume (m^3) 1 package	Volume (m^3) 61 packages
Waste	0,85	52
Void	0,15	9

8.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 8-6. The transuranic elements have been calculated in a different way and it is not possible to calculate a reference waste type. An inventory for transuranic elements for all drums at the year 2030 is presented in appendix B.

Table 8-6. Radionuclide composition of a reference waste package of the type C.01.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Cs-137	
Co-60	$1,3\cdot10^{12}$	Cs-137	$3,8\cdot10^{11}$
Ag-108m	$8,1\cdot10^{7}$	Cd-113m	$2,3\cdot10^{8}$
Ba-133	$1,3\cdot10^{7}$	Cl-36	$3,8\cdot10^{6}$
Be-10	$8,1\cdot10^{2}$	Cs-134	$3,8\cdot10^{11}$
C-14	$1,3\cdot10^{9}$	Cs-135	$1,9\cdot10^{6}$
Fe-55	$1,3\cdot10^{12}$	Eu-152	$2,7\cdot10^{7}$
H-3	$1,3\cdot10^{8}$	Eu-154	$3,8\cdot10^{10}$
Ho-166m	$5,4\cdot10^{6}$	Eu-155	$2,7\cdot10^{10}$
Mo-93	$6,7\cdot10^{6}$	I-129	$1,2\cdot10^{5}$
Nb-93m	$1,3\cdot10^{9}$	Pd-107	$3,8\cdot10^{5}$
Nb-94	$1,3\cdot10^{7}$	Pm-147	$3,5\cdot10^{11}$
Ni-59	$1,3\cdot10^{9}$	Ru-106	$1,9\cdot10^{9}$
Ni-63	$2,7\cdot10^{11}$	Se-79	$1,5\cdot10^{6}$
Sb-125	$1,3\cdot10^{11}$	Sm-151	$1,2\cdot10^{9}$
Zr-93	$1,3\cdot10^{6}$	Sn-126	$1,9\cdot10^{5}$
		Sr-90	$3,8\cdot10^{10}$
		Tc-99	$1,9\cdot10^{9}$

A reference waste package of the type C.01 has a surface dose rate of 30 mSv/h and no surface contamination.

8.3 Uncertainties

- No production of O.01 is planned but production is possible.
- General uncertainties are described in chapter 1.3.

9 O.23

9.1 Waste type description

9.1.1 Waste package

General

The O.23 waste type consists of 1,73 m^3 concrete moulds with scrap metal and refuse in a concrete matrix. The raw waste material consists of mainly iron/steel, cellulose and other organics generated at the Oskarshamn nuclear power plant. The material is classified as intermediate level waste. All data comes from /Ingemansson, 2000; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The concrete mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are 10 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg. The variations between moulds are minimal. Total weight of package including waste is approximately 2400 kg but differs between 1900–4000 kg.

In some special cases a concrete mould with 25 cm or 35 cm thick walls can be used

The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

Waste from the power plant is sorted in compactible and non-compactible. Non-compactible is put directly in a mould and the mould is then filled with concrete. Compactible waste is put in the mould and compacted. A ‘middle-lid’ is placed in the mould to prevent re-expansion of the waste. This operation is repeated until the mould is full. Then the mould is filled with concrete, which is allowed to harden for two days. Pouring concrete on top of the package makes a lid.

9.1.2 Materials – chemical composition

The amounts of different materials in a O.23 mould are given in Table 9-1. The waste is fairly well defined and consists mainly of scrap metal and refuses as filters, wood, cloth, plastics and cables. The weight of the raw waste material is normally 780 kg waste per package but varies, see Table 9-1.

The matrix is made of concrete. The brand used is Betokem EXM 4PA.

Table 9-1. Amounts of different material in waste type O.23 10-cm concrete mould (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Sludges	52,5		6,2
Cellulose	30		3,5
Other organic material	66,5		7,9
Iron/steel	112	5,7	13,2
Other inorganic material	17,5		2,1
Aluminium	3,5	0,5	0,4
Concrete**	565		66,7

* Variation of amounts of material is not available in referred documents.

** Including 0,13 kg water/kg concrete.

9.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $1 \cdot 10^{11}$ Bq for Co-60 and between 0 and $2 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 30 mSv/h but normally it is between 0–2 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

9.1.4 Waste production

The waste type has been in production since 1981 and is still in production. The number of packages produced until 1998-12-31 is 411; annual production is estimated to 15 packages per year, see appendix A.

9.2 Reference waste type description

9.2.1 Waste package and material

The number of packages that will be produced is calculated to 696 packages during the operation of Oskarshamn.

Table 9-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of O.23 is given in Table 9-3.

Table 9-2. Estimated reference packaging composition, surface area and thickness of components in steel mould of O.23.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		10
Lid	Steel	13	1,8	2
Reinforcement	Steel	261	10	12

Table 9-3. Estimated reference waste composition and surface area and thickness of components in one O.23.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Sludge	52,5		
Cellulose	30		
Other organic material	66,5		
Iron/steel	112	5,7	5
Other inorganics	17,5		
Aluminium	3,5	0,5	5
Concrete*	565		

* Including 0,13 kg water/kg concrete.

The total amounts of different materials in all the packages of O.23 are summarised in Table 9-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 9-5. The waste volume is estimated from the weights of the waste components in Table 9-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 9-5.

Table 9-4. Reference composition and surface area of metallic components in 696 steel moulds O.23.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	77 900	3 970	190 700	8 210	268 600	12 180
Sludges	36 540				36 540	
Cellulose	20 880				20 880	
Other organic material	46 280				46 280	
Other inorganics	12 180				12 180	
Aluminium	2 440	350			2 440	350
Concrete*	393 000		933 000		1 330 000	

* Including 0,13 kg water/kg concrete.

Table 9-5. Volumes in 1 and 696 reference waste packages of O.23.

	Volume (m^3) 1 package	Volume (m^3) 696 packages
Waste	0,95	661
Void	0,05	35

9.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 9-6. Inventory based on data for B.12, F.12 and R.12.

Table 9-6. Radionuclide composition of a reference waste package of the type O.23.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$9,4\cdot10^{9}$	Pu-239	$2,5\cdot10^{4}$
Ag-108m	$5,6\cdot10^{5}$	Pu-240	$5,0\cdot10^{4}$
Ba-133	$9,4\cdot10^{4}$	Pb-210	$1,5\cdot10^{-6}$
Be-10	$5,6\cdot10^{0}$	Ra-226	$1,5\cdot10^{-5}$
C-14	$9,4\cdot10^{6}$	Ac-227	$3,0\cdot10^{-4}$
Fe-55	$9,4\cdot10^{9}$	Th-229	$2,2\cdot10^{-5}$
H-3	$9,4\cdot10^{5}$	Th-230	$6,7\cdot10^{-3}$
Ho-166m	$3,8\cdot10^{4}$	Th-232	$7,5\cdot10^{-9}$
Mo-93	$4,7\cdot10^{4}$	Pa-231	$2,2\cdot10^{-3}$
Nb-93m	$9,4\cdot10^{6}$	U-232	$2,2\cdot10^{0}$
Nb-94	$9,4\cdot10^{4}$	U-233	$1,5\cdot10^{-3}$
Ni-59	$9,4\cdot10^{6}$	U-234	$7,5\cdot10^{1}$
Ni-63	$1,9\cdot10^{9}$	U-235	$1,5\cdot10^{0}$
Sb-125	$9,4\cdot10^{8}$	U-236	$2,2\cdot10^{1}$
Zr-93	$9,4\cdot10^{3}$	U-238	$3,0\cdot10^{1}$
		Np-237	$3,0\cdot10^{1}$
Correlated to Cs-137		Pu-238	$3,0\cdot10^{5}$
Cs-137	$1,6\cdot10^{9}$	Pu-241	$7,5\cdot10^{6}$
Cd-113m	$9,6\cdot10^{5}$	Pu-242	$2,2\cdot10^{2}$
Cl-36	$1,6\cdot10^{4}$	Am-241	$7,5\cdot10^{4}$
Cs-134	$1,6\cdot10^{9}$	Am-242m	$7,5\cdot10^{2}$
Cs-135	$8,0\cdot10^{3}$	Am-243	$2,2\cdot10^{3}$
Eu-152	$1,1\cdot10^{5}$	Cm-243	$1,5\cdot10^{3}$
Eu-154	$1,6\cdot10^{8}$	Cm-244	$2,2\cdot10^{5}$
Eu-155	$1,1\cdot10^{8}$	Cm-245	$2,2\cdot10^{1}$
I-129	$4,8\cdot10^{2}$	Cm-246	$6,0\cdot10^{0}$
Pd-107	$1,6\cdot10^{3}$	Pu-244	$5,2\cdot10^{-5}$
Pm-147	$1,4\cdot10^{9}$		
Ru-106	$8,0\cdot10^{6}$		
Se-79	$6,4\cdot10^{3}$		
Sm-151	$4,8\cdot10^{6}$		
Sn-126	$8,0\cdot10^{2}$		
Sr-90	$1,6\cdot10^{8}$		
Tc-99	$8,0\cdot10^{6}$		

A reference waste package of the type O.23 has a surface dose rate of 30 mSv/h and no surface contamination.

9.3 Uncertainties

- General uncertainties are described in chapter 1.3.

10 C.23

10.1 Waste type description

10.1.1 Waste package

General

The O.23 waste type consists of 1,73 m^3 concrete moulds with scrap metal and refuse in a concrete matrix. The raw waste material consists of mainly iron/steel, cellulose and other organics generated at the Oskarshamn nuclear power plant. The material is classified as intermediate level waste /Ingemansson, 2000; Johansson, 2000; TRIUMF, 2000/.

The C.23 waste type is identical with O.23 with some small exceptions. The type is in everyday use called O.23.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The concrete mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are 10 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg. The variations between moulds are minimal. Total weight of package including waste is approximately 2400 kg but differs between 1900–4000 kg.

In some special cases a concrete mould with 25 cm or 35 cm thick walls can be used

The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

Waste from the power plant is sorted in compactible and non-compactible. Non-compactible is put directly in a mould and the mould is then filled with concrete. Compactible waste is put in the mould and compacted. A 'middle-lid' is placed in the mould to prevent re-expansion of the waste. This operation is repeated until the mould is full. Then the mould is filled with concrete, which is allowed to harden for two days. Pouring concrete on top of the package makes a lid.

10.1.2 Materials – chemical composition

The amounts of different materials in a O.23 mould are given in Table 10-1. The waste is fairly well defined and consists mainly of scrap metal and refuses as filters, wood, cloth, plastics and cables. The weight of the raw waste material is normally 780 kg waste per package but varies, see Table 10-1.

The matrix is made of concrete. The brand used is Betokem EXM 4PA.

Table 10-1. Amounts of different material in waste type O.23 10-cm concrete mould (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Sludges	52,5		6,2
Cellulose	30		3,5
Other organic material	66,5		7,9
Iron/steel	112	5,7	13,2
Other inorganic material	17,5		2,1
Aluminium	3,5	0,5	0,4
Concrete**	565		66,7

* Variation of amounts of material is not available in referred documents.
** Including 0,13 kg water/kg concrete.

10.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $1 \cdot 10^{11}$ Bq for Co-60 and between 0 and $2 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 30 mSv/h but normally it is between 0–2 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

10.1.4 Waste production

The waste type has been in production since 1985 and is still in production. The number of packages produced until 1998-12-31 is 26; annual production is estimated to 2 packages per year, see appendix A.

10.2 Reference waste type description

10.2.1 Waste package and material

The number of packages that will be produced is calculated to 88 packages during the operation of Oskarshamn.

Table 10-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of C.23 is given in Table 10-3.

Table 10-2. Estimated reference packaging composition, surface area and thickness of components in steel mould of C.23.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		10
Lid	Steel	13	1,8	2
Reinforcement	Steel	261	10	12

Table 10-3. Estimated reference waste composition and surface area and thickness of components in one C.23.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Sludge	52,5		
Cellulose	30		
Other organic material	66,5		
Iron/steel	112	5,7	5
Other inorganics	17,5		
Aluminium	3,5	0,5	5
Concrete*	565		

* Including 0,13 kg water/kg concrete.

The total amounts of different materials in all the packages of C.23 are summarised in Table 10-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 10-5. The waste volume is estimated from the weights of the waste components in Table 10-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 10-5.

Table 10-4. Reference composition and surface area of metallic components in 88 concrete moulds C.23.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	9 850	500	24 100	1 040	33 900	1 540
Sludges	4 620				4 620	
Cellulose	2 640				2 640	
Other organic	5 850				5 850	
Other inorganics	1 540				1 540	
Aluminium	310	40			310	40
Concrete*	4 9700		118 000		168 000	

* Including 0,13 kg water/kg concrete.

Table 10-5. Volumes in 1 and 88 reference waste packages of C.23.

	Volume (m^3) 1 package	Volume (m^3) 88 packages
Waste	0,95	84
Void	0,05	4
Waste package	1,73	152

10.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 10-6.

Table 10-6. Radionuclide composition of a reference waste package of the type C.23.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1{,}8\cdot10^{11}$	Pu-239	$3{,}7\cdot10^{3}$
Ag-108m	$1{,}1\cdot10^{7}$	Pu-240	$7{,}4\cdot10^{3}$
Ba-133	$1{,}8\cdot10^{6}$	Pb-210	$2{,}2\cdot10^{-7}$
Be-10	$1{,}1\cdot10^{2}$	Ra-226	$2{,}2\cdot10^{-6}$
C-14	$1{,}8\cdot10^{8}$	Ac-227	$4{,}5\cdot10^{-5}$
Fe-55	$1{,}8\cdot10^{11}$	Th-229	$3{,}3\cdot10^{-6}$
H-3	$1{,}8\cdot10^{7}$	Th-230	$1{,}0\cdot10^{-3}$
Ho-166m	$7{,}3\cdot10^{5}$	Th-232	$1{,}1\cdot10^{-9}$
Mo-93	$9{,}2\cdot10^{5}$	Pa-231	$3{,}3\cdot10^{-4}$
Nb-93m	$1{,}8\cdot10^{8}$	U-232	$3{,}3\cdot10^{-1}$
Nb-94	$1{,}8\cdot10^{6}$	U-233	$2{,}2\cdot10^{-4}$
Ni-59	$1{,}8\cdot10^{8}$	U-234	$1{,}1\cdot10^{1}$
Ni-63	$3{,}7\cdot10^{10}$	U-235	$2{,}2\cdot10^{-1}$
Sb-125	$1{,}8\cdot10^{10}$	U-236	$3{,}3\cdot10^{0}$
Zr-93	$1{,}8\cdot10^{5}$	U-238	$4{,}5\cdot10^{0}$
		Np-237	$4{,}5\cdot10^{0}$
Correlated to Cs-137		Pu-238	$4{,}5\cdot10^{4}$
Cs-137	$3{,}1\cdot10^{10}$	Pu-241	$1{,}1\cdot10^{6}$
Cd-113m	$1{,}9\cdot10^{7}$	Pu-242	$3{,}3\cdot10^{1}$
Cl-36	$3{,}1\cdot10^{5}$	Am-241	$1{,}1\cdot10^{4}$
Cs-134	$3{,}1\cdot10^{10}$	Am-242m	$1{,}1\cdot10^{2}$
Cs-135	$1{,}6\cdot10^{5}$	Am-243	$3{,}3\cdot10^{2}$
Eu-152	$2{,}2\cdot10^{6}$	Cm-243	$2{,}2\cdot10^{2}$
Eu-154	$3{,}1\cdot10^{9}$	Cm-244	$3{,}3\cdot10^{4}$
Eu-155	$2{,}2\cdot10^{9}$	Cm-245	$3{,}3\cdot10^{0}$
I-129	$9{,}4\cdot10^{3}$	Cm-246	$8{,}9\cdot10^{-1}$
Pd-107	$3{,}1\cdot10^{4}$	Pu-244	$7{,}8\cdot10^{-6}$
Pm-147	$2{,}8\cdot10^{10}$		
Ru-106	$1{,}6\cdot10^{8}$		
Se-79	$1{,}3\cdot10^{5}$		
Sm-151	$9{,}4\cdot10^{7}$		
Sn-126	$1{,}6\cdot10^{4}$		
Sr-90	$3{,}1\cdot10^{9}$		
Tc-99	$1{,}6\cdot10^{8}$		

A reference waste package of the type C.23 has a surface dose rate of 30 mSv/h and no surface contamination.

10.3 Uncertainties

- General uncertainties are described in chapter 1.3.

11 R.01

11.1 Waste type description

11.1.1 Waste package

General

The R.01 waste type consists of 1,73 m^3 concrete moulds containing ion-exchange resins and inert filter-aid in a concrete matrix. The raw waste material consists of ion-exchange resins and filter aids generated at the Ringhals nuclear power plant. The material is classified as intermediate level waste /Eriksson, 1990; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are normally 10 cm thick but can in some exceptional cases be 25 cm thick. The reinforcement is made of steel bars with a total surface of 7,9 m^2 and a weight of 160 kg in a 10-cm mould and 11,8 m^2 and 250 kg in a 25-cm mould. The 10-cm mould weighs approximately 1600 kg and the 25-cm weighs about 3100 kg. A stirrer made of carbon steel is included in the waste package. It weighs 16 kg and has an estimated surface of 1 m^2. To avoid cracking of the mould, due to expansion of the concrete matrix, a lining with compressible material (polyethene or polystyrene) is put inside the walls of the mould. The lining has a thickness of 20 mm and a total weight of 10 kg in a 10-cm mould and 5 mm and approximately 1 kg in a 25-cm mould. The variations between moulds are minimal.

Some changes in the design have been made since the start of production of this package. Before 1976 no lining was used. Some changes have been made regarding reinforcement and steel details in the mould. For the lid Betokem EXM-4 was used, nowadays Fiberbruk VF50 is used. Today no chemical cement additives are used but earlier Silix GP and Sika AER were used.

The weight of a package including waste and is approximately 3400 kg but differs between 3000–3700 kg. The maximum allowed weight of a waste package is 4000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 60 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to interim storage. The lid is at least 10 cm thick.

11.1.2 Materials – chemical composition

The amounts of different materials in a R.01 mould are given in Table 11-1. The waste is well defined and consists of ion exchange resins and filter-aid with radionuclides.

The resins are:

- Bead resin from PWR: cleaning of the primary reactor circuit (system 334), the fuel ponds (system 324), the waste water (system 342), water from the secondary side of the steam generators (system 417/337) and from drainage water.
- Bead resin from BWR: systems for cleaning reactor water (system 331), treatment of liquid waste (system 342), analytical ion-exchangers (system 336) and cleaning of fuel ponds (system 324).
- Powder resins from BWR: cleaning of condensate (system 332), fuel ponds (system 324) and treatment of liquid waste (system 324). The resins from liquid waste treatment contain filter-aids.

Resins from the PWR-reactors contain boric acid (H_3BO_3) up to 90 g/kg of resin. Some resins contain lithium. Resins from system 417/337 can contain ammonia and hydrazine.

The weight of the raw waste material is normally 130 kg of ion exchange resin per package but varies, see Table 11-1.

The matrix is made of cement. The specific brand of cement has changed during the years of production of this waste type. The brand used nowadays is Skövde standardcement. In earlier days Limhamn LH-cement was used.

Table 11-1. Amounts of different material in waste type R.01 (per package).

Material	Weight	Weight-%
Ion-exchange resin	100-150 kg	5,9-12,0 %
Cement*	1100-1600 kg	88,0-94,1%

* Including water 0,4 kg/kg cement.

11.1.3 Radionuclide inventory

Before the waste is transported from Ringhals NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $4 \cdot 10^{12}$ Bq for Co-60 and between 0 and $1 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 30 mSv/h on the surface. Normal dose rate at 1 m is 4 mSv/h but varies between 0–20 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package.

11.1.4 Waste production

The waste type has been in production since 1984 and is still in production even though in very small scale. The number of packages produced until 1998-12-31 is 1779, annual production is estimated to 2 packages per year, see appendix A.

11.2 Reference waste type description

11.2.1 Waste package and material

The number of packages that will be produced is calculated to 1821 packages during the operation of Ringhals.

Table 11-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of R.01 is given in Table 11-3.

Table 11-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of R.01.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		100
Reinforcement	Steel	261	10	12
Steel lid	Steel	13	1,8	2
Stirrer	Steel	16	1	5
Other organics	Polyethene	10		

Table 11-3. Estimated reference waste composition and surface area and thickness of components in one of R.01.

Material	Weight
Ion-exchange resin	130 kg
Cement*	1400 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of R.01 are summarised in Table 11-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 11-5. The waste volume is estimated from the weights of the waste components in Table 11-3 and approximate densities of the different material. Average void is estimated to 15 % in a package.

Void and waste volume is specified in Table 11-5.

Table 11-4. Reference composition and surface area of metallic components in 1821 concrete moulds in R.01.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		528 000	23300	528 000	23300
Ion-exchange resin	236 700			236 700	
Other organics	18 200			18 200	
Cement*	2 549 000	2 440 000**		4 989 000	

* Including water 0,4 kg/kg cement for the waste.
** Given as concrete.

Table 11-5. Volumes in 1 and 1821 reference waste packages of R.01.

	Volume (m^3) 1 package	Volume (m^3) 1821 packages
Waste	0,85	1548
Void	0,15	273

11.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 11-6.

Table 11-6. Radionuclide composition of a reference waste package of the type R.01.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$7,7\cdot10^{10}$	Pu-239	$4,1\cdot10^{6}$
Ag-108m	$4,6\cdot10^{6}$	Pu-240	$8,2\cdot10^{6}$
Ba-133	$7,7\cdot10^{5}$	Pb-210	$2,5\cdot10^{-4}$
Be-10	$4,6\cdot10^{1}$	Ra-226	$2,5\cdot10^{-3}$
C-14	$7,7\cdot10^{7}$	Ac-227	$4,9\cdot10^{-2}$
Fe-55	$7,7\cdot10^{10}$	Th-229	$3,7\cdot10^{-3}$
H-3	$7,7\cdot10^{6}$	Th-230	$1,1\cdot10^{0}$
Ho-166m	$3,1\cdot10^{5}$	Th-232	$1,2\cdot10^{-6}$
Mo-93	$3,9\cdot10^{5}$	Pa-231	$3,7\cdot10^{-1}$
Nb-93m	$7,7\cdot10^{7}$	U-232	$3,7\cdot10^{2}$
Nb-94	$7,7\cdot10^{5}$	U-233	$2,5\cdot10^{-1}$
Ni-59	$7,7\cdot10^{7}$	U-234	$1,2\cdot10^{4}$
Ni-63	$1,5\cdot10^{10}$	U-235	$2,5\cdot10^{2}$
Sb-125	$7,7\cdot10^{9}$	U-236	$3,7\cdot10^{3}$
Zr-93	$7,7\cdot10^{4}$	U-238	$4,9\cdot10^{3}$
		Np-237	$4,9\cdot10^{3}$
Correlated to Cs-137		Pu-238	$4,9\cdot10^{7}$
Cs-137	$1,3\cdot10^{10}$	Pu-241	$1,2\cdot10^{9}$
Cd-113m	$7,7\cdot10^{6}$	Pu-242	$3,7\cdot10^{4}$
Cl-36	$1,3\cdot10^{5}$	Am-241	$1,2\cdot10^{7}$
Cs-134	$1,3\cdot10^{10}$	Am-242m	$1,2\cdot10^{5}$
Cs-135	$6,4\cdot10^{4}$	Am-243	$3,7\cdot10^{5}$
Eu-152	$9,0\cdot10^{5}$	Cm-243	$2,5\cdot10^{5}$
Eu-154	$1,3\cdot10^{9}$	Cm-244	$3,7\cdot10^{7}$
Eu-155	$9,0\cdot10^{8}$	Cm-245	$3,7\cdot10^{3}$
I-129	$3,8\cdot10^{3}$	Cm-246	$9,8\cdot10^{2}$
Pd-107	$1,3\cdot10^{4}$	Pu-244	$8,6\cdot10^{-3}$
Pm-147	$1,2\cdot10^{10}$		
Ru-106	$6,4\cdot10^{7}$		
Se-79	$5,1\cdot10^{4}$		
Sm-151	$3,8\cdot10^{7}$		
Sn-126	$6,4\cdot10^{3}$		
Sr-90	$1,3\cdot10^{9}$		
Tc-99	$6,4\cdot10^{7}$		

A reference waste package of the type R.01 has a surface dose rate of 30 mSv/h and no surface contamination.

11.3 Uncertainties

- General uncertainties are described in chapter 1.3.

12 R.10

12.1 Waste type description

12.1.1 Waste package

General

The R.10 waste type consists of 1,73 m^3 concrete moulds containing sludges in a concrete matrix. The raw waste material consists of ion-exchange resins and filter aids generated at the Ringhals nuclear power plant. The material is classified as intermediate level waste /Ahlqvist, 1995; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are normally 10 cm thick but can in some exceptional cases be 25 cm thick. The reinforcement is made of steel bars with a total surface of 7,9 m^2 and a weight of 160 kg in a 10-cm mould and 11,8 m^2 and 250 kg in a 25-cm mould. The 10-cm mould weighs approximately 1600 kg and the 25-cm weighs about 3100 kg. A stirrer made of carbon steel is included in the waste package. It weighs 16 kg and has an estimated surface of 1 m^2. To avoid cracking of the mould, due to expansion of the concrete matrix, a lining with compressible material (polyethene or polystyrene) is put inside the walls of the mould. The lining has a thickness of 20 mm and a total weight of 10 kg in a 10-cm mould and 5 mm and approximately 1 kg in a 25-cm mould. The variations between moulds are minimal.

The weight of a package including waste and is approximately 4000 kg but differs between 2700–4500 kg. The maximum allowed weight of a waste package is 4000 kg. some packages weighs more than 4000 kg, but it is possible to handle packages up to 5000 kg.

Treatment and conditioning

The waste is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 60 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to interim storage. The lid is at least 10 cm thick.

12.1.2 Materials – chemical composition

The amounts of different materials in a R.10 mould are given in Table 12-1. The waste is quite well defined and consists of sludges from different waste streams in Ringhals.

Table 12-1. Amounts of different material in waste type R.10 (per package)

Material	Weight	Weight-%
Sludge	56-128 kg	5-12 %
Cement*	980-1120 kg	88-95 %

* Including water 0,4 kg/kg cement.

12.1.3 Radionuclide inventory

Before the waste is transported from Ringhals NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $4 \cdot 10^{12}$ Bq for Co-60 and between 0 and $1 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 100 mSv/h on the surface. Normal dose rate at 1 m varies between 0–9 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package.

12.1.4 Waste production

The number of packages produced until 1998-12-31 is 76, annual production is estimated to 4 per year, see appendix A.

12.2 Reference waste type description

12.2.1 Waste package and material

The number of packages that will be produced is calculated to 160 packages during the operation of Ringhals.

Table 12-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of R.10 is given in Table 12-3.

Table 12-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of R.10.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		100
Reinforcement	Steel	261	10	12
Steel lid	Steel	13	1,8	2
Stirrer	Steel	16	1	5
Other organics	Polyethene	10		

Table 12-3. Estimated reference waste composition and surface area and thickness of components in one of R.10.

Material	Weight
sludge	115 kg
Cement*	1120 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of R.10 are summarised in Table 12-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 12-5. The waste volume is estimated from the weights of the waste components in Table 12-3 and approximate densities of the different material. Average void is estimated to 10 % in a package.

Void and waste volume is specified in Table 12-5.

Table 12-4. Reference composition and surface area of metallic components in 1821 concrete moulds in R.10.

Content	Waste	Packaging		Waste packages	
	Weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		464 000	2 050	464 000	2 050
Sludge	18 400			18 400	
Other organics		1 600		1 600	
Cement*	179 200	214 400		342 400	

* Including water 0,4 kg/kg cement for the waste.
** Given as concrete.

Table 12-5. Volumes in 1 and 1821 reference waste packages of R.10.

	Volume (m^3) 1 package	Volume (m^3) 1821 packages
Waste	0,90	144
Void	0,10	16

12.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 12-6.

Table 12-6. Radionuclide composition of a reference waste package of the type R.10.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$2,7\cdot10^{10}$	Pu-239	$1,5\cdot10^{6}$
Ag-108m	$1,6\cdot10^{6}$	Pu-240	$2,9\cdot10^{6}$
Ba-133	$2,7\cdot10^{5}$	Pb-210	$8,7\cdot10^{-5}$
Be-10	$1,6\cdot10^{1}$	Ra-226	$8,7\cdot10^{-4}$
C-14	$2,7\cdot10^{7}$	Ac-227	$1,7\cdot10^{-2}$
Fe-55	$2,7\cdot10^{10}$	Th-229	$1,3\cdot10^{-3}$
H-3	$2,7\cdot10^{6}$	Th-230	$3,9\cdot10^{-1}$
Ho-166m	$1,1\cdot10^{5}$	Th-232	$4,4\cdot10^{-7}$
Mo-93	$1,4\cdot10^{5}$	Pa-231	$1,3\cdot10^{-1}$
Nb-93m	$2,7\cdot10^{7}$	U-232	$1,3\cdot10^{2}$
Nb-94	$2,7\cdot10^{5}$	U-233	$8,7\cdot10^{-2}$
Ni-59	$2,7\cdot10^{7}$	U-234	$4,4\cdot10^{3}$
Ni-63	$5,5\cdot10^{9}$	U-235	$8,7\cdot10^{1}$
Sb-125	$2,7\cdot10^{9}$	U-236	$1,3\cdot10^{3}$
Zr-93	$2,7\cdot10^{4}$	U-238	$1,7\cdot10^{3}$
		Np-237	$1,7\cdot10^{3}$
Correlated to Cs-137		Pu-238	$1,7\cdot10^{7}$
Cs-137	$2,3\cdot10^{8}$	Pu-241	$4,4\cdot10^{8}$
Cd-113m	$1,4\cdot10^{5}$	Pu-242	$1,3\cdot10^{4}$
Cl-36	$2,3\cdot10^{3}$	Am-241	$4,4\cdot10^{6}$
Cs-134	$2,3\cdot10^{8}$	Am-242m	$4,4\cdot10^{4}$
Cs-135	$1,2\cdot10^{3}$	Am-243	$1,3\cdot10^{5}$
Eu-152	$1,6\cdot10^{4}$	Cm-243	$8,7\cdot10^{4}$
Eu-154	$2,3\cdot10^{7}$	Cm-244	$1,3\cdot10^{7}$
Eu-155	$1,6\cdot10^{7}$	Cm-245	$1,3\cdot10^{3}$
I-129	$7,0\cdot10^{1}$	Cm-246	$3,5\cdot10^{2}$
Pd-107	$2,3\cdot10^{2}$	Pu-244	$3,1\cdot10^{-3}$
Pm-147	$2,1\cdot10^{8}$		
Ru-106	$1,2\cdot10^{6}$		
Se-79	$9,3\cdot10^{2}$		
Sm-151	$7,0\cdot10^{5}$		
Sn-126	$1,2\cdot10^{2}$		
Sr-90	$2,3\cdot10^{7}$		
Tc-99	$1,2\cdot10^{6}$		

A reference waste package of the type R.10 has a surface dose rate of 30 mSv/h and no surface contamination.

12.3 Uncertainties

- General uncertainties are described in chapter 1.3.

13 R.15

13.1 Waste type description

13.1.1 Waste package

General

The R.15 waste type consists of 1,73 m^3 steel moulds containing ion-exchange resins and inert filter-aid in a concrete matrix. The raw waste material consists of ion-exchange resins and filter aids generated at the Ringhals nuclear power plant. The material is classified as intermediate level waste. All data comes from /Ahlqvist, 1998; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of steel with the dimensions 1,2 m ·1,2 m ·1,2 m. The wall is 5 mm thick, the bottom is 6 mm thick. The mould weighs approximately 425 kg and the surface area is approximately 20 m^2. The variations between moulds are minimal. No major change in design has been made since the start of production of this package.

The weight in total of a package including waste and is approximately 3000 kg but differs between 2600–3300 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 60 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to interim storage. The lid is at least 10 cm thick.

13.1.2 Materials – chemical composition

The amounts of different materials in a R.15 mould are given in Table 13-1. The waste is well defined and consists of ion-exchange resins and filter-aid with radionuclides.

The resins are:

- Bead resin from PWR: cleaning of the primary reactor circuit (system 334), the fuel ponds (system 324), the waste water (system 342), water from the secondary side of the steam generators (system 417/337) and from drainage water.

- Bead resin from BWR: systems for cleaning reactor water (system 331), treatment of liquid waste (system 342), analytical ion-exchangers (system 336) and cleaning of fuel ponds (system 324).
- Powder resins from BWR: cleaning of condensate (system 332), fuel ponds (system 324) and treatment of liquid waste (system 324).
  The resins from liquid waste treatment contain filter-aids.

Resins from the PWR-reactors contain boric acid (H_3BO_3) up to 90 g/kg of resin. Some resins contain lithium. Resins from system 417/337 can contain ammonia and hydrazine.

The weight of the raw waste material is normally 130 kg of ion exchange resin per package but varies, see Table 8-1.

The matrix is made of cement. The brand used is Skövde standardcement. Nowadays also Degerham standardcement can be used. Silix GP and Sika AER was used as additives until 1997 (and a few exceptions during 1998), from 1997 to 1998 Hydrafix was used and from 1997 a special additive is used (brand name is kept on commercial secrecy by demand from Ringhals NPP).

Table 13-1. Amounts of different material in waste type R.15 (per package).

Material	Weight	Weight-%
Ion-exchange resin	10-500 kg	0,4-26,3%
Cement*	1400-2800 kg	99,6-73,7 %

* Including water 0,4 kg/kg cement.

13.1.3 Radionuclide inventory

Before the waste is transported from Ringhals NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $3\cdot10^{11}$ Bq for Co-60 and between 0 and $7\cdot10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 100 mSv/h but normally it is between 0,1–10 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

13.1.4 Waste production

The waste type has been in production since 1991 and is still in production. The number of packages produced until 1999-12-31 is 127; annual production is estimated to 9 packages per year, see appendix A.

13.2 Reference waste type description

13.2.1 Waste package and material

The number of packages that will be produced is calculated to 295 packages during the operation of Ringhals.

Table 13-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of R.15 is given in Table 13-3.

Table 13-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of R.15.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel box	Stainless steel	400	17	5
Stirrer	Stainless steel	25	3	2

Table 13-3. Estimated reference waste composition and surface area and thickness of components in one of R.15.

Material	Weight
Ion-exchange resin	250 kg
Cement*	2100 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of R.15 are summarised in Table 13-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 13-5. The waste volume is estimated from the weights of the waste components in Table 13-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 13-5.

Table 13-4. Reference composition and surface area of metallic components in 295 concrete moulds in R.15.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		125 400	5 900	125 400	5 900
Ion-exchange resin	73 700			73 700	
Cement*	619 500			619 500	

* Including water 0,4 kg/kg cement.

Table 13-5. Volumes in 1 and 295 reference waste packages of R.15.

	Volume (m^3) 1 package	Volume (m^3) 295 packages
Waste	1,615	476
Void	0,085	25

13.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 13-6.

Table 13-6. Radionuclide composition of a reference waste package of the type R.15.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$8,9 \cdot 10^{10}$	Pu-239	$4,7 \cdot 10^{6}$
Ag-108m	$5,3 \cdot 10^{6}$	Pu-240	$9,5 \cdot 10^{6}$
Ba-133	$8,9 \cdot 10^{5}$	Pb-210	$2,8 \cdot 10^{-4}$
Be-10	$5,3 \cdot 10^{1}$	Ra-226	$2,8 \cdot 10^{-3}$
C-14	$8,9 \cdot 10^{7}$	Ac-227	$5,7 \cdot 10^{-2}$
Fe-55	$8,9 \cdot 10^{10}$	Th-229	$4,3 \cdot 10^{-3}$
H-3	$8,9 \cdot 10^{6}$	Th-230	$1,3 \cdot 10^{0}$
Ho-166m	$3,6 \cdot 10^{5}$	Th-232	$1,4 \cdot 10^{-6}$
Mo-93	$4,5 \cdot 10^{5}$	Pa-231	$4,3 \cdot 10^{-1}$
Nb-93m	$8,9 \cdot 10^{7}$	U-232	$4,3 \cdot 10^{2}$
Nb-94	$8,9 \cdot 10^{5}$	U-233	$2,8 \cdot 10^{-1}$
Ni-59	$8,9 \cdot 10^{7}$	U-234	$1,4 \cdot 10^{4}$
Ni-63	$1,8 \cdot 10^{10}$	U-235	$2,8 \cdot 10^{2}$
Sb-125	$8,9 \cdot 10^{9}$	U-236	$4,3 \cdot 10^{3}$
Zr-93	$8,9 \cdot 10^{4}$	U-238	$5,7 \cdot 10^{3}$
		Np-237	$5,7 \cdot 10^{3}$
Correlated to Cs-137		Pu-238	$5,7 \cdot 10^{7}$
Cs-137	$1,5 \cdot 10^{10}$	Pu-241	$1,4 \cdot 10^{9}$
Cd-113m	$8,8 \cdot 10^{6}$	Pu-242	$4,3 \cdot 10^{4}$
Cl-36	$1,5 \cdot 10^{5}$	Am-241	$1,4 \cdot 10^{7}$
Cs-134	$1,5 \cdot 10^{10}$	Am-242m	$1,4 \cdot 10^{5}$
Cs-135	$7,4 \cdot 10^{4}$	Am-243	$4,3 \cdot 10^{5}$
Eu-152	$1,0 \cdot 10^{6}$	Cm-243	$2,8 \cdot 10^{5}$
Eu-154	$1,5 \cdot 10^{9}$	Cm-244	$4,3 \cdot 10^{7}$
Eu-155	$1,0 \cdot 10^{9}$	Cm-245	$4,3 \cdot 10^{3}$
I-129	$4,4 \cdot 10^{3}$	Cm-246	$1,1 \cdot 10^{3}$
Pd-107	$1,5 \cdot 10^{4}$	Pu-244	$9,9 \cdot 10^{-3}$
Pm-147	$1,3 \cdot 10^{10}$		
Ru-106	$7,4 \cdot 10^{7}$		
Se-79	$5,9 \cdot 10^{4}$		
Sm-151	$4,4 \cdot 10^{7}$		
Sn-126	$7,4 \cdot 10^{3}$		
Sr-90	$1,5 \cdot 10^{9}$		
Tc-99	$7,4 \cdot 10^{7}$		

A reference waste package of the type R.15 has a surface dose rate of 100 mSv/h and no surface contamination.

13.3 Uncertainties

- General uncertainties are described in chapter 1.3.

14 R.23

14.1 Waste type description

14.1.1 Waste package

General

The R.23 waste type consists of 1,73 m^3 concrete or steel moulds with scrap metal and refuse in a concrete matrix. The raw waste material consists of mainly iron/steel, cellulose and other organics generated at the Ringhals nuclear power plant. The material is classified as intermediate level waste. All data comes from /Ahlqvist, 1993; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The steel mould has the dimension 1,2 m · 1,2 m · 1,2 m. The weight is 661 kg including lid and the total metal surface area of package is 23 m^2. The wall of the package is 5 mm thick, the bottom is 6 mm thick. The mould also has two lids and some reinforcements. The variations between moulds are minimal. Total weight of package including waste is approximately 2700 kg but differs between 2100–4900 kg.

The concrete mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are 10 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The mould weighs approximately 1600 kg. The variations between moulds are minimal. Total weight of package including waste is approximately 2400 kg but differs between 2200–4100 kg.

In some special cases a concrete mould with 25 cm thick walls can be used.

The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

Waste from the power plant is sorted in compactible and non-compactible. Non-compactible is put directly in a mould and the mould is then filled with concrete. Compactible waste is put in the mould and compacted. A ‘middle-lid’ is placed in the mould to prevent re-expansion of the waste. This operation is repeated until the mould is full. Then the mould is filled with concrete.

Pouring concrete on top of the package makes a lid.

14.1.2 Materials – chemical composition

The amounts of different materials in a R.23 mould are given in Table 14-1. The waste is fairly well defined and consists mainly of scrap metal and refuses as filters, wood, cloth, plastics and cables. The weight of the raw waste material is normally 770 kg waste per package but varies, see Table 14-1a and b.

The matrix is made of concrete. The brand used is of the standard Portland.

Table 14-1a. Amounts of different material in waste type R.23 steel mould (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Cellulose	44		2,7
Other organic material	100		6,2
Iron/steel	100	5,1	6,2
Aluminium	4	0,6	0,2
Concrete**	1356		84,5

* Variation of amounts of material is not available in referred documents.

** Including 0,13 kg water/kg concrete.

Table 14-1b. Amounts of different material in waste type R.23 10-cm concrete mould (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Cellulose	11		1,8
Other organic material	25		4,0
Iron/steel	25	1,3	4,0
Aluminium	1	0,1	0,2
Concrete**	565		90

* Variation of amounts of material is not available in referred documents.

** Including 0,13 kg water/kg concrete.

14.1.3 Radionuclide inventory

Before the waste is transported from Ringhals to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $6 \cdot 10^{11}$ Bq for Co-60 and between 0 and $7 \cdot 10^{10}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 100 mSv/h but normally it is between 0,01–10 mSv/h on 1 meter. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

14.1.4 Waste production

The waste type has been in production since 1960 and is still in production. The number of packages produced until 1998-12-31 is 416; annual production is estimated to 20 packages per year, see appendix A.

14.2 Reference waste type description

14.2.1 Waste package and material

The steel mould is used as reference waste package. The number of packages that will be produced is calculated to 836 packages during the operation of Ringhals, whereof 486 steel moulds and 350 concrete moulds. 7 concrete moulds placed in BTF.

Table 14-2a and b shows the content of different materials and the steel surface areas of the packaging in the reference packages.

The assumed composition of the waste in the reference waste packages of R.23 is given in Table 14-3a and b.

Table 14-2a. Estimated reference packaging composition, surface area and thickness of components in steel mould of R.23.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel box	Steel	478	14,4	5
Lid	Steel	183	8,6	6

Table 14-2b. Estimated reference packaging composition, surface area and thickness of components in concrete mould of R.23.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		10
Lid	Steel	13	1,8	2
Reinforcement	Steel	261	10	12

Table 14-3a. Estimated reference waste composition and surface area and thickness of components in one steel mould R.23.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Cellulose	44		2,7
Other organic material	100		6,2
Iron/steel	100	5,1	6,2
Aluminium	4	0,6	0,2
Concrete*	1356		84,5

* Including 0,13 kg water/kg concrete.

Table 14-3b. Estimated reference waste composition and surface area and thickness of components in one concrete mould R.23.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Cellulose	11		1,8
Other organic material	25		4,0
Iron/steel	25	1,3	4,0
Aluminium	1	0,1	0,2
Concrete*	565		90

The total amounts of different materials in all the packages of R.23 steel and concrete moulds are summarised in Table 14-4 a and b.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 14-5. The waste volume is estimated from the weights of the waste components in Table 14-3a and b and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 14-5.

Table 14-4 a. Reference composition and surface area of components in 486 concrete moulds R.23.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	48 600	2 480	321 200	11 200	370 000	13 700
Cellulose	21 400				21 400	
Other organic material	48 600				48 600	
Aluminium	1 940	290			1 940	290
Concrete*	659 000				659 000	

* Including 0,13 kg water/kg concrete.

Table 14-4 b. Reference composition and surface area of components in 343 steel moulds R.23.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	8 570	445	94 000	4 050	102 000	4 500
Cellulose	3 770				3 770	
Other organic material	8 570				8 570	
Aluminium	340	34			340	34
Concrete*	194 000				194 000	

* Including 0,13 kg water/kg concrete.

Table 14-5. Volumes in 1 and 836 reference waste packages of R.23.

	Volume (m^3) 1 package	Volume (m^3) 836 packages
Waste	1,615	1350
Void	0,085	71

14.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 14-6.

Table 14-6. Radionuclide composition of a reference waste package of the type R.23.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$2,6\cdot10^{10}$	Pu-239	$2,4\cdot10^{6}$
Ag-108m	$1,6\cdot10^{6}$	Pu-240	$4,8\cdot10^{6}$
Ba-133	$2,6\cdot10^{5}$	Pb-210	$1,4\cdot10^{-4}$
Be-10	$1,6\cdot10^{1}$	Ra-226	$1,4\cdot10^{-3}$
C-14	$2,6\cdot10^{7}$	Ac-227	$2,9\cdot10^{-2}$
Fe-55	$2,6\cdot10^{10}$	Th-229	$2,1\cdot10^{-3}$
H-3	$2,6\cdot10^{6}$	Th-230	$6,4\cdot10^{-1}$
Ho-166m	$1,0\cdot10^{5}$	Th-232	$7,1\cdot10^{-7}$
Mo-93	$1,3\cdot10^{5}$	Pa-231	$2,1\cdot10^{-1}$
Nb-93m	$2,6\cdot10^{7}$	U-232	$2,1\cdot10^{2}$
Nb-94	$2,6\cdot10^{5}$	U-233	$1,4\cdot10^{-1}$
Ni-59	$2,6\cdot10^{7}$	U-234	$7,1\cdot10^{3}$
Ni-63	$5,2\cdot10^{9}$	U-235	$1,4\cdot10^{2}$
Sb-125	$2,6\cdot10^{9}$	U-236	$2,1\cdot10^{3}$
Zr-93	$2,6\cdot10^{4}$	U-238	$2,9\cdot10^{3}$
		Np-237	$2,9\cdot10^{3}$
Correlated to Cs-137		Pu-238	$2,9\cdot10^{7}$
Cs-137	$6,1\cdot10^{8}$	Pu-241	$7,1\cdot10^{8}$
Cd-113m	$3,6\cdot10^{5}$	Pu-242	$2,1\cdot10^{4}$
Cl-36	$6,1\cdot10^{3}$	Am-241	$7,1\cdot10^{6}$
Cs-134	$6,1\cdot10^{8}$	Am-242m	$7,1\cdot10^{4}$
Cs-135	$3,0\cdot10^{3}$	Am-243	$2,1\cdot10^{5}$
Eu-152	$4,2\cdot10^{4}$	Cm-243	$1,4\cdot10^{5}$
Eu-154	$6,1\cdot10^{7}$	Cm-244	$2,1\cdot10^{7}$
Eu-155	$4,2\cdot10^{7}$	Cm-245	$2,1\cdot10^{3}$
I-129	$1,8\cdot10^{2}$	Cm-246	$5,7\cdot10^{2}$
Pd-107	$6,1\cdot10^{2}$	Pu-244	$5,0\cdot10^{-3}$
Pm-147	$5,5\cdot10^{8}$		
Ru-106	$3,0\cdot10^{6}$		
Se-79	$2,4\cdot10^{3}$		
Sm-151	$1,8\cdot10^{6}$		
Sn-126	$3,0\cdot10^{2}$		
Sr-90	$6,1\cdot10^{7}$		
Tc-99	$3,0\cdot10^{6}$		

A reference waste package of the type R.23 has a surface dose rate of 100 mSv/h and no surface contamination.

14.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- All future production of R.23 is assumed to be in steel moulds. Some packages may be of the concrete kind.

15 S.09

15.1 Waste type description

15.1.1 Waste package

General

The S.09 waste type consists of a standard 200-litre drum containing sludges in a cement matrix. The raw waste material consists sludges generated at the Studsvik research centre. The material is classified as intermediate level waste. All data comes from /Chyssler, 2000a; Johansson, 2000; Studsvik, 2000/.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- The content of complexing agents should be well known.

Packaging

The steel drum is made of stainless steel with diameter 0,57 m and 0,84 m in height. The wall thickness is 1,5 mm. The drum weighs approximately 60 kg and surface area is approximately 5,1 m^2. To facilitate the handling in SFR the drums are placed four by four on a steel plate with the dimension 1,2 m ·1,2 m and the thickness of 4 mm. The weight of the steel plate is 66 kg with surface area of 4,0 m^2. The variations between packages are minimal. No major changes in design have been made since the start of production of this package.

The weight in total of a package including waste and is approximately 350 kg. The maximum allowed weight of a waste package is 500 kg.

Treatment and conditioning

The sludges containing radionuclides are mixed with concrete in a custom-made facility at the Studsvik site. Cement is added in the drum and then sludge and water is pumped into the drum.

When the waste is added the stirrer is started and the waste matrix is mixed. The matrix is then allowed to harden for one day. After measurements a steel lid is placed on top of the drum. The drums are placed on the steel plate when the drums are sent to SFR.

The void varies but is estimated to 0,01 m^3 in a drum.

15.1.2 Materials – chemical composition

The average amounts of different materials in an 'typical package' are given in Table 15-1. Waste matrix contains sludge (with dry weight 3–5 %) from cleaning up system for Studsvik radioactive waste water treatment. Main compounds in the sludge is ferric hydroxide, cupper ferric cyanide, this waste could also contain some complexing agents originating form the laundry.

Most important from laundry is the organic chelating compounds EDTA and gluconic acid. The weight of the raw waste material is normally 5 kg sludge per package, see Table 15-1.

The matrix is made of concrete. No cement additives are used.

Table 15-1. Amounts of different material in waste type S.09 (per package).

Material	Weight*	Weight-%
Sludge	5 kg	1,8 %
Concrete	280 kg	98,2 %

* No data concerning variations is available.

15.1.3 Radionuclide inventory

Before the waste is solidified a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $2 \cdot 10^{10}$ Bq for Co-60 and between 0 and $4 \cdot 10^{9}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 50 mSv/h. No estimation on variation of dosrates are available in referred documents. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

15.1.4 Waste production

The number of packages produced until 1998-12-31 is 67, the annual production is estimated to 15, see appendix A.

15.2 Reference waste type description

15.2.1 Waste package and material

The number of packages that will be produced is calculated to 382 during the operation of Studsvik.

Table 15-2 shows the content of different materials and the surface areas of the packaging in S.09 package from Studsvik. Since the steel plate and expansion box is shared between four drums ¼ of the plate and box is included in a package of S.09.

The assumed composition of the waste in a reference waste package of S.09 is given in Table 15-3.

Table 15-2. Estimated reference packaging composition and surface area and thickness of components in each steel drum and one ¼ of a steel plate and expansion box of S.09.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel drum	steel	60	5,1	1,5
Steel plate	steel	16,6	1,0	4

Table 15-3. Estimated reference waste composition in one steel drum of S.09.

Material	Weight
Sludge	5 kg
Cement*	280 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of S.09 are summarised in Table 15-4.

Void and waste volume is specified in Table 15-5.

Average void is estimated to 0,01 m^3 in a steel drum.

Table 15-4. Reference composition and surface area of metallic components in 382 steel drums including ¼ steel plate and expansion box per drum of S.09.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		29 300	2 330	29 300	2 330
Sludge	1 910			1 910	
Cement*	107 000			107 000	

* Including water 0,4 kg/kg cement.

Table 15-5. Volumes in 1 and 382 reference waste packages of steel drums including ¼ steel plate and expansion box per drum of S.09.

	Volume (m^3) 1 package	Volume (m^3) 382 packages
Waste	0,2	76
Void	0,01	3,8

15.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 15-6.

Table 15-6. Radionuclide composition of a reference waste package of the type S.09.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1{,}1\cdot10^{8}$	Pu-239	$9{,}9\cdot10^{3}$
Ag-108m	$6{,}6\cdot10^{3}$	Pu-240	$2{,}0\cdot10^{4}$
Ba-133	$1{,}1\cdot10^{3}$	Pb-210	$5{,}9\cdot10^{-7}$
Be-10	$6{,}6\cdot10^{-2}$	Ra-226	$5{,}9\cdot10^{-6}$
C-14	$1{,}1\cdot10^{5}$	Ac-227	$1{,}2\cdot10^{-4}$
Fe-55	$1{,}1\cdot10^{8}$	Th-229	$8{,}9\cdot10^{-6}$
H-3	$1{,}1\cdot10^{4}$	Th-230	$2{,}7\cdot10^{-3}$
Ho-166m	$4{,}4\cdot10^{2}$	Th-232	$3{,}0\cdot10^{-9}$
Mo-93	$5{,}5\cdot10^{2}$	Pa-231	$8{,}9\cdot10^{-4}$
Nb-93m	$1{,}1\cdot10^{5}$	U-232	$8{,}9\cdot10^{-1}$
Nb-94	$1{,}1\cdot10^{3}$	U-233	$5{,}9\cdot10^{-4}$
Ni-59	$1{,}1\cdot10^{5}$	U-234	$3{,}0\cdot10^{1}$
Ni-63	$2{,}2\cdot10^{7}$	U-235	$5{,}9\cdot10^{-1}$
Sb-125	$1{,}1\cdot10^{7}$	U-236	$8{,}9\cdot10^{0}$
Zr-93	$1{,}1\cdot10^{2}$	U-238	$1{,}2\cdot10^{1}$
		Np-237	$1{,}2\cdot10^{1}$
Correlated to Cs-137		Pu-238	$1{,}2\cdot10^{5}$
Cs-137	$7{,}0\cdot10^{8}$	Pu-241	$3{,}0\cdot10^{6}$
Cd-113m	$4{,}2\cdot10^{5}$	Pu-242	$8{,}9\cdot10^{1}$
Cl-36	$7{,}0\cdot10^{3}$	Am-241	$3{,}0\cdot10^{4}$
Cs-134	$7{,}0\cdot10^{8}$	Am-242m	$3{,}0\cdot10^{2}$
Cs-135	$3{,}5\cdot10^{3}$	Am-243	$8{,}9\cdot10^{2}$
Eu-152	$4{,}9\cdot10^{4}$	Cm-243	$5{,}9\cdot10^{2}$
Eu-154	$7{,}0\cdot10^{7}$	Cm-244	$8{,}9\cdot10^{4}$
Eu-155	$4{,}9\cdot10^{7}$	Cm-245	$8{,}9\cdot10^{0}$
I-129	$2{,}1\cdot10^{2}$	Cm-246	$2{,}4\cdot10^{0}$
Pd-107	$7{,}0\cdot10^{2}$	Pu-244	$2{,}1\cdot10^{-5}$
Pm-147	$6{,}3\cdot10^{8}$		
Ru-106	$3{,}5\cdot10^{6}$		
Se-79	$2{,}8\cdot10^{3}$		
Sm-151	$2{,}1\cdot10^{6}$		
Sn-126	$3{,}5\cdot10^{2}$		
Sr-90	$7{,}0\cdot10^{7}$		
Tc-99	$3{,}5\cdot10^{6}$		

A reference waste package of the type S.09 has a surface dose rate of 50 mSv/h and no surface contamination.

15.3 Uncertainties

- General uncertainties are described in chapter 1.3.

16 S.21

16.1 Waste type description

16.1.1 Waste package

General

The S.21 waste type consists of a 100-litre steel drum inside a 200-litre steel drum with concrete in-between. The waste is placed in the 100-litre drum and consists of scrap metal and refuse. The raw waste material consists of mainly iron/steel, cellulose and other organic material generated at Studsvik nuclear research site. The material is classified as intermediate level waste. Data comes from /Chyssler, 2000b; Johansson, 2000; Studsvik, 2000/.

The physical properties and chemical conditions can vary a lot, but the following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.
- The content of transuranic nuclides must be well known.

Packaging

The 100 litre inner drum has more exactly the volume of 113 l. The height is 0,70 m and the diameter 0,46 m. The walls has a thickness of 1 mm and the whole drum weighs 10 kg.

The outer 200 litre drum has a volume of 218 l, the height of 0,84 m ± 20 %, and the diameter 0,57 m. The wall of the drum is 1 mm and the drum weighs 20 kg.

In order to handle the drums in SFR four drums are placed in a steel box with the dimension 1,2 m · 1,2 m · 1,2 m. The box weighs 330 kg and the walls of it are between 2–5 mm. Holes are made in the walls to ensure that concrete can enter the box when the waste is placed in the Silo in SFR-1.

The weight of a drum including waste is approximately 300 kg but differs between 250–500 (estimated from references) kg. The weight of a package including waste and steel box is approximately 450 kg. The maximum allowed weight of a box is 2500 kg.

Treatment and conditioning

The raw waste is, after eventual fragmentation, packed in the inner drum. The inner drum is then placed inside the outer drum. The space between the two drums is pre-conditioned with concrete. Concrete is poured upon the drum to make a lid.

16.1.2 Materials – chemical composition

The amounts of different materials in a S.21 drum are given in Table 16-1. The waste is varies a lot and consists mainly of scrap metal and garbage e.g. iron scrap, aluminium, wood, cloth, paper, plastics, cable etc. The amount of burnable (N.B. due to materials and radionuclide content) waste is smaller than waste from a ordinary nuclear power reactor since the preferred option in Studsvik is to burn the waste. The weight of the raw waste material is normally 91 kg waste per package but varies, see Table 16-1.

Table 16-1. Amounts of different material in waste type S.21 (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Iron/steel	74	3,8	39,6
Aluminium	5	0,7	2,7
Cellulose	7,9		4,2
Other organics	4		2,1
Concrete**	96		5,1

* Variation of amounts of material is not available in referred documents.

** Including 0,13 kg water/kg concrete.

16.1.3 Radionuclide inventory

Before the waste is transported from Studsvik to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $7 \cdot 10^9$ Bq for Co-60 and between 0 and $4 \cdot 10^7$ for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 2 mSv/h. Normal doserate at 1 meter is between 0,01–1,0 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

16.1.4 Waste production

The waste type has been in production since before 1980 and is still in production. The numbers of packages produced until 1998-12-31 is 1283, annual production is estimated to 10, see appendix A.

16.2 Reference waste type description

16.2.1 Waste package and material

The number of packages that will be produced is estimated to 1493 packages during the operation of Studsvik.

Table 16-2 shows the content of different materials and the steel surface areas of the packaging in package of S.21 from Studsvik which includes a conditioned steel drum both outer and inner drum and ¼ of a steel box.

The assumed composition of the waste in a reference waste package of S.21 is given in Table 16-3. The surface area on metal components in the waste are estimated assuming planar plates with a thickness of 5 mm, and assuming a density of 7860 kg/m^3 for carbon and stainless steel and 2700 kg/m^3 for aluminium.

Table 16-2. Estimated reference packaging composition, surface area and thickness of components in drum of S.21.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Inner drum	Carbon steel	10	2,7	1
Outer drum	Carbon steel	20	4,4	1
Steel box	Carbon steel	82,5	4,25	2,5

Table 16-3. Estimated reference waste composition and surface area and thickness of components in one of S.21.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	74	3,8	5
Aluminium	5	0,7	5
Cellulose	7,9		
Other organics	4		
Concrete*	96		

* Including 0,13 kg water/kg concrete.

The total amounts of different materials in all the packages of S.21 are summarised in Table 16-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 16-5. The waste volume is estimated from the weights of the waste components in Table 16-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 16-5.

Table 16-4. Reference composition and surface area of metallic components in 1493 drums in S.21.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	110 500	5 670	161 900	24 100	272 400	29 800
Aluminium	7 460	1 040			7 460	1 040
Cellulose	11 800				11 800	
Other organics	5 970				5 970	
Concrete*	143 300				143 300	

* Including 0,13 kg water/kg concrete.

Table 16-5. Volumes in 1 and 1493 reference waste packages of S.21.

	Volume (m^3) 1 package	Volume (m^3) 1493 packages
Waste	0,1	43
Void	0,005	2,1
Waste package	0,36	155

16.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 16-6.

Table 16-6. Radionuclide composition of a reference waste package of the type S.21.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$4{,}9\cdot10^{7}$	Pu-239	$4{,}4\cdot10^{3}$
Ag-108m	$2{,}9\cdot10^{3}$	Pu-240	$8{,}8\cdot10^{3}$
Ba-133	$4{,}9\cdot10^{2}$	Pb-210	$2{,}6\cdot10^{-7}$
Be-10	$2{,}9\cdot10^{-2}$	Ra-226	$2{,}6\cdot10^{-6}$
C-14	$4{,}9\cdot10^{4}$	Ac-227	$5{,}3\cdot10^{-5}$
Fe-55	$4{,}9\cdot10^{7}$	Th-229	$3{,}9\cdot10^{-6}$
H-3	$4{,}9\cdot10^{3}$	Th-230	$1{,}2\cdot10^{-3}$
Ho-166m	$2{,}0\cdot10^{2}$	Th-232	$1{,}3\cdot10^{-9}$
Mo-93	$2{,}4\cdot10^{2}$	Pa-231	$3{,}9\cdot10^{-4}$
Nb-93m	$4{,}9\cdot10^{4}$	U-232	$3{,}9\cdot10^{-1}$
Nb-94	$4{,}9\cdot10^{2}$	U-233	$2{,}6\cdot10^{-4}$
Ni-59	$4{,}9\cdot10^{4}$	U-234	$1{,}3\cdot10^{1}$
Ni-63	$9{,}8\cdot10^{6}$	U-235	$2{,}6\cdot10^{-1}$
Sb-125	$4{,}9\cdot10^{6}$	U-236	$3{,}9\cdot10^{0}$
Zr-93	$4{,}9\cdot10^{1}$	U-238	$5{,}3\cdot10^{0}$
		Np-237	$5{,}3\cdot10^{0}$
Correlated to Cs-137		Pu-238	$5{,}3\cdot10^{4}$
Cs-137	$7{,}7\cdot10^{6}$	Pu-241	$1{,}3\cdot10^{6}$
Cd-113m	$4{,}6\cdot10^{3}$	Pu-242	$3{,}9\cdot10^{1}$
Cl-36	$7{,}7\cdot10^{1}$	Am-241	$1{,}3\cdot10^{4}$
Cs-134	$7{,}7\cdot10^{6}$	Am-242m	$1{,}3\cdot10^{2}$
Cs-135	$3{,}9\cdot10^{1}$	Am-243	$3{,}9\cdot10^{2}$
Eu-152	$5{,}4\cdot10^{2}$	Cm-243	$2{,}6\cdot10^{2}$
Eu-154	$7{,}7\cdot10^{5}$	Cm-244	$3{,}9\cdot10^{4}$
Eu-155	$5{,}4\cdot10^{5}$	Cm-245	$3{,}9\cdot10^{0}$
I-129	$2{,}3\cdot10^{0}$	Cm-246	$1{,}1\cdot10^{0}$
Pd-107	$7{,}7\cdot10^{0}$	Pu-244	$9{,}2\cdot10^{-6}$
Pm-147	$6{,}9\cdot10^{6}$		
Ru-106	$3{,}9\cdot10^{4}$		
Se-79	$3{,}1\cdot10^{1}$		
Sm-151	$2{,}3\cdot10^{4}$		
Sn-126	$3{,}9\cdot10^{0}$		
Sr-90	$7{,}7\cdot10^{5}$		
Tc-99	$3{,}9\cdot10^{4}$		

A reference waste package of the type S.21 has a surface dose rate of 2 mSv/h and no surface contamination.

16.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- Waste volume in individual packages depends on fragmentation and the possibility to compact in the inner of the two steel drums.

17 S.23

17.1 Waste type description

17.1.1 Waste package

General

The S.23 waste type consists of 1,73 m^3 concrete moulds with scrap metal and refuse in a concrete matrix. The raw waste material consists of mainly iron/steel, cellulose and other organics generated at the Studsvik research site. The material is classified as intermediate level waste. All data comes from /Chyssler, 1997; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The concrete mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are 10 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg. The variations between moulds are minimal. Total weight of package including waste is approximately 3500 kg but differs between 2900–4900 kg.

The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

Waste from the power plant is sorted in compactible and non-compactible. Non-compactible is put directly in a mould and the mould is then filled with concrete. Compactible waste is put in the mould and compacted. A ‘middle-lid’ is placed in the mould to prevent re-expansion of the waste. This operation is repeated until the mould is full. Then the mould is filled with concrete, which is allowed to harden. Pouring concrete on top of the package makes a lid.

17.1.2 Materials – chemical composition

The amounts of different materials in a S.23 mould are given in Table 17-1. The waste is fairly well defined and consists mainly of scrap metal and refuses as filters, wood, cloth, plastics and cables. The weight of the raw waste material is normally 780 kg waste per package but varies, see Table 17-1.

The matrix is made of concrete. The brand used is Betokem EXM 4PA.

Table 17-1. Amounts of different material in waste type S.23 10-cm concrete mould (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Sludge	3,8		0,5
Cellulose	29		3,4
Iron/steel	113	5,8	13,2
Aluminium	3,8	0,6	0,5
Other inorganic material	139		16,3
Concrete**	565		66,2

* Variation of amounts of material is not available in referred documents.
** Including 0,13 kg water/kg concrete.

17.1.3 Radionuclide inventory

Before the waste is transported from Studsvik to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 100 mSv/h, information on variations are not available. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

17.1.4 Waste production

The number of packages produced until 1998-12-31 is 40; annual production is estimated to 1 package per year, see appendix A.

17.2 Reference waste type description

17.2.1 Waste package and material

The number of packages that will be produced is calculated to 61 packages during the operation of Studsvik.

Table 17-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of S.23 is given in Table 17-3.

Table 17-2. Estimated reference packaging composition, surface area and thickness of components in steel mould of S.23.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		10
Lid	Steel	13	1,8	2
Reinforcement	Steel	261	10	12

Table 17-3. Estimated reference waste composition and surface area and thickness of components in one S.23.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Sludge	3,8		0,5
Cellulose	29		3,4
Iron/steel	113	5,8	13,2
Aluminium	3,8	0,6	0,5
Other inorganic	139		16,3
Concrete*	565		66,2

* Including 0,13 kg water/kg concrete.

The total amounts of different materials in all the packages of S.23 are summarised in Table 17-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 17-5. The waste volume is estimated from the weights of the waste components in Table 17-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 17-5.

Table 17-4. Reference composition and surface area of metallic components in 61 steel moulds S.23.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Sludge	230				230	
Cellulose	1 770				1 770	
Iron/steel	8 480	350	15 920	610	28 800	960
Aluminium	230	40			230	
Other inorganic material	8 440				8 440	
Concrete*	34 500		81 700		116 200	

* Including 0,13 kg water/kg concrete.

Table 17-5. Volumes in 1 and 61 reference waste packages of S.23.

	Volume (m^3) 1 package	Volume (m^3) 61 packages
Waste	0,95	58
Void	0,05	3

17.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 17-6. Inventory based on data for B.12, F.12 and R.12.

Table 17-6. Radionuclide composition of a reference waste package of the type S.23.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1,7\cdot10^{10}$	Pu-239	$1,5\cdot10^{6}$
Ag-108m	$1,0\cdot10^{6}$	Pu-240	$3,1\cdot10^{6}$
Ba-133	$1,7\cdot10^{5}$	Pb-210	$9,2\cdot10^{-5}$
Be-10	$1,0\cdot10^{1}$	Ra-226	$9,2\cdot10^{-4}$
C-14	$1,7\cdot10^{7}$	Ac-227	$1,8\cdot10^{-2}$
Fe-55	$1,7\cdot10^{10}$	Th-229	$1,4\cdot10^{-3}$
H-3	$1,7\cdot10^{6}$	Th-230	$4,1\cdot10^{-1}$
Ho-166m	$6,8\cdot10^{4}$	Th-232	$4,6\cdot10^{-7}$
Mo-93	$8,5\cdot10^{4}$	Pa-231	$1,4\cdot10^{-1}$
Nb-93m	$1,7\cdot10^{7}$	U-232	$1,4\cdot10^{2}$
Nb-94	$1,7\cdot10^{5}$	U-233	$9,2\cdot10^{-2}$
Ni-59	$1,7\cdot10^{7}$	U-234	$4,6\cdot10^{3}$
Ni-63	$3,4\cdot10^{9}$	U-235	$9,2\cdot10^{1}$
Sb-125	$1,7\cdot10^{9}$	U-236	$1,4\cdot10^{3}$
Zr-93	$1,7\cdot10^{4}$	U-238	$1,8\cdot10^{3}$
		Np-237	$1,8\cdot10^{3}$
Correlated to Cs-137		Pu-238	$1,8\cdot10^{7}$
Cs-137	$9,4\cdot10^{8}$	Pu-241	$4,6\cdot10^{8}$
Cd-113m	$5,6\cdot10^{5}$	Pu-242	$1,4\cdot10^{4}$
Cl-36	$9,4\cdot10^{3}$	Am-241	$4,6\cdot10^{6}$
Cs-134	$9,4\cdot10^{8}$	Am-242m	$4,6\cdot10^{4}$
Cs-135	$4,7\cdot10^{3}$	Am-243	$1,4\cdot10^{5}$
Eu-152	$6,6\cdot10^{4}$	Cm-243	$9,2\cdot10^{4}$
Eu-154	$9,4\cdot10^{7}$	Cm-244	$1,4\cdot10^{7}$
Eu-155	$6,6\cdot10^{7}$	Cm-245	$1,4\cdot10^{3}$
I-129	$2,8\cdot10^{2}$	Cm-246	$3,7\cdot10^{2}$
Pd-107	$9,4\cdot10^{2}$	Pu-244	$3,2\cdot10^{-3}$
Pm-147	$8,4\cdot10^{8}$		
Ru-106	$4,7\cdot10^{6}$		
Se-79	$3,8\cdot10^{3}$		
Sm-151	$2,8\cdot10^{6}$		
Sn-126	$4,7\cdot10^{2}$		
Sr-90	$9,4\cdot10^{7}$		
Tc-99	$4,7\cdot10^{6}$		

A reference waste package of the type S.23 has a surface dose rate of 100 mSv/h and no surface contamination.

17.3 Uncertainties

- General uncertainties are described in chapter 1.3.

18 Other waste types

18.1.1 General

Since SFR-1 still is in operation there is always the possibility that new waste types are needed. It is not possible to define these types per se; this can only be done when more data is available. Still, there is a need to include this waste in the safety assessment of the SFR-1 repository. In order to make some sort of analysis one has to make some rather crude assumptions.

The assumptions made are:

- The waste consists of large components or scrap metal.
- The materials of the waste package is based on several large components and is set to approximately 10 % steel, 45 % concrete and 45% void.
- The geometry is set to the same as a mould, i.e. 1,2 m · 1,2 m · 1,2 m. The actual packages can differ considerably from this, the geometry has no other meaning than facilitate easy calculations.
- No waste container is assumed for this waste, the waste itself is assumed to be the container.
- The radionuclide inventory is equal to the volume the waste takes in the cavern, i.e. if there is 10 % of odd waste in the cavern, the radionuclides are 10 % of what is allowed.
- Surface dose rate is estimated to the limiting dose rate in the cavern, i.e. 100 mSv/h.

At present no 'odd' waste is placed in BMA.

18.2 Reference waste type description

18.2.1 Waste package and material

The number of packages that will be produced is 238.

Table 18-1 shows the content of different materials and the surface areas of steel in the odd waste. The surface area on metal components in the waste are estimated by assuming planar plates with a thickness of 10 mm, the density is set to 7860 kg/m^3 for carbon and stainless steel.

Table 18-1. Estimated typical packaging composition and surface area and thickness of components of odd waste type.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Carbon steel	1211	61,6	10
Concrete	1557		

The total amount of different material in all of the packages of the odd waste are summarised in Table 18-2.

Void and waste volume is specified in Table 18-3.

Table 18-2. Reference composition and surface area of metallic components in 238 packages of odd waste.

Content	Waste packages weight (kg)	 area (m^2)
Iron/steel	288 000	14 700
Concrete	370 000	

Table 18-3. Volumes in 1 and 238 typical waste packages of odd waste.

	Volume (m^3) 1 package	Volume (m^3) 238 packages
Waste	0,95	226
Void	0,78	185

18.2.2 Radionuclide inventory

The reference inventory in one package at the time of production has not been calculated since waste type is hypothetical and hence there is no need for a reference inventory. A inventory for all boxes at the year 2030 is presented in appendix B.

A reference waste package of the odd waste type has a surface dose rate of 100 mSv/h and no surface contamination.

18.3 Uncertainties

- Up to this date no kind of odd waste has been disposed off in BMA, in future odd waste types could be disposed off.
- General uncertainties are described in chapter 1.3.

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Appendix F

Waste types in the Silo

1 General

1.1 Waste in the Silo

In SFR, in the Silo – Silo for intermediate level waste – short-lived wastes from the nuclear power plants and the Studsvik research site are disposed off. The Silo consists of a cylindrical concrete construction with shafts of different sizes for waste packages. The biggest shafts are 2,5 m by 2,5 m. The Silo is operated with remote controlled equipment for waste handling. The Silo is approximately 50 m high and has a diameter of approximately 30 m. The Silo has been designed to handle 80–90 % of the activity in SFR-1 and hence has the most efficient barriers in the repository. The Silo is placed in a low flow area of the rock, there is approximately 1 m of bentonite clay filling between the rock and the concrete construction and finally the void between the construction and the waste packages are back-filled with concrete. All this will ensure that after closure of the facility the transport of radionuclides will be very small.

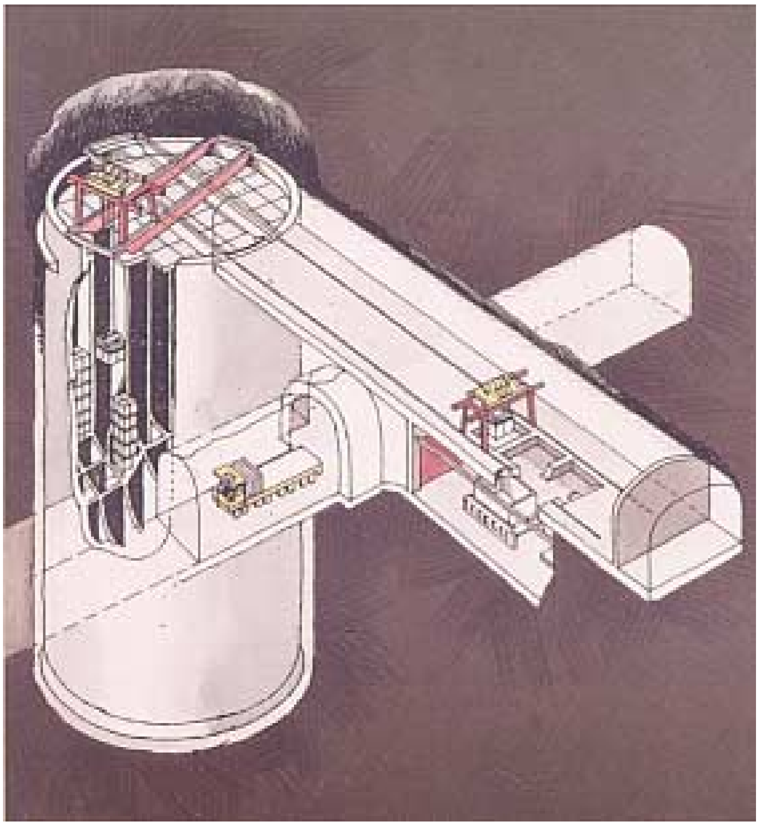

Figure 1-1. *The Silo and some adjacent tunnels.*

The waste that is intended in the Silo comes from many different waste streams but the most important one is ion exchange resins from the nuclear power plants. Other waste like metal components of different origin is also disposed off in Silo. The amount of organic material is kept to a minimum.

Dose rates allowed on a package is maximum 500 mSv/h on the surface. The dominating nuclides are Co-60 and Cs-137. Most of the transuranic elements in SFR-1 are following the waste streams to the Silo.

Other criteria for acceptance are:

- Construction, geometry, dimensions and weight must be suited to the handling system in SFR and the transportation system in general and in the Silo in particular. The strength of the packages must be sufficient to withstand normal and unnormal handling.
- Each package must have an individual identity and the radionuclide content of gamma emitting nuclides shall be known.
- Surface contamination should not exceed 40 kBq/m^2 for gamma and beta emitting nuclides and 4 kBq/m^2 for alpha emitting nuclides.
- The internal dosrates and integrated dose must not affect the barrier properties in the repository.
- The chemical and physical properties and the structure of the waste should be known.
- Chemical aggressive or explosive material, pressurised gas and free liquid are not allowed.
- Gas production from the waste must not be to big.
- The waste shall have enough resistance towards corrosion that the integrity of the package is kept until sealing of the repository.
- Burnable waste must not be subject to self-ignition.
- Complexing agents should be avoided.

All waste in Silo are normally packed in concrete or steel moulds, other packages that are used are steel drums.

1.2 Definitions

- Surface area is defined as the area subject to anaerobic corrosion and gas production after sealing of the repository.

1.3 Uncertainties

- The presented waste types describe the types that have been, are in or can be foreseen to be produced in Sweden. New waste types may be present in the future.
- Almost all data is based on literature values, smaller changes may not been properly documented.

- All future production is based on a relative simple prognosis model. This model, described in appendix A, was chosen since the uncertainties about processes etc are large.
- No regard has been taken to improvements in processes etc.
- A reference package has been chosen. Actual packages may differ considerably from this reference package, the uncertainty for the whole population of packages is judged to be smaller.
- Void presented in this report is based on best estimates; the estimates can be quite crude.

2 B.06

2.1 Waste type description

2.1.1 Waste package

General

The B.06 waste type consists of a standard 200-litre drum containing ion exchange resins in a bitumen matrix. The raw waste material consists of ion exchange resins and sludges generated at the Barsebäck nuclear power plant. The material is classified as intermediate level waste. All data comes from /Roth, 1996; Johansson, 2000; TRIUMF, 2000/.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.

Packaging

The steel drum is made of stainless steel with diameter 0,595 m and 0,882 m in height. The thickness of the material is 1,2 mm. The drum weighs approximately 23 kg and the surface area is approximately 3 m^2. To facilitate the handling in SFR the drums are placed four by four on a steel plate with the dimension 1,2 m ·1,2 m and the thickness of 0,004 m. Between the four drums a expansion box is placed to provide expansion volume in case of swelling of the bitumen matrix. The box is made of steel and has a weight of 20 kg, the walls are 6 mm thick and the whole box has a surface area of 0,8 m^2. The weight of the steel plate is 49 kg with surface area of 2,9 m^2. The variations between packages are minimal. No major changes in design have been made since the start of production of this package except that since 1985 the drums are made of stainless steel. The weight in total of a package including waste and is approximately 200 kg. The maximum allowed weight of a waste package is 500 kg.

Treatment and conditioning

The ion exchange resin containing metal hydroxides and other substances are mixed with bitumen in a custom made facility in the Barsebäck NPP. The flow in the bitumenisation process is measured with electrical conductivity. A small amount of Na_2SO_4 is mixed with the product to give correct measurements of the conductivity. Emulgator is added in order to make the product more homogene. After filling, a steel lid is placed upon the drum. The drums are placed on the steel plate when they are sent to SFR.

The void varies but is estimated to 0,03 m^3 in a drum (not including expansion box).

2.1.2 Materials – chemical composition

The amounts of different materials in a B.06 drum are given in Table 2-1. The waste matrix contains metal hydroxides from the clean-up system for the reactor and evaporation residues from back flush water from the fuel storage pools. The weight of the raw waste material is normally 50 kg ion exchange resin per package but varies, see Table 2-1.

The matrix is made of bitumen. The specific brand of bitumen has changed during the many years of production of this waste type but it is always of the distilled sort. The brands used are Mexphalate until 1982, Nynäs industrial bitumen IB 45 between 1983–1995 and Nynäs industrial bitumen IB 55 used from 1995. The amounts of added chemicals are:

Na_2SO_4	0,2–0,5 kg/drum
Emulgator	0,4–1,1 kg/drum

Table 2-1. Amounts of different material in waste type B.06 (per package).

Material	Weight	Weight-%
Ion-exchange resin	30-55 kg	16-43 %
Bitumen	129-155 kg	57-84 %

2.1.3 Radionuclide inventory

Before the waste is transported from Barsebäck NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $1,1 \cdot 10^{11}$ Bq for Co-60 and between 0 and $2,7 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 500 mSv/h. Normal doserate at 1 m is between 0–10 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

2.1.4 Waste production

The waste type has been in production since 1985 and is still in production. The number of packages produced until 1998-12-31 is 2684, the annual production is estimated to 150, see appendix A.

2.2 Reference waste type description

2.2.1 Waste package and material

The number of packages that will be produced is calculated to 6902 during the operation of Barsebäck.

Table 2-2 shows the content of different materials and the surface areas of the packaging in B.06 package from Barsebäck. Since the steel plate and expansion box is shared between four drums ¼ of the plate and box is included in a package of B.06.

The assumed composition of the waste in a reference waste package of B.06 is given in Table 2-3.

Table 2-2. Estimated reference packaging composition and surface area and thickness of components in each steel drum and one ¼ of a steel plate and expansion box of B.06.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel drum	Stainless steel	23	3	1,2
Steel plate	Carbon steel	12,25	0,7	4
Expansion box	Carbon steel	5	0,2	6

Table 2-3. Estimated reference waste composition in one steel drum of B.06.

Material	Weight
Ion-exchange resin	50 kg
Bitumen	150 kg
Chemicals(Na-sulphate)	0,5 kg

The total amounts of different materials in all the packages of B.06 are summarised in Table 2-4.

Void and waste volume is specified in Table 2-5.

Average void is estimated to 0,03 m^3 in a steel drum.

Table 2-4. Reference composition and surface area of metallic components in 6902 steel drums including ¼ steel plate and expansion box per drum of B.06.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		277 800	26 900	278 000 800	26 900
Bitumen	1 035 000			1 035 000	
Ion-exchange resin	345 000			345 000	
Chemicals (Na-sulphate)	3 450			3 450	

Table 2-5. Volumes in 1 and 6902 reference waste packages of steel drums including ¼ steel plate and expansion box per drum of B.06.

	Volume (m^3) 1 package	Volume (m^3) 6902 packages
Waste	0,2	1380
Void	0,03	207

2.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 2-6.

Table 2-6. Radionuclide composition of a reference waste package of the type B.06.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$6,3 \cdot 10^{10}$	Pu-239	$1,3 \cdot 10^{4}$
Ag-108m	$3,8 \cdot 10^{6}$	Pu-240	$2,5 \cdot 10^{4}$
Ba-133	$6,3 \cdot 10^{5}$	Pb-210	$7,5 \cdot 10^{-7}$
Be-10	$3,8 \cdot 10^{1}$	Ra-226	$7,5 \cdot 10^{-6}$
C-14	$6,3 \cdot 10^{7}$	Ac-227	$1,5 \cdot 10^{-4}$
Fe-55	$6,3 \cdot 10^{10}$	Th-229	$1,1 \cdot 10^{-5}$
H-3	$6,3 \cdot 10^{6}$	Th-230	$3,4 \cdot 10^{-3}$
Ho-166m	$2,5 \cdot 10^{5}$	Th-232	$3,8 \cdot 10^{-9}$
Mo-93	$3,2 \cdot 10^{5}$	Pa-231	$1,1 \cdot 10^{-3}$
Nb-93m	$6,3 \cdot 10^{7}$	U-232	$1,1 \cdot 10^{0}$
Nb-94	$6,3 \cdot 10^{5}$	U-233	$7,5 \cdot 10^{-4}$
Ni-59	$6,3 \cdot 10^{7}$	U-234	$3,8 \cdot 10^{1}$
Ni-63	$1,3 \cdot 10^{10}$	U-235	$7,5 \cdot 10^{-1}$
Sb-125	$6,3 \cdot 10^{9}$	U-236	$1,1 \cdot 10^{1}$
Zr-93	$6,3 \cdot 10^{4}$	U-238	$1,5 \cdot 10^{1}$
		Np-237	$1,5 \cdot 10^{1}$
Correlated to Cs-137		Pu-238	$1,5 \cdot 10^{5}$
Cs-137	$5,1 \cdot 10^{9}$	Pu-241	$3,8 \cdot 10^{6}$
Cd-113m	$3,1 \cdot 10^{6}$	Pu-242	$1,1 \cdot 10^{2}$
Cl-36	$5,1 \cdot 10^{4}$	Am-241	$3,8 \cdot 10^{4}$
Cs-134	$5,1 \cdot 10^{9}$	Am-242m	$3,8 \cdot 10^{2}$
Cs-135	$2,6 \cdot 10^{4}$	Am-243	$1,1 \cdot 10^{3}$
Eu-152	$3,6 \cdot 10^{5}$	Cm-243	$7,5 \cdot 10^{2}$
Eu-154	$5,1 \cdot 10^{8}$	Cm-244	$1,1 \cdot 10^{5}$
Eu-155	$3,6 \cdot 10^{8}$	Cm-245	$1,1 \cdot 10^{1}$
I-129	$1,5 \cdot 10^{3}$	Cm-246	$3,0 \cdot 10^{0}$
Pd-107	$5,1 \cdot 10^{3}$	Pu-244	$2,6 \cdot 10^{-5}$
Pm-147	$4,6 \cdot 10^{9}$		
Ru-106	$2,6 \cdot 10^{7}$		
Se-79	$2,0 \cdot 10^{4}$		
Sm-151	$1,5 \cdot 10^{7}$		
Sn-126	$2,6 \cdot 10^{3}$		
Sr-90	$5,1 \cdot 10^{8}$		
Tc-99	$2,6 \cdot 10^{7}$		

A reference waste package of the type B.06 has a surface dose rate of 100 mSv/h and no surface contamination.

2.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- The production of type B.06 was closed down in the end of 2000. Since the replacing type is not decided yet the B.06 is used in the calculations.

3 F.18

3.1 Waste type description

3.1.1 Waste package

General

The F.18 waste type consists of 1,73 m^3 steel moulds containing ion-exchange resins in a bitumen matrix. The raw waste material consists of ion exchange resins generated at the Forsmark nuclear power plant. The material is classified as intermediate level waste. All data comes from /Jansson, 1995; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.
- Since the package contains burnable substances the restrictions regarding self-ignition etc are of special importance.

Packaging

The mould is a cubic box made of steel with the dimensions 1,2 m ·1,2 m · 1,2 m. The wall is 5 mm thick, the bottom is 6 mm thick. The mould weighs approximately 400 kg and the surface area is approximately 10 m^2. The variations between moulds are minimal. No major change in design has been made since the start of production of this package.

The weight in total of a package including waste and is approximately 1960 kg but differs between 1860–2260 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The ion-exchange resins are dried in 150°C in a conical dryer and are then homogenised with bitumen in a conical mixer. The mixed waste is then poured in a steel mould. Each batch is maximum 500 litres. The mix is then allowed to cool for at least 17 h before a thin layer (~1 cm) of pure bitumen is poured upon the waste matrix. The waste package is thereafter lidded with a steel lid.

The void varies but is estimated to 10 % in a package.

3.1.2 Materials – chemical composition

The amounts of different materials in a F.18 mould are given in Table 3-1. The waste is well defined and consists of ion exchange resins with radionuclides from system 324 and 331. The weight of the raw waste material is normally 600 kg ion exchange resin per package but varies, see Table 3-1.

The matrix is made of bitumen. The specific brand of bitumen has changed during the years of production of this waste type but it is always the distilled sort. The brands used are IB 45 Nynäs industrial bitumen used until 1994 and IB 55 Nynäs industrial bitumen from 1995.

Table 3-1. Amounts of different material in waste type F.18 (per package).

Material	Weight	Weight-%
Ion-exchange resin	600 kg	38 %
Bitumen	960 kg	62 %

No variation of material is identified in references.

3.1.3 Radionuclide inventory

Before the waste is transported from Forsmark NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $2{,}5 \cdot 10^{12}$ Bq for Co-60 and between 0 and $1{,}9 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 500 mSv/h on the surface. Normal doserate at one meter is approximately 30 mSv/h; normal interval for doserate at one meter is between 5–80 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package. The waste packages are usually free of contamination.

3.1.4 Waste production

The waste type has been in production since 1991 and is still in production. The number of packages produced until 1998-12-31 is 181; annual production is estimated to 17 packages per year, see appendix A.

3.2 Reference waste type description

3.2.1 Waste package and material

The number of packages that will be produced is calculated to 938 packages during the operation of Forsmark.

Table 3-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of F.18 is given in Table 3-3.

Table 3-2. Estimated reference packaging composition and surface area and thickness of components in steel mould of F.18.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel mould	steel	400	10	5

Table 3-3. Estimated reference waste composition and surface area and thickness of components in one of F.18.

Material	**Weight**
Ion-exchange resin	600 kg
Bitumen	960 kg

The total amounts of different materials in all the packages of F.18 are summarised in Table 3-4.

Average void is estimated 10 % in a steel mould. Void and waste volume is specified in Table 3-5.

Table 3-4. Reference composition and surface area of metallic components in 938 steel moulds of F.18.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		375 200	9 380	375 200	9 380
Ion-exchange resin	562 800			562 800	
Bitumen	900 500			900 500	

Table 3-5. Volumes in 1 and 938 reference waste packages of F.18.

	Volume (m^3) 1 package	**Volume (m^3) 938 packages**
Waste	1,53	1435
Void	0,17	159

3.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 3-6.

Table 3-6. Radionuclide composition of a reference waste package of the type F.18.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$8,2\cdot10^{11}$	Pu-239	$1,8\cdot10^{6}$
Ag-108m	$4,9\cdot10^{7}$	Pu-240	$3,6\cdot10^{6}$
Ba-133	$8,2\cdot10^{6}$	Pb-210	$1,1\cdot10^{-4}$
Be-10	$4,9\cdot10^{2}$	Ra-226	$1,1\cdot10^{-3}$
C-14	$8,2\cdot10^{8}$	Ac-227	$2,2\cdot10^{-2}$
Fe-55	$8,2\cdot10^{11}$	Th-229	$1,6\cdot10^{-3}$
H-3	$8,2\cdot10^{7}$	Th-230	$4,9\cdot10^{-1}$
Ho-166m	$3,3\cdot10^{6}$	Th-232	$5,4\cdot10^{-7}$
Mo-93	$4,1\cdot10^{6}$	Pa-231	$1,6\cdot10^{-1}$
Nb-93m	$8,2\cdot10^{8}$	U-232	$1,6\cdot10^{2}$
Nb-94	$8,2\cdot10^{6}$	U-233	$1,1\cdot10^{-1}$
Ni-59	$8,2\cdot10^{8}$	U-234	$5,4\cdot10^{3}$
Ni-63	$1,6\cdot10^{11}$	U-235	$1,1\cdot10^{2}$
Sb-125	$8,2\cdot10^{10}$	U-236	$1,6\cdot10^{3}$
Zr-93	$8,2\cdot10^{5}$	U-238	$2,2\cdot10^{3}$
		Np-237	$2,2\cdot10^{3}$
Correlated to Cs-137		Pu-238	$2,2\cdot10^{7}$
Cs-137	$8,6\cdot10^{10}$	Pu-241	$5,4\cdot10^{8}$
Cd-113m	$5,2\cdot10^{7}$	Pu-242	$1,6\cdot10^{4}$
Cl-36	$8,6\cdot10^{5}$	Am-241	$5,4\cdot10^{6}$
Cs-134	$8,6\cdot10^{10}$	Am-242m	$5,4\cdot10^{4}$
Cs-135	$4,3\cdot10^{5}$	Am-243	$1,6\cdot10^{5}$
Eu-152	$6,0\cdot10^{6}$	Cm-243	$1,1\cdot10^{5}$
Eu-154	$8,6\cdot10^{9}$	Cm-244	$1,6\cdot10^{7}$
Eu-155	$6,0\cdot10^{9}$	Cm-245	$1,6\cdot10^{3}$
I-129	$2,6\cdot10^{4}$	Cm-246	$4,3\cdot10^{2}$
Pd-107	$8,6\cdot10^{4}$	Pu-244	$3,8\cdot10^{-3}$
Pm-147	$7,7\cdot10^{10}$		
Ru-106	$4,3\cdot10^{8}$		
Se-79	$3,4\cdot10^{5}$		
Sm-151	$2,6\cdot10^{8}$		
Sn-126	$4,3\cdot10^{4}$		
Sr-90	$8,6\cdot10^{9}$		
Tc-99	$4,3\cdot10^{8}$		

A reference waste package of the type F.18 has a surface dose rate of 500 mSv/h and no surface contamination.

3.3 Uncertainties

- General uncertainties are described in chapter 1.3.

4 O.02

4.1 Waste type description

4.1.1 Waste package

General

The O.02 waste type consists of 1,73 m^3 concrete moulds containing ion-exchange resins and inert filter-aid in a concrete matrix. The raw waste material consists of ion exchange resins and filter aids generated at the Oskarshamn nuclear power plant. The material is classified as intermediate level waste. All data comes from /Ingemansson, 1999; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are normally 10 cm thick but can in some exceptional cases be 25 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg and the 25-cm one weighs about 3200 kg. A stirrer made of carbon steel is included in the waste package. It weighs 16 kg and has a estimated surface of 1 m^2. To avoid cracking of the mould, due to expansion of the concrete matrix, a lining of compactible material (polyethene) is put inside of the mould, the lining has a thickness of 20 mm and a total weight of 10 kg. Lining is only placed in the 10-cm mould. The variations between moulds are minimal.

Some changes in the design have been made since the start of production of this package. 1975–78 the reinforcement was gradually improved and in 1981 a new design of reinforcement was introduced. In 1979 the moulds was fitted with a expansion cassette of polyurethane and wood, this was used until 1988 when the polyethene cassette was introduced. In 1986 a new brand of concrete to make the lid was introduced, instead of Sabema A, the Betokem EXM-4 was used. Today no chemical cement additives is used, earlier Silix GP was used.

The weight of a package including waste is approximately 3200 kg but differs between 3300–3600 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 30 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The lid is at least 10 cm thick. The concrete is allowed 24 hours to harden before the waste is transported to intermediate storage. Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 30 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to intermediate storage. The lid is at least 10 cm thick.

4.1.2 Materials – chemical composition

The amounts of different materials in a O.02 mould are given in Table 4-1. The waste is well defined and consists of ion exchange resins and filter-aid with radionuclides from systems for cleaning reactor water (system 331), treatment of liquid waste (system 342), decontamination (system 347) and cleaning of fuel ponds (system 324). Systems 331, 347 and 342 uses bead resin, system 342 uses powder resin. The weight of the raw waste material is normally 130 kg ion exchange resin per package but varies, see Table 4-1.

The matrix is made of cement. The specific brand of cement has changed during the years of production of this waste type. The brands used are:
Sabema A-bruk 1970–1986,
LH cement 1970–1981,
Massiv cement 1981–1986,
Anläggningscement 1986–1999,
Höghållfasthetscement from 1999–,
Betokem EXM used from 1986–.

Table 4-1. Amounts of different material in waste type O.02 (per package).

Material	Weight	Weight-%
Ion-exchange resin	90-150 kg	5,7-10,0 %
Cement*	1350-1500 kg	90,0-94,3 %

* Including water 0,4 kg/kg cement.

4.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $9,4 \cdot 10^{11}$ Bq for Co-60 and between 0 and $7,9 \cdot 10^{12}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 30 mSv/h on the surface. Normal dose rate at one meter is 2 mSv/h but varies between 0–10 mSv/h. The contamination on surface should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package. The waste packages are usually free of contamination.

4.1.4 Waste production

The waste type has been in production since 1970 and is still in production. The number of packages produced until 1998-12-31 is 574, annual production is estimated to 39 packages per year, see appendix A.

4.2 Reference waste type description

4.2.1 Waste package and material

The number of packages that will be produced is calculated to 2094 packages during the operation of Oskarshamn.

Table 4-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of O.02 is given in Table 4-3.

Table 4-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of O.02.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete mould	Concrete	1340		100
Reinforcement	Steel	261	10	12
Steel lid	Steel	13	1,8	2
Stirrer	Steel	16	1	5
Other organics	Polyethene	10		

Table 4-3. Estimated reference waste composition and surface area and thickness of components in one of O.02.

Material	Weight
Ion-exchange resin	130 kg
Cement*	1540 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of O.02 are summarised in Table 4-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 4-5. The waste volume is estimated from the weights of the waste components in Table 4-3 and approximate densities of the different material. Average void is estimated to 15 % in a package.

Void and waste volume is specified in Table 4-5.

Table 4-4. Reference composition and surface area of metallic components in 2094 concrete moulds in O.02.

Content	Waste weight (kg)	Packaging weight (kg)	area (m^2)	Waste packages weight (kg)	area (m^2)
Iron/steel		607 300	26 800	607 300	26 800
Ion-exchange resin	272 200			272 200	
Other organics	20 900			20 900	
Cement*	3 220 000	2 806 000**		5 109 000	

* Including water 0,4 kg/kg cement for the waste.

** Given as concrete.

Table 4-5. Volumes in 1 and 2094 reference waste packages of O.02.

	Volume (m^3) 1 package	Volume (m^3) 938 packages
Waste	0,85	1780
Void	0,15	314

4.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 4-6.

Table 4-6. Radionuclide composition of a reference waste package of the type O.02.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1,1\cdot10^{11}$	Pu-239	$1,7\cdot10^{3}$
Ag-108m	$6,3\cdot10^{6}$	Pu-240	$3,5\cdot10^{3}$
Ba-133	$1,1\cdot10^{6}$	Pb-210	$1,0\cdot10^{-7}$
Be-10	$6,3\cdot10^{1}$	Ra-226	$1,0\cdot10^{-6}$
C-14	$1,1\cdot10^{8}$	Ac-227	$2,1\cdot10^{-5}$
Fe-55	$1,1\cdot10^{11}$	Th-229	$1,6\cdot10^{-6}$
H-3	$1,1\cdot10^{7}$	Th-230	$4,7\cdot10^{-4}$
Ho-166m	$4,2\cdot10^{5}$	Th-232	$5,2\cdot10^{-10}$
Mo-93	$5,3\cdot10^{5}$	Pa-231	$1,6\cdot10^{-4}$
Nb-93m	$1,1\cdot10^{8}$	U-232	$1,6\cdot10^{-1}$
Nb-94	$1,1\cdot10^{6}$	U-233	$1,0\cdot10^{-4}$
Ni-59	$1,1\cdot10^{8}$	U-234	$5,2\cdot10^{0}$
Ni-63	$2,1\cdot10^{10}$	U-235	$1,0\cdot10^{-1}$
Sb-125	$1,1\cdot10^{10}$	U-236	$1,6\cdot10^{0}$
Zr-93	$1,1\cdot10^{5}$	U-238	$2,1\cdot10^{0}$
		Np-237	$2,1\cdot10^{0}$
Correlated to Cs-137		Pu-238	$2,1\cdot10^{4}$
Cs-137	$8,7\cdot10^{10}$	Pu-241	$5,2\cdot10^{5}$
Cd-113m	$5,2\cdot10^{7}$	Pu-242	$1,6\cdot10^{1}$
Cl-36	$8,7\cdot10^{5}$	Am-241	$5,2\cdot10^{3}$
Cs-134	$8,7\cdot10^{10}$	Am-242m	$5,2\cdot10^{1}$
Cs-135	$4,4\cdot10^{5}$	Am-243	$1,6\cdot10^{2}$
Eu-152	$6,1\cdot10^{6}$	Cm-243	$1,0\cdot10^{2}$
Eu-154	$8,7\cdot10^{9}$	Cm-244	$1,6\cdot10^{4}$
Eu-155	$6,1\cdot10^{9}$	Cm-245	$1,6\cdot10^{0}$
I-129	$2,6\cdot10^{4}$	Cm-246	$4,2\cdot10^{-1}$
Pd-107	$8,7\cdot10^{4}$	Pu-244	$3,6\cdot10^{-6}$
Pm-147	$7,9\cdot10^{10}$		
Ru-106	$4,4\cdot10^{8}$		
Se-79	$3,5\cdot10^{5}$		
Sm-151	$2,6\cdot10^{8}$		
Sn-126	$4,4\cdot10^{4}$		
Sr-90	$8,7\cdot10^{9}$		
Tc-99	$4,4\cdot10^{8}$		

A reference waste package of the type O.02 has a surface dose rate of 30 mSv/h and no surface contamination.

4.3 Uncertainties

- General uncertainties are described in chapter 1.3.

5 C.02

5.1 Waste type description

5.1.1 Waste package

General

The C.02 waste type consists of 1,73 m^3 concrete moulds containing ion-exchange resins and inert filter-aid in a concrete matrix. The raw waste material consists of ion exchange resins and filter aids generated at the CLAB facility in Oskarshamn. The material is classified as intermediate level waste. All data comes from /Ingemansson, 1999; Johansson, 2000; TRIUMF, 2000/.

Basically the C.02 waste type is identical with O.02 with some small exceptions. The type is in everyday use called O.02.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are normally 10 cm thick but can in some exceptional cases be 25 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg and the 25-cm one weighs about 3200 kg. A stirrer made of carbon steel is included in the waste package. It weighs 16 kg and has a estimated surface of 1 m^2. To avoid cracking of the mould, due to expansion of the concrete matrix, a lining of compactible material (polyethene) is put inside of the mould, the lining has a thickness of 20 mm and a total weight of 10 kg. Lining is only placed in the 10-cm mould. The variations between moulds are minimal.

Some changes in the design have been made since the start of production of this package. In 1986 a new brand of concrete to make the lid was introduced, instead of Sabema A, the Betokem EXM-4 was used. Today no chemical cement additives is used, earlier Silix GP was used.

The weight of a package including waste is approximately 3200 kg but differs between 3300–3600 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 30 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The lid is at least 10 cm thick. The concrete is allowed 24 hours to harden before the waste is transported to intermediate storage. Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 30 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to intermediate storage. The lid is at least 10 cm thick.

5.1.2 Materials – chemical composition

The amounts of different materials in a C.02 mould are given in Table 5-1. The waste is well defined and consists of ion exchange resins and filter-aid with radionuclides from systems for cooling and cleaning of fuel ponds (system 313, 324), treatment of process water (system 371)and treatment of drainage (system 372). The systems contains both bead and power resins. The weight of the raw waste material is normally 130 kg ion exchange resin per package but varies, see Table 5-1.

The matrix is made of cement. The specific brand of cement has changed during the years of production of this waste type. The brands used are:
Sabema A-bruk 1985–1986,
Massiv cement 1985–1986,
Anläggningscement 1986–1999,
Höghållfasthetscement from 1999–,
Betokem EXM used from 1986–.

Table 5-1. Amounts of different material in waste type C.02 (per package).

Material	Weight	Weight-%
Ion-exchange resin	90-150 kg	5,7-10,0 %
Cement*	1350-1500 kg	90,0-94,3 %

* Including water 0,4 kg/kg cement.

5.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn NPP/CLAB to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $6{,}38 \cdot 10^{11}$ Bq for Co-60 and between 0 and $8{,}8 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 30 mSv/h on the surface. Normal dose rate at one meter is 2 mSv/h but varies between 0–10 mSv/h. The contamination on surface should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package. The waste packages are usually free of contamination.

5.1.4 Waste production

The waste type has been in production since 1985 and is still in production. The number of packages produced until 1998-12-31 is 238, annual production is estimated to 20 packages per year, see appendix A.

5.2 Reference waste type description

5.2.1 Waste package and material

The number of packages that will be produced is calculated to 1438 packages during the operation of CLAB.

Table 5-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of C.02 is given in Table 5-3.

Table 5-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of C.02.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete mould	Concrete	1340		100
Reinforcement	Steel	261	10	12
Steel lid	Steel	13	1,8	2
Stirrer	Steel	16	1	5
Other organics	Polyethene	10		

Table 5-3. Estimated reference waste composition and surface area and thickness of components in one of C.02.

Material	Weight
Ion-exchange resin	130 kg
Cement*	1540 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of C.02 are summarised in Table 5-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 5-5. The waste volume is estimated from the weights of the waste components in Table 5-3 and approximate densities of the different material. Average void is estimated to 15 % in a package.

Void and waste volume is specified in Table 5-5.

Table 5-4. Reference composition and surface area of metallic components in 1438 concrete moulds in C.02.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		417 000	18 400	417 000	18 400
Ion-exchange resin	186 900			186 900	
Other organics	14 400			14 400	
Cement*	2 210 000	1 927 000**		4 140 000	

* Including water 0,4 kg/kg cement for the waste.

** Given as concrete.

Table 5-5. Volumes in 1 and 1438 reference waste packages of C.02.

	Volume (m^3) 1 package	Volume (m^3) 1438 packages
Waste	0,85	1222
Void	0,15	216

5.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 5-6.

Table 5-6. Radionuclide composition of a reference waste package of the type C.02.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$4{,}5\cdot10^{11}$	Pu-239	$1{,}0\cdot10^{5}$
Ag-108m	$2{,}7\cdot10^{7}$	Pu-240	$2{,}0\cdot10^{5}$
Ba-133	$4{,}5\cdot10^{6}$	Pb-210	$6{,}0\cdot10^{-6}$
Be-10	$2{,}7\cdot10^{2}$	Ra-226	$6{,}0\cdot10^{-5}$
C-14	$4{,}5\cdot10^{8}$	Ac-227	$1{,}2\cdot10^{-3}$
Fe-55	$4{,}5\cdot10^{11}$	Th-229	$9{,}0\cdot10^{-5}$
H-3	$4{,}5\cdot10^{7}$	Th-230	$2{,}7\cdot10^{-2}$
Ho-166m	$1{,}8\cdot10^{6}$	Th-232	$3{,}0\cdot10^{-8}$
Mo-93	$2{,}2\cdot10^{6}$	Pa-231	$9{,}0\cdot10^{-3}$
Nb-93m	$4{,}5\cdot10^{8}$	U-232	$9{,}0\cdot10^{0}$
Nb-94	$4{,}5\cdot10^{6}$	U-233	$6{,}0\cdot10^{-3}$
Ni-59	$4{,}5\cdot10^{8}$	U-234	$3{,}0\cdot10^{2}$
Ni-63	$8{,}9\cdot10^{10}$	U-235	$6{,}0\cdot10^{0}$
Sb-125	$4{,}5\cdot10^{10}$	U-236	$9{,}0\cdot10^{1}$
Zr-93	$4{,}5\cdot10^{5}$	U-238	$1{,}2\cdot10^{2}$
		Np-237	$1{,}2\cdot10^{2}$
Correlated to Cs-137		Pu-238	$1{,}2\cdot10^{6}$
Cs-137	$1{,}3\cdot10^{11}$	Pu-241	$3{,}0\cdot10^{7}$
Cd-113m	$7{,}7\cdot10^{7}$	Pu-242	$9{,}0\cdot10^{2}$
Cl-36	$1{,}3\cdot10^{6}$	Am-241	$3{,}0\cdot10^{5}$
Cs-134	$1{,}3\cdot10^{11}$	Am-242m	$3{,}0\cdot10^{3}$
Cs-135	$6{,}4\cdot10^{5}$	Am-243	$9{,}0\cdot10^{3}$
Eu-152	$9{,}0\cdot10^{6}$	Cm-243	$6{,}0\cdot10^{3}$
Eu-154	$1{,}3\cdot10^{10}$	Cm-244	$9{,}0\cdot10^{5}$
Eu-155	$9{,}0\cdot10^{9}$	Cm-245	$9{,}0\cdot10^{1}$
I-129	$3{,}8\cdot10^{4}$	Cm-246	$2{,}4\cdot10^{1}$
Pd-107	$1{,}3\cdot10^{5}$	Pu-244	$2{,}1\cdot10^{-4}$
Pm-147	$1{,}2\cdot10^{11}$		
Ru-106	$6{,}4\cdot10^{8}$		
Se-79	$5{,}1\cdot10^{5}$		
Sm-151	$3{,}8\cdot10^{8}$		
Sn-126	$6{,}4\cdot10^{4}$		
Sr-90	$1{,}3\cdot10^{10}$		
Tc-99	$6{,}4\cdot10^{8}$		

A reference waste package of the type C.02 has a surface dose rate of 30 mSv/h and no surface contamination.

5.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- The allowed doserate will probably be raised in the future.

6 C.24

6.1 Waste type description

6.1.1 Waste package

General

The C.24 waste type consists of 1,73 m^3 concrete moulds with scrap metal in a concrete matrix. A small volume of garbage is allowed. The raw waste material consists of mainly iron/steel. Cellulose and other organic material may be present but is kept to a minimum. All waste is generated at the CLAB facility in Oskarshamn. The material is classified as intermediate level waste. All data comes from /Ingemansson, 2000; Johansson, 2000/.

The type is in everyday use called O.24.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are 10 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg. The variations between moulds are minimal.

Inside the concrete mould, modified steel drums could be used as an inner package for the waste. A special drum basket is used inside the concrete mould to centre the drum inside the mould. Approximately 10 % of the concrete moulds are foreseen to have this inner drum.

The weight of a package including waste is approximately 2600 kg. No variation of weight is documented. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste is transported to the 'treatment hot cell' in CLAB where the waste is packed in the moulds or in the inner drums mentioned above. When the mould is filled the package is filled with concrete. The waste package is then allowed two days to harden. Pouring concrete on top of the package makes a lid.

6.1.2 Materials – chemical composition

The amounts of different materials in a C.24 mould are given in Table 6-1. The waste is fairly well defined and consists mainly of scrap metal e.g. valves, filters, packings. A small fraction consists of garbage as e.g. air filters or plastics used in the hot cell. The weight of the raw waste material is normally 640 kg waste per package but can vary, see Table 6-1.

The matrix is made of concrete. The brand used is Betokem EXM 4.

Table 6-1. Amounts of different material in waste type C.24 (per package).

Material	Weight (kg)***	Area (m^2)	Weight-%
Cellulose	35		5,4
Iron/steel**	17	0,9	2,7
Other inorganics	24		3,7
Concrete*	565		88,1

* Including 0,13 kg water/kg concrete.
** Up to 10 % of the packages could have a content of special boxes of steel with a weight of 420 kg and an area of 2,3 m^2 per each.
*** No variation of material is available in references.

6.1.3 Radionuclide inventory

Before the waste is transported from Oskarshamn NPP/CLAB to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. Variations of nuclides are not available. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 30 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

6.1.4 Waste production

The waste type has been in production since 1985 and is still in production. The number of packages produced until 1998-12-31 is 32, annual production is estimated to 2 packages per year, see appendix A.

6.2 Reference waste type description

6.2.1 Waste package and material

The number of packages that will be produced is calculated to 150 packages during the operation of CLAB.

Table 6-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of C.24 is given in Table 6-3.

Table 6-2. Estimated reference packaging composition, surface area and thickness of components in concrete mould of C.24.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete mould	Concrete	1340		100
Reinforcement	Steel	261	10	12
Steel packaging	Steel	420	2,3	5

Table 6-3. Estimated reference waste composition and surface area and thickness of components in one of C.24.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Cellulose	35		
Iron/steel	17	0,9	5
Other inorganics	24		
Concrete*	565		

* Including 0,13 kg water/kg concrete.

The total amounts of different materials in all the packages of C.24 are summarised in Table 6-4. 10 % of the packages is calculated to have steel packages inside the concrete mould. These packages are averaged over all packages.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 6-5. The waste volume is estimated from the weights of the waste components in Table 6-3 and approximate densities of the different material. Average void is estimated to 1 % in a package.

Void and waste volume is specified in Table 6-5.

Table 6-4. Reference composition and surface area of metallic components in 150 concrete moulds in C.24, of which 10 % have a content of extra steel packages.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	2 550	130	51700	1560	54200	1 690
Cellulose	5 250				5 250	
Other inorganics	3 600				3 600	
Concrete	85 000				85 000	

* Including 0,13 kg water/kg concrete.

Table 6-5. Volumes in 1 and 150 reference waste packages of C.24.

	Volume (m^3) 1 package	Volume (m^3) 150 packages
Waste	0,99	148
Void	0,01	2

6.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 6-6.

Table 6-6. Radionuclide composition of a reference waste package of the type C.24.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$1{,}5\cdot10^{11}$	Pu-239	$3{,}0\cdot10^{3}$
Ag-108m	$9{,}0\cdot10^{6}$	Pu-240	$6{,}1\cdot10^{3}$
Ba-133	$1{,}5\cdot10^{6}$	Pb-210	$1{,}8\cdot10^{-7}$
Be-10	$9{,}0\cdot10^{1}$	Ra-226	$1{,}8\cdot10^{-6}$
C-14	$1{,}5\cdot10^{8}$	Ac-227	$3{,}6\cdot10^{-5}$
Fe-55	$1{,}5\cdot10^{11}$	Th-229	$2{,}7\cdot10^{-6}$
H-3	$1{,}5\cdot10^{7}$	Th-230	$8{,}2\cdot10^{-4}$
Ho-166m	$6{,}0\cdot10^{5}$	Th-232	$9{,}1\cdot10^{-10}$
Mo-93	$7{,}5\cdot10^{5}$	Pa-231	$2{,}7\cdot10^{-4}$
Nb-93m	$1{,}5\cdot10^{8}$	U-232	$2{,}7\cdot10^{-1}$
Nb-94	$1{,}5\cdot10^{6}$	U-233	$1{,}8\cdot10^{-4}$
Ni-59	$1{,}5\cdot10^{8}$	U-234	$9{,}1\cdot10^{0}$
Ni-63	$3{,}0\cdot10^{10}$	U-235	$1{,}8\cdot10^{-1}$
Sb-125	$1{,}5\cdot10^{10}$	U-236	$2{,}7\cdot10^{0}$
Zr-93	$1{,}5\cdot10^{5}$	U-238	$3{,}6\cdot10^{0}$
		Np-237	$3{,}6\cdot10^{0}$
Correlated to Cs-137		Pu-238	$3{,}6\cdot10^{4}$
Cs-137	$6{,}5\cdot10^{10}$	Pu-241	$9{,}1\cdot10^{5}$
Cd-113m	$3{,}9\cdot10^{7}$	Pu-242	$2{,}7\cdot10^{1}$
Cl-36	$6{,}5\cdot10^{5}$	Am-241	$9{,}1\cdot10^{3}$
Cs-134	$6{,}5\cdot10^{10}$	Am-242m	$9{,}1\cdot10^{1}$
Cs-135	$3{,}3\cdot10^{5}$	Am-243	$2{,}7\cdot10^{2}$
Eu-152	$4{,}6\cdot10^{6}$	Cm-243	$1{,}8\cdot10^{2}$
Eu-154	$6{,}5\cdot10^{9}$	Cm-244	$2{,}7\cdot10^{4}$
Eu-155	$4{,}6\cdot10^{9}$	Cm-245	$2{,}7\cdot10^{0}$
I-129	$2{,}0\cdot10^{4}$	Cm-246	$7{,}3\cdot10^{-1}$
Pd-107	$6{,}5\cdot10^{4}$	Pu-244	$6{,}4\cdot10^{-6}$
Pm-147	$5{,}9\cdot10^{10}$		
Ru-106	$3{,}3\cdot10^{8}$		
Se-79	$2{,}6\cdot10^{5}$		
Sm-151	$2{,}0\cdot10^{8}$		
Sn-126	$3{,}3\cdot10^{4}$		
Sr-90	$6{,}5\cdot10^{9}$		
Tc-99	$3{,}3\cdot10^{8}$		

A reference waste package of the type C.24 has a surface dose rate of 30 mSv/h and no surface contamination.

6.3 Uncertainties

- Production of C.24 is estimated to optimise available volume in Silo, probably the total production of C.24 will be lower than foreseen above.

7 R.02

7.1 Waste type description

7.1.1 Waste package

General

The R.02 waste type consists of 1,73 m^3 concrete moulds containing ion-exchange resins and inert filter-aid in a concrete matrix. The raw waste material consists of ion exchange resins and filter aids generated at the Ringhals nuclear power plant. The material is classified as intermediate level waste. All data comes from /Eriksson, 1990; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are normally 10 cm thick but can in some exceptional cases be 25 cm thick. The reinforcement is made of steel bars with a total surface of 7,9 m^2 and a weight of 160 kg in a 10-cm mould and 11,8 m^2 and 250 kg in a 25-cm mould. The 10-cm mould weighs approximately 1600 kg and the 25-cm weighs about 3100 kg. A stirrer made of carbon steel is included in the waste package. It weighs 16 kg and has an estimated surface of 1 m^2. To avoid cracking of the mould, due to expansion of the concrete matrix, a lining with compressible material (polyethene or polystyrene) is put inside the walls of the mould. The lining has a thickness of 20 mm and a total weight of 10 kg in a 10-cm mould and 5 mm and approximately 1 kg in a 25-cm mould. The variations between moulds are minimal.

Some changes in the design have been made since the start of production of this package. Before 1976 no lining was used. Some changes have been made regarding reinforcement and steel details in the mould. For the lid Betokem EXM-4 was used, nowadays Fiberbruk VF50 is used. Today no chemical cement additives are used but earlier Silix GP and Sika AER were used.

The weight of a package including waste and is approximately 3400 kg but differs between 3000–3700 kg. The maximum allowed weight of a waste package is 4000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 60 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to interim storage. The lid is at least 10 cm thick.

7.1.2 Materials – chemical composition

The amounts of different materials in a R.02 mould are given in Table 7-1. The waste is well defined and consists of ion exchange resins and filter-aid with radionuclides.

The resins are:

- Bead resin from PWR: cleaning of the primary reactor circuit (system 334), the fuel ponds (system 324), the waste water (system 342), water from the secondary side of the steam generators (system 417/337) and from drainage water.
- Bead resin from BWR: systems for cleaning reactor water (system 331), treatment of liquid waste (system 342), analytical ion-exchangers (system 336) and cleaning of fuel ponds (system 324).
- Powder resins from BWR: cleaning of condensate (system 332), fuel ponds (system 324) and treatment of liquid waste (system 324). The resins from liquid waste treatment contain filter-aids.

Resins from the PWR-reactors contain boric acid (H_3BO_3) up to 90 g/kg of resin. Some resins contain lithium. Resins from system 417/337 can contain ammonia and hydrazine.

The weight of the raw waste material is normally 130 kg of ion exchange resin per package but varies, see Table 7-1.

The matrix is made of cement. The specific brand of cement has changed during the years of production of this waste type. The brand used nowadays is Skövde standardcement. In earlier days Limhamn LH-cement was used.

Table 7-1. Amounts of different material in waste type R.02 (per package).

Material	Weight	Weight-%
Ion-exchange resin	100-150 kg	5,9-12,0 %
Cement*	1100-1600 kg	88,0-94,1 %

* Including water 0,4 kg/kg cement.

7.1.3 Radionuclide inventory

Before the waste is transported from Ringhals NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $1{,}4\cdot10^{12}$ Bq for Co-60 and between 0 and $7{,}7\cdot10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 500 mSv/h on the surface. Normal dose rate at 1 m is 4 mSv/h but varies between 0–14 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package.

7.1.4 Waste production

The waste type has been in production since 1984 and is still in production even though in a small scale. Type R.16 is used for this kind of waste nowadays. The number of packages produced until 1998-12-31 is 459, annual production is estimated to 4 packages per year, see appendix A.

7.2 Reference waste type description

7.2.1 Waste package and material

The number of packages that will be produced is calculated to 705 packages during the operation of Ringhals.

Table 7-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of R.02 is given in Table 7-3.

Table 7-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of R.02.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		100
Reinforcement	Steel	261	10	12
Steel lid	Steel	13	1,8	2
Stirrer	Steel	16	1	5
Other organics	Polyethene	10		

Table 7-3. Estimated reference waste composition and surface area and thickness of components in one of R.02.

Material	Weight
Ion-exchange resin	130 kg
Cement*	1400 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of R.02 are summarised in Table 7-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 7-5. The waste volume is estimated from the weights of the waste components in Table 7-3 and approximate densities of the different material. Average void is estimated to 15 % in a package.

Void and waste volume is specified in Table 7-5.

Table 7-4. Reference composition and surface area of metallic components in 705 concrete moulds in R.02.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		204 400	9 020	204 400	9 020
Ion-exchange resin	91 650			91 650	
Other organics	7 050			7 050	
Cement*	987 000	944 700		1 932 000	

* Including water 0,4 kg/kg cement for the waste.

** Given as concrete.

Table 7-5. Volumes in 1 and 705 reference waste packages of R.02.

	Volume (m^3) 1 package	Volume (m^3) 705 packages
Waste	0,85	599
Void	0,15	106

7.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 7-6.

Table 7-6. Radionuclide composition of a reference waste package of the type R.02.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$7,5\cdot10^{10}$	Pu-239	$4,0\cdot10^{6}$
Ag-108m	$4,5\cdot10^{6}$	Pu-240	$7,9\cdot10^{6}$
Ba-133	$7,5\cdot10^{5}$	Pb-210	$2,4\cdot10^{-4}$
Be-10	$4,5\cdot10^{1}$	Ra-226	$2,4\cdot10^{-3}$
C-14	$7,5\cdot10^{7}$	Ac-227	$4,7\cdot10^{-2}$
Fe-55	$7,5\cdot10^{10}$	Th-229	$3,6\cdot10^{-3}$
H-3	$7,5\cdot10^{6}$	Th-230	$1,1\cdot10^{0}$
Ho-166m	$3,0\cdot10^{5}$	Th-232	$1,2\cdot10^{-6}$
Mo-93	$3,7\cdot10^{5}$	Pa-231	$3,6\cdot10^{-1}$
Nb-93m	$7,5\cdot10^{7}$	U-232	$3,6\cdot10^{2}$
Nb-94	$7,5\cdot10^{5}$	U-233	$2,4\cdot10^{-1}$
Ni-59	$7,5\cdot10^{7}$	U-234	$1,2\cdot10^{4}$
Ni-63	$1,5\cdot10^{10}$	U-235	$2,4\cdot10^{2}$
Sb-125	$7,5\cdot10^{9}$	U-236	$3,6\cdot10^{3}$
Zr-93	$7,5\cdot10^{4}$	U-238	$4,7\cdot10^{3}$
		Np-237	$4,7\cdot10^{3}$
Correlated to Cs-137		Pu-238	$4,7\cdot10^{7}$
Cs-137	$4,6\cdot10^{10}$	Pu-241	$1,2\cdot10^{9}$
Cd-113m	$2,8\cdot10^{7}$	Pu-242	$3,6\cdot10^{4}$
Cl-36	$4,6\cdot10^{5}$	Am-241	$1,2\cdot10^{7}$
Cs-134	$4,6\cdot10^{10}$	Am-242m	$1,2\cdot10^{5}$
Cs-135	$2,3\cdot10^{5}$	Am-243	$3,6\cdot10^{5}$
Eu-152	$3,2\cdot10^{6}$	Cm-243	$2,4\cdot10^{5}$
Eu-154	$4,6\cdot10^{9}$	Cm-244	$3,6\cdot10^{7}$
Eu-155	$3,2\cdot10^{9}$	Cm-245	$3,6\cdot10^{3}$
I-129	$1,4\cdot10^{4}$	Cm-246	$9,5\cdot10^{2}$
Pd-107	$4,6\cdot10^{4}$	Pu-244	$8,3\cdot10^{-3}$
Pm-147	$4,2\cdot10^{10}$		
Ru-106	$2,3\cdot10^{8}$		
Se-79	$1,8\cdot10^{5}$		
Sm-151	$1,4\cdot10^{8}$		
Sn-126	$2,3\cdot10^{4}$		
Sr-90	$4,6\cdot10^{9}$		
Tc-99	$2,3\cdot10^{8}$		

A reference waste package of the type R.02 has a surface dose rate of 100 mSv/h and no surface contamination.

7.3 Uncertainties

- General uncertainties are described in chapter 1.3.

8 R.16

8.1 Waste type description

8.1.1 Waste package

General

The R.16 waste type consists of 1,73 m^3 steel moulds containing ion-exchange resins and inert filter-aid in a concrete matrix. The raw waste material consists of ion exchange resins and filter aids generated at the Ringhals nuclear power plant. The material is classified as intermediate level waste. Data comes from /Ahlqvist, 1998; Johansson, 2000; TRIUMF, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of steel with the dimensions 1,2 m ·1,2 m · 1,2 m. The wall is 5 mm thick, the bottom is 6 mm thick. The mould weighs approximately 425 kg and the surface area is approximately 20 m^2. The variations between moulds are minimal. No major change in design has been made since the start of production of this package.

The weight in total of a package including waste and is approximately 3200 kg but differs between 2700–3500 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste, used ion-exchange resin, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed for 60 minutes. The matrix is then allowed to harden for two days. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to interim storage. The lid is at least 10 cm thick.

8.1.2 Materials – chemical composition

The amounts of different materials in a R.16 mould are given in Table 8-1. The waste is well defined and consists of ion exchange resins and filter-aid with radionuclides.

The resins are:

- Bead resin from PWR: cleaning of the primary reactor circuit (system 334), the fuel ponds (system 324), the waste water (system 342), water from the secondary side of the steam generators (system 417/337) and from drainage water.

- Bead resin from BWR: systems for cleaning reactor water (system 331), treatment of liquid waste (system 342), analytical ion-exchangers (system 336) and cleaning of fuel ponds (system 324).

- Powder resins from BWR: cleaning of condensate (system 332), fuel ponds (system 324) and treatment of liquid waste (system 324).
  The resins from liquid waste treatment contain filter-aids.

Resins from the PWR-reactors contain boric acid (H_3BO_3) up to 90 g/kg of resin. Some resins contain lithium. Resins from system 417/337 can contain ammonia and hydrazine.

The weight of the raw waste material is normally 130 kg of ion exchange resin per package but varies, see Table 8-1.

The matrix is made of cement. The brand used is Skövde standardcement. Nowadays also Degerham standardcement can be used. Silix GP and Sika AER was used as additives until 1997 (and a few exceptions during 1998), from 1997 to 1998 Hydrafix was used and from 1997 a special additive is used (brand name is kept on commercial secrecy by demand from Ringhals NPP).

Table 8-1. Amounts of different material in waste type R.16 (per package).

Material	Weight	Weight-%
Ion-exchange resin	10-500 kg	0,4-26,3 %
Cement*	1400-2800 kg	99,6-73,7 %

* Including water 0,4 kg/kg cement.

8.1.3 Radionuclide inventory

Before the waste is transported from Ringhals NPP to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $9{,}0 \cdot 10^{11}$ Bq for Co-60 and between 0 and $2{,}0 \cdot 10^{11}$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 500 mSv/h on the surface. Normal dose rate at one meter is 9 mSv/h but varies between 0,1–35 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package. The waste packages are usually free of contamination.

8.1.4 Waste production

The waste type has been in production since 1991 and is still in production. The number of packages produced until 1998-12-31 is 664, annual production is estimated to 80 packages per year, see appendix A.

8.2 Reference waste type description

8.2.1 Waste package and material

The number of packages that will be produced is calculated to 3733 packages during the operation of Ringhals.

Table 8-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of R.16 is given in Table 8-3.

Table 8-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of R.16.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel box	Stainless steel	400	17	5
Stirrer	Stainless steel	25	3	2

Table 8-3. Estimated reference waste composition and surface area and thickness of components in one of R.16.

Material	Weight
Ion-exchange resin	250 kg
Cement*	2100 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of R.16 are summarised in Table 8-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 8-5. The waste volume is estimated from the weights of the waste components in Table 8-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 8-5.

Table 8-4. Reference composition and surface area of metallic components in 3733 concrete moulds in R.16.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		1 587 000	74 700	1 587 000	74 700
Ion-exchange resin	933 200			933 200	
Cement*	7 840 000			7 840 000	

* Including water 0,4 kg/kg cement.

Table 8-5. Volumes in 1 and 3733 reference waste packages of R.16.

	Volume (m^3) 1 package	Volume (m^3) 3733 packages
Waste	1,615	6029
Void	0,085	317

8.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 8-6.

Table 8-6. Radionuclide composition of a reference waste package of the type R.16.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$2,2\cdot10^{11}$	Pu-239	$1,2\cdot10^{7}$
Ag-108m	$1,3\cdot10^{7}$	Pu-240	$2,3\cdot10^{7}$
Ba-133	$2,2\cdot10^{6}$	Pb-210	$7,0\cdot10^{-4}$
Be-10	$1,3\cdot10^{2}$	Ra-226	$7,0\cdot10^{-3}$
C-14	$2,2\cdot10^{8}$	Ac-227	$1,4\cdot10^{-1}$
Fe-55	$2,2\cdot10^{11}$	Th-229	$1,0\cdot10^{-2}$
H-3	$2,2\cdot10^{7}$	Th-230	$3,1\cdot10^{0}$
Ho-166m	$8,8\cdot10^{5}$	Th-232	$3,5\cdot10^{-6}$
Mo-93	$1,1\cdot10^{6}$	Pa-231	$1,0\cdot10^{0}$
Nb-93m	$2,2\cdot10^{8}$	U-232	$1,0\cdot10^{3}$
Nb-94	$2,2\cdot10^{6}$	U-233	$7,0\cdot10^{-1}$
Ni-59	$2,2\cdot10^{8}$	U-234	$3,5\cdot10^{4}$
Ni-63	$4,4\cdot10^{10}$	U-235	$7,0\cdot10^{2}$
Sb-125	$2,2\cdot10^{10}$	U-236	$1,0\cdot10^{4}$
Zr-93	$2,2\cdot10^{5}$	U-238	$1,4\cdot10^{4}$
		Np-237	$1,4\cdot10^{4}$
Correlated to Cs-137		Pu-238	$1,4\cdot10^{8}$
Cs-137	$3,4\cdot10^{10}$	Pu-241	$3,5\cdot10^{9}$
Cd-113m	$2,0\cdot10^{7}$	Pu-242	$1,0\cdot10^{5}$
Cl-36	$3,4\cdot10^{5}$	Am-241	$3,5\cdot10^{7}$
Cs-134	$3,4\cdot10^{10}$	Am-242m	$3,5\cdot10^{5}$
Cs-135	$1,7\cdot10^{5}$	Am-243	$1,0\cdot10^{6}$
Eu-152	$2,4\cdot10^{6}$	Cm-243	$7,0\cdot10^{5}$
Eu-154	$3,4\cdot10^{9}$	Cm-244	$1,0\cdot10^{8}$
Eu-155	$2,4\cdot10^{9}$	Cm-245	$1,0\cdot10^{4}$
I-129	$1,0\cdot10^{4}$	Cm-246	$2,8\cdot10^{3}$
Pd-107	$3,4\cdot10^{4}$	Pu-244	$2,4\cdot10^{-2}$
Pm-147	$3,0\cdot10^{10}$		
Ru-106	$1,7\cdot10^{8}$		
Se-79	$1,3\cdot10^{5}$		
Sm-151	$1,0\cdot10^{8}$		
Sn-126	$1,7\cdot10^{4}$		
Sr-90	$3,4\cdot10^{9}$		
Tc-99	$1,7\cdot10^{8}$		

A reference waste package of the type R.16 has a surface dose rate of 100 mSv/h and no surface contamination.

8.3 Uncertainties

- Production of R.16 is estimated to optimise available volume in Silo, probably the total production of R.16 will be lower than foreseen above.

9 S.04

9.1 Waste type description

9.1.1 Waste package

General

The S.04 waste type consists of a standard 200-litre drum containing ion exchange resins in a cement matrix. The raw waste material consists of ion exchange resins generated at the Studsvik research centre. The material is classified as intermediate level waste. All data comes from /Öberg, 1997; Johansson, 2000; Studsvik, 2000/.

The physical properties and chemical conditions are well known. The following restrictions are always applicable:

- The general restrictions listed in chapter 1.1.

Packaging

The steel drum is made of stainless steel with diameter 0,57 m and 0,84 m in height. The wall thickness is 1,5 mm. The drum weighs approximately 60 kg and surface area is approximately 5,1 m^2. To facilitate the handling in SFR the drums are placed four by four on a steel plate with the dimension 1,2 m ·1,2 m and the thickness of 4 mm. The weight of the steel plate is 66 kg with surface area of 4,0 m^2. The variations between packages are minimal. No major changes in design have been made since the start of production of this package.

The weight in total of a package including waste and is approximately 350 kg. The maximum allowed weight of a waste package is 500 kg.

Treatment and conditioning

The ion exchange resin containing metal hydroxides and other substances is mixed with concrete in a custom-made facility at the Studsvik site. Cement is added in the drum and then the waste, used ion-exchange resin, and water is pumped into the drum.

When the waste is added the stirrer is started and the waste matrix is mixed. The matrix is then allowed to harden for one day. After measurements a steel lid is placed on top of the drum. The drums are placed on the steel plate when the drums are sent to SFR.

The void varies but is estimated to 0,01 m^3 in a drum.

9.1.2 Materials – chemical composition

The amounts of different materials in a S.04 drum are given in Table 9-1. The waste contains ion-exchange resins (bead-type) with metal hydroxides from the fuel ponds and primary circuits in the Studsvik R2-reactor. The weight of the raw waste material is normally 65 kg ion-exchange resin per package but varies, see Table 9-1.

The matrix is made of concrete. No cement additives are used.

Table 9-1. Amounts of different material in waste type S.04 (per package).

Material	Weight	Weight-%
Ion-exchange resin	20 kg	25 %
Concrete	60 kg	75 %

9.1.3 Radionuclide inventory

Before the waste is solidified a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $4{,}6 \cdot 10^8$ Bq for Co-60 and between 0 and $1{,}2 \cdot 10^9$ Bq for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 50 mSv/h. No estimation on variation of doserates are available in referred documents. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

9.1.4 Waste production

The number of packages produced until 1998-12-31 is 34, the annual production is estimated to 4, see appendix A.

9.2 Reference waste type description

9.2.1 Waste package and material

The number of packages that will be produced is calculated to 134 during the operation of Studsvik.

Table 9-2 shows the content of different materials and the surface areas of the packaging in S.04 package from Studsvik. Since the steel plate and expansion box is shared between four drums ¼ of the plate and box is included in a package of S.04.

The assumed composition of the waste in a reference waste package of S.04 is given in Table 9-3.

Table 9-2. Estimated reference packaging composition and surface area and thickness of components in each steel drum and one ¼ of a steel plate and expansion box of S.04.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel drum	steel	60	5,1	1,5
Steel plate	steel	16,6	1,0	4

Table 9-3. Estimated reference waste composition in one steel drum of S.04.

Material	Weight
Ion-exchange resin	65 kg
Cement*	238 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of S.04 are summarised in Table 9-4.

Void and waste volume is specified in Table 9-5.

Average void is estimated to 0,01 m^3 in a steel drum.

Table 9-4. Reference composition and surface area of metallic components in 134 steel drums including ¼ steel plate and expansion box per drum of S.04.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		10 300	820	10 300	820
Ion-exchange resin	8 700			8 700	
Cement*	31 900			31 900	

* Including water 0,4 kg/kg cement.

Table 9-5. Volumes in 1 and 134 reference waste packages of steel drums including ¼ steel plate and expansion box per drum of S.04.

	Volume (m^3) 1 package	Volume (m^3) 134 packages
Waste	0,2	27
Void	0,01	1,3

9.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 9-6.

Table 9-6. Radionuclide composition of a reference waste package of the type S.04.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Pu	
Co-60	$5,6\cdot10^{7}$	Pu-239	$7,4\cdot10^{6}$
Ag-108m	$3,4\cdot10^{3}$	Pu-240	$1,5\cdot10^{7}$
Ba-133	$5,6\cdot10^{2}$	Pb-210	$4,4\cdot10^{-4}$
Be-10	$3,4\cdot10^{-2}$	Ra-226	$4,4\cdot10^{-3}$
C-14	$5,6\cdot10^{4}$	Ac-227	$8,9\cdot10^{-2}$
Fe-55	$5,6\cdot10^{7}$	Th-229	$6,6\cdot10^{-3}$
H-3	$5,6\cdot10^{3}$	Th-230	$2,0\cdot10^{0}$
Ho-166m	$2,3\cdot10^{2}$	Th-232	$2,2\cdot10^{-6}$
Mo-93	$2,8\cdot10^{2}$	Pa-231	$6,6\cdot10^{-1}$
Nb-93m	$5,6\cdot10^{4}$	U-232	$6,6\cdot10^{2}$
Nb-94	$5,6\cdot10^{2}$	U-233	$4,4\cdot10^{-1}$
Ni-59	$5,6\cdot10^{4}$	U-234	$2,2\cdot10^{4}$
Ni-63	$1,1\cdot10^{7}$	U-235	$4,4\cdot10^{2}$
Sb-125	$5,6\cdot10^{6}$	U-236	$6,6\cdot10^{3}$
Zr-93	$5,6\cdot10^{1}$	U-238	$8,9\cdot10^{3}$
		Np-237	$8,9\cdot10^{3}$
Correlated to Cs-137		Pu-238	$8,9\cdot10^{7}$
Cs-137	$2,1\cdot10^{7}$	Pu-241	$2,2\cdot10^{9}$
Cd-113m	$1,3\cdot10^{4}$	Pu-242	$6,6\cdot10^{4}$
Cl-36	$2,1\cdot10^{2}$	Am-241	$2,2\cdot10^{7}$
Cs-134	$2,1\cdot10^{7}$	Am-242m	$2,2\cdot10^{5}$
Cs-135	$1,1\cdot10^{2}$	Am-243	$6,6\cdot10^{5}$
Eu-152	$1,5\cdot10^{3}$	Cm-243	$4,4\cdot10^{5}$
Eu-154	$2,1\cdot10^{6}$	Cm-244	$6,6\cdot10^{7}$
Eu-155	$1,5\cdot10^{6}$	Cm-245	$6,6\cdot10^{3}$
I-129	$6,4\cdot10^{0}$	Cm-246	$1,8\cdot10^{3}$
Pd-107	$2,1\cdot10^{1}$	Pu-244	$1,5\cdot10^{-2}$
Pm-147	$1,9\cdot10^{7}$		
Ru-106	$1,1\cdot10^{5}$		
Se-79	$8,6\cdot10^{1}$		
Sm-151	$6,4\cdot10^{4}$		
Sn-126	$1,1\cdot10^{1}$		
Sr-90	$2,1\cdot10^{6}$		
Tc-99	$1,1\cdot10^{5}$		

A reference waste package of the type S.04 has a surface dose rate of 50 mSv/h and no surface contamination.

9.3 Uncertainties

- General uncertainties are described in chapter 1.3.

10 S.11

10.1 Waste type description

10.1.1 Waste package

General

The S.11 waste type consists of 1,73 m^3 steel moulds containing ion-exchange resins and sludges in a cement matrix. The raw waste material consists of ion-exchange resins and sludges generated at the Studsvik site or at the closed down Ågesta Reactor. The material is classified as intermediate level waste. All data comes from /Rolandsson, 1998; Johansson, 2000/.

Following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of steel with the dimensions 1,2 m ·1,2 m · 1,2 m. The wall is 5 mm thick, the bottom is 6 mm thick. The mould weighs approximately 425 kg including stirrer and the surface area is approximately 20 m^2. The variations between moulds are minimal.

The weight in total of a package including waste and is approximately 4000 kg. The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

The waste, is pumped into the mould and cement is added. If needed, water is added. When the cement is added the stirrer is started and the waste matrix is mixed. The matrix is then allowed to harden. Pouring concrete on top of the matrix then makes a lid. The concrete is allowed 24 hours to harden before the waste is transported to interim storage. The lid is at least 10 cm thick.

10.1.2 Materials – chemical composition

The amounts of different materials in a S.11 mould are given in Table 10-1. The waste has been thoroughly analysed and is fairly well defined. It consists of ion exchange resins and sludges containing radionuclides. No harmful amounts of complexing agents are present in the waste matrix that could improve mobility of the radionuclides.

The weight of the raw waste material is normally 667 kg of ion exchange resin and 333 kg sludge per package but varies, some parameters have an estimated variation see Table 10-1.

The matrix is made of cement. No additives are used in this waste.

Table 10-1. Amounts of different material in waste type S.11 (per package).

Material	Weight	Weight-%
Ion-exchange resin	667 kg	21-26,2 %
Sludge	333 kg	10,7-13,1 %
Cellulose	3 kg	0-0,1 %
Cement*	1540-2100 kg	60,6-67,7 %

* Including water 0,4 kg/kg cement.

10.1.3 Radionuclide inventory

Before the waste is transported from Studsvik to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137, no data is available since no production of waste packages has been done yet. Other nuclides than gamma emitting ones must be calculated according to appendix B.

The dose rate limit for this package is 5 mSv/h on the surface. No variation on doserate is available since no production of waste packages has been done yet. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package. Usually the packages are free of contamination.

10.1.4 Waste production

The waste type has not yet been put in production. The amount of waste is limited to about 50 m^3 stored in a Silo in at the Studsvik site. The number of packages foreseen is 60, production up to 96 packages could be possible.

10.2 Reference waste type description

10.2.1 Waste package and material

The number of packages that will be produced is calculated to 96 packages during the operation of Studsvik.

Table 10-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of S.11 is given in Table 10-3.

Table 10-2. Estimated reference packaging composition and surface area and thickness of components in concrete mould of S.11.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Steel box	Stainless steel	400	17	5
Stirrer	Stainless steel	25	3	2

Table 10-3. Estimated reference waste composition and surface area and thickness of components in one of S.11.

Material	Weight
Ion-exchange resin	667 kg
Sludge	333 kg
Cellulose	3 kg
Cement*	1820 kg

* Including water 0,4 kg/kg cement.

The total amounts of different materials in all the packages of S.11 are summarised in Table 10-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 10-5. The waste volume is estimated from the weights of the waste components in Table 10-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 10-5.

Table 10-4. Reference composition and surface area of metallic components in 96 concrete moulds in S.11.

Content	Waste	Packaging		Waste packages	
	weight (kg)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel		40 800	1 920	40 800	1 920
Ion-exchange resin	64 000			64 000	
Sludge	32 000			32 000	
Cellulose	290			290	
Cement*	175 000			175 000	

* Including water 0,4 kg/kg cement.

Table 10-5. Volumes in 1 and 96 reference waste packages of S.11.

	Volume (m^3) 1 package	Volume (m^3) 96 packages
Waste	1,615	155
Void	0,085	8

10.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 10-6. The transuranic elements have been calculated in a different way and it is not possible to calculate inventory for a reference waste type for them. An inventory for transuranic elements for all moulds at the year 2030 is presented in appendix B.

Table 10-6. Radionuclide composition of a reference waste package of the type S.11.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Cs-137	
Co-60	$1,4\cdot10^{10}$	Cs-137	$1,4\cdot10^{11}$
Ag-108m	$8,4\cdot10^{5}$	Cd-113m	$8,5\cdot10^{7}$
Ba-133	$1,4\cdot10^{5}$	Cl-36	$1,4\cdot10^{6}$
Be-10	$8,4\cdot10^{0}$	Cs-134	$1,4\cdot10^{11}$
C-14	$1,4\cdot10^{7}$	Cs-135	$7,1\cdot10^{5}$
Fe-55	$1,4\cdot10^{10}$	Eu-152	$9,9\cdot10^{6}$
H-3	$1,4\cdot10^{6}$	Eu-154	$1,4\cdot10^{10}$
Ho-166m	$5,6\cdot10^{4}$	Eu-155	$9,9\cdot10^{9}$
Mo-93	$7,0\cdot10^{4}$	I-129	$4,3\cdot10^{4}$
Nb-93m	$1,4\cdot10^{7}$	Pd-107	$1,4\cdot10^{5}$
Nb-94	$1,4\cdot10^{5}$	Pm-147	$1,3\cdot10^{11}$
Ni-59	$1,4\cdot10^{7}$	Ru-106	$7,1\cdot10^{8}$
Ni-63	$2,8\cdot10^{9}$	Se-79	$5,7\cdot10^{5}$
Sb-125	$1,4\cdot10^{9}$	Sm-151	$4,3\cdot10^{8}$
Zr-93	$1,4\cdot10^{4}$	Sn-126	$7,1\cdot10^{4}$
		Sr-90	$1,4\cdot10^{10}$
		Tc-99	$7,1\cdot10^{8}$

A reference waste package of the type S.11 has a surface dose rate of 5 mSv/h and no surface contamination.

10.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- This waste type is not produced yet, which means that the uncertainties are larger than other waste types.

11 S.22

11.1 Waste type description

11.1.1 Waste package

General

The S.22 waste type consists of a 100-litre steel drum inside a 200-litre steel drum with concrete in-between. The waste is placed in the 100-litre drum and consists of scrap metal and refuse. The raw waste material consists of mainly iron/steel, cellulose and other organic material generated at Studsvik nuclear research site. The material is classified as intermediate level waste. Data comes from /Chyssler, 2000; Johansson, 2000; Studsvik, 2000/.

The physical properties and chemical conditions can vary a lot, but the following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.
- The content of transuranic nuclides must be well known.

At present it is not fully decided if this waste type will be suitable, with respect to the general restrictions, in the Silo. The waste type is included in the inventory although.

Packaging

The 100 litre inner drum has more exactly the volume of 113 l. The height is 0,70 m and the diameter 0,46 m. The walls has a thickness of 1 mm and the whole drum weighs 10 kg.

The outer 200 litre drum has a volume of 218 l, the height of 0,84 m ± 20 %, and the diameter 0,57 m. The wall of the drum is 1 mm and the drum weighs 20 kg.

In order to handle the drums in SFR four drums are placed in a steel box with the dimension 1,2 m · 1,2 m · 1,2 m. The box weighs 330 kg and the walls of it are between 2–5 mm. Holes are made in the walls to ensure that concrete can enter the box when the waste is placed in the Silo in SFR-1.

The weight of a drum including waste is approximately 300 kg but differs between 250–500 (estimated from references) kg. The weight of a package including waste and steel box is approximately 450 kg. The maximum allowed weight of a box is 2500 kg.

Treatment and conditioning

The raw waste is, after eventual fragmentation, packed in the inner drum. The inner drum is then placed inside the outer drum. The space between the two drums is pre-conditioned with concrete. Concrete is poured upon the drum to make a lid.

11.1.2 Materials – chemical composition

The amounts of different materials in a S.22 drum are given in Table 11-1. The waste is varies a lot and consists mainly of scrap metal and garbage e.g. iron scrap, aluminium, wood, cloth, paper, plastics, cable etc. The amount of burnable (N.B. due to materials and radionuclide content) waste is smaller than waste from a ordinary nuclear power reactor since the preferred option in Studsvik is to burn the waste. The weight of the raw waste material is normally 91 kg waste per package but varies, see Table 11-1.

Table 11-1. Amounts of different material in waste type S.22 (per package).

Material	Weight (kg)*	Area (m^2)	Weight-%
Iron/steel	74	3,8	39,6
Aluminium	5	0,7	2,7
Cellulose	7,9		4,2
Other organics	4		2,1
Concrete**	96		5,1

* Variation of amounts of material is not available in referred documents.
** Including 0,13 kg water/kg concrete.

11.1.3 Radionuclide inventory

Before the waste is transported from Studsvik to SFR-1 a measurement of gamma emitting nuclides is performed. Dominating nuclides are Co-60 and Cs-137. The amounts of these nuclides are between 0 and $1{,}1\cdot10^9$ Bq for Co-60 and between 0 and $7{,}1\cdot10^9$ for Cs-137. Other nuclides than gamma emitting ones must be calculated according to appendix B.

Dose rate limit for this package is 2 mSv/h. Normal doserate at 1 meter is between 0,01–1,0 mSv/h. The surface contamination should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides. The waste packages are usually free of contamination.

11.1.4 Waste production

The waste type has been in production since before 1980 and is still in production. The numbers of packages produced until 1998-12-31 is 270, annual production is not estimated, see appendix A.

11.2 Reference waste type description

11.2.1 Waste package and material

The number of packages that will be produced is estimated to 430 packages during the operation of Studsvik.

Table 11-2 shows the content of different materials and the steel surface areas of the packaging in package of S.22 from Studsvik which includes a conditioned steel drum both outer and inner drum and ¼ of a steel box.

The assumed composition of the waste in a reference waste package of S.22 is given in Table 11-3. The surface area on metal components in the waste are estimated assuming planar plates with a thickness of 5 mm, and assuming a density of 7860 kg/m^3 for carbon and stainless steel and 2700 kg/m^3 for aluminium.

Table 11-2. Estimated reference packaging composition, surface area and thickness of components in drum of S.22.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Inner drum	Carbon steel	10	2,7	1
Outer drum	Carbon steel	20	4,4	1
Steel box	Carbon steel	82,5	4,25	2,5

Table 11-3. Estimated reference waste composition and surface area and thickness of components in one of S.22.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	74	3,8	5
Aluminium	5	0,7	5
Cellulose	7,9		
Other organics	4		
Concrete*	96		

* Including 0,13 kg water/kg concrete.

The total amounts of different materials in all the packages of S.22 are summarised in Table 11-4.

The estimated volumes of the waste, the packaging materials and the void volume inside the package for a reference package are given in Table 11-5. The waste volume is estimated from the weights of the waste components in Table 11-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 11-5.

Table 11-4. Reference composition and surface area of metallic components in 430 drums in S.22.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	31 820	1 630	48 400	4 880	80 200	6 510
Aluminium	2 150	300			2 150	300
Cellulose	3 400				3 400	
Other organics	1 700				1 700	
Concrete*	41 300				41 300	

* Including 0,13 kg water/kg concrete.

Table 11-5. Volumes in 1 and 430 reference waste packages of S.22.

	Volume (m^3) 1 package	Volume (m^3) 430 packages
Waste	0,1	43
Void	0,005	2,1
Waste package	0,36	155

11.2.2 Radionuclide inventory

The radionuclide composition of a reference waste package is calculated from the amount of Co-60 and Cs-137 in the waste according to appendix B. The reference inventory in one package at the time of production is presented in Table 11-6. The transuranic elements have been calculated in a different way and it is not possible to calculate inventory for a reference waste type for them. An inventory for transuranic elements for all moulds at the year 2030 is presented in appendix B.

Table 11-6. Radionuclide composition of a reference waste package of the type S.22.

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Correlated to Co-60		Correlated to Cs-137	
Co-60	$7{,}2 \cdot 10^{7}$	Cs-137	$2{,}4 \cdot 10^{8}$
Ag-108m	$4{,}3 \cdot 10^{3}$	Cd-113m	$1{,}4 \cdot 10^{5}$
Ba-133	$7{,}2 \cdot 10^{2}$	Cl-36	$2{,}4 \cdot 10^{3}$
Be-10	$4{,}3 \cdot 10^{-2}$	Cs-134	$2{,}4 \cdot 10^{8}$
C-14	$7{,}2 \cdot 10^{4}$	Cs-135	$1{,}2 \cdot 10^{3}$
Fe-55	$7{,}2 \cdot 10^{7}$	Eu-152	$1{,}7 \cdot 10^{4}$
H-3	$7{,}2 \cdot 10^{3}$	Eu-154	$2{,}4 \cdot 10^{7}$
Ho-166m	$2{,}9 \cdot 10^{2}$	Eu-155	$1{,}7 \cdot 10^{7}$
Mo-93	$3{,}6 \cdot 10^{2}$	I-129	$7{,}2 \cdot 10^{1}$
Nb-93m	$7{,}2 \cdot 10^{4}$	Pd-107	$2{,}4 \cdot 10^{2}$
Nb-94	$7{,}2 \cdot 10^{2}$	Pm-147	$2{,}2 \cdot 10^{8}$
Ni-59	$7{,}2 \cdot 10^{4}$	Ru-106	$1{,}2 \cdot 10^{6}$
Ni-63	$1{,}4 \cdot 10^{7}$	Se-79	$9{,}7 \cdot 10^{2}$
Sb-125	$7{,}2 \cdot 10^{6}$	Sm-151	$7{,}2 \cdot 10^{5}$
Zr-93	$7{,}2 \cdot 10^{1}$	Sn-126	$1{,}2 \cdot 10^{2}$
		Sr-90	$2{,}4 \cdot 10^{7}$
		Tc-99	$1{,}2 \cdot 10^{6}$

A reference waste package of the type S.22 has a surface dose rate of 2 mSv/h and no surface contamination.

11.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- Waste volume in individual packages depends on fragmentation and the possibility to compact in the inner of the two steel drums.
- Future production is uncertain, eventually will all packages of this type be disposed off in the future repository SFL 3.

12 S.24

12.1 Waste type description

12.1.1 Waste package

General

The S.24 waste type consists of 1,73 m^3 concrete moulds with scrap metal in a concrete matrix. Waste material consists of iron/steel, aluminium and other inorganic material generated at Studsvik nuclear research centre. This package is supposed to contain smoke detectors with the dominating radionuclide Am-241. The material is classified as intermediate level waste. All data comes from /Chyssler, 1997; Johansson, 2000/. The packages are not produced yet.

The physical properties and chemical conditions can vary a lot, but the following restrictions are always applicable on this waste:

- The general restrictions listed in chapter 1.1.

Packaging

The mould is a cubic box made of reinforced concrete with the dimensions 1,2 m ·1,2 m ·1,2 m. The walls are 10 cm thick. The reinforcement is made of 12 mm steel bars with a total surface of 10 m^2. The 10-cm mould weighs approximately 1600 kg. The variations between moulds are minimal.

The maximum allowed weight of a waste package is 5000 kg.

Treatment and conditioning

Waste, mostly smoke detectors are placed in the mould, which is then filled with concrete. Pouring concrete on top of the package makes a lid.

12.1.2 Materials – chemical composition

The amounts of different materials in a S.24 mould are given in Table 12-1. The waste is fairly well defined and consists mainly of smoke detectors. Some other scrap metal and other inorganic waste could be present. No variation of material is estimated.

The matrix is made of concrete.

Table 12-1. Amounts of different material in waste type S.24 (per package).

Material	Weight (kg)	Area (m^2)	Weight-%
Iron/steel	113	5,8	13,8
Aluminium	3,8	0,6	0,5
Other inorganic material	139		16,9
Concrete*	565		68,8

* Including 0,13 kg water/kg concrete.

12.1.3 Radionuclide inventory

The dominating nuclide is Am-241, the amount in total is estimated to $5{,}0 \cdot 10^{11}$ Bq. Other nuclides may be present but amounts will probably be very small.

The surface dose rate limit for this package is 500 mSv/h but the actual dose rate will probably be a lot less. The contamination on surface should not exceed 40 kBq/m^2 for gamma and beta and 4 kBq/m^2 for alpha emitting nuclides on the package. Based on experience of other waste type no contamination is expected.

12.1.4 Waste production

The waste type has not yet been in production. The number of packages will be 1 or 2, see appendix A.

12.2 Reference waste type description

12.2.1 Waste package and material

The number of packages that will be produced is calculated to 2 packages during the operation of Studsvik.

Table 12-2 shows the content of different materials and the steel surface areas of the packaging in a reference package.

The assumed composition of the waste in a reference waste package of S.24 is given in Table 12-3.

Table 12-2. Estimated reference packaging composition, surface area and thickness of components in concrete mould of S.24.

Component	Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Concrete box	Concrete	1340		10
Reinforcement	Steel	261	10	12
Lid	Steel	13	1,8	2

Table 12-3. Estimated reference waste composition and surface area and thickness of components in one of S.24.

Material	Weight (kg)	Surface area (m^2)	Thickness (mm)
Iron/steel	113	5,8	
Aluminium	3,8	0,6	5
Other inorganic material	139		5
Concrete*	565		

* Including 0,13 kg water/kg concrete.

The total amounts of different materials in all the packages of S.24 are summarised in Table 12-4.

The estimated volumes of the waste and the packaging materials and the void volume inside the package for a typical package of concrete box are given in Table 12-5. The waste volume is estimated from the weights of the waste components in Table 12-3 and approximate densities of the different material. Average void is estimated to 5 % in a package.

Void and waste volume is specified in Table 12-5.

Table 12-4. Reference composition and surface area of metallic components in 2 concrete moulds in S.24.

Content	Waste		Packaging		Waste packages	
	weight (kg)	area (m^2)	weight (kg)	area (m^2)	weight (kg)	area (m^2)
Iron/steel	220	10	550	20	770	30
Inorganic material	280				280	
Aluminium	8	1			8	1
Concrete*	1 130		2 700		3800	

* Including 0,13 kg water/kg concrete.

Table 12-5. Volumes in 1 and 2 reference waste packages of S.24.

	Volume (m^3) 1 package	Volume (m^3) 2 packages
Waste	0,95	1,9
Void	0,05	0,1

12.2.2 Radionuclide inventory

The reference inventory in one package at the time of production has not been calculated since it is assumed that the activity in the waste comes solely from the smoke detectors, i.e. only Am-241, the amount in total is $5{,}0 \cdot 10^{11}$ Bq. An inventory for all moulds at the year 2030 is presented in appendix B.

A reference waste package of the type S.24 has a surface dose rate of 500 mSv/h and no surface contamination.

12.3 Uncertainties

- General uncertainties are described in chapter 1.3.
- This type has not been produced yet, there are large uncertainties regarding all data.

13 Other waste types

Since SFR-1 still is in operation there is always the possibility that new waste types are needed. It is not possible to define these types per se. Since the Silo is not well suited for odd geometries, no other waste types have been assumed.

13.1 Uncertainties

Up to this date no kind of odd wastes have been disposed off in the Silo, in the future odd waste types could be disposed off.

14 References

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