PRACTICE TO MINIMIZE NUCLEAR WASTE AMOUNTS IN LOVIISA NPS

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ABSTRACT

In the two units of the Loviisa Nuclear Power Station in Finland, 16 reactor years have accumulated. So far, there have been no problems with the radioactive waste management. According to the agreement with the Soviet vendor, spent fuel from the Loviisa NPS is sent back to the Soviet Union. Not more than some 500 m^3 of wet wastes have accumulated, and their radioactivity content is just a fraction of the annual release limit for the plant. No solidification or other conditioning plant for any type of wastes has been built. Neither is there any need for a separate interim store for solid wastes. The amount of dry solid wastes collected is very small, though neither supercompacting nor incineration has been used. Several study projects are going on aimed at a further reduction of the waste volumes. Some of these projects have already given promising results. There will, however, be some amounts of wastes to be disposed of in Loviisa. Final disposal of these wastes into the bedrock of the power plant site has been designed. The Preliminary Safety Analysis Report was submitted to the authorities on 15 December 1986.

This paper describes the accumulation rates for different waste types, the methods to keep the waste accumulation rates at a minimum and the plans for future treatment.

INTRODUCTION

The Loviisa NPS is the first nuclear power station in Finland. It is owned and operated by the state owned power company Imatran Voima Oy. The plant consists of 2 x 465 MWe PWR, the Loviisa 1 and the Loviisa 2. Some 70% of the plant has been planned and constructed by domestic industry. The reactor with auxiliary systems, the steam generators, the turbines and generators were delivered by Atomenergoexport in the Soviet Union. Additionally, half a dozen western countries contributed with equipment and installations. The annual load factor has often exceeded 90%, and the average for both units during the last five years is 86%.

Loviisa 1 was connected to the grid on 8 February 1977, and Loviisa 2 on 4 November 1980. Their commercial operation started on 9 May 1977 and on 5 January 1981, respectively. Totally 16 reactor years thus have accumulated in the Loviisa NPS.

The release of radioactivity into the environment has been some permilles or percents of the annual release limits and the average collective dose to personnel less than 1 manSv per year per reactor. In spite of this, the amounts of accumulated radioactive wastes are very small. So far, no final or separate interim storage facility for low and intermediate level wastes has been built. There is not even a solidification plant in Loviisa. All low and intermediate level wastes are stored at the power plant site. Studies are going on to minimize the amounts of wastes to be solidified.

NO HIGH LEVEL WASTE CONDITIONING

Imatran Voima Oy has bought the plant inclusive of nuclear fuel services. According to the agreement, nuclear fuel is delivered back to the Soviet vendor Atomenergoexport, who takes care of the management of the back end of the fuel cycle.

After three years in the reactor core the fuel is removed into storage pools. After a cooling period of five years the fuel is sent back to the vendor.

HANDLING OF ION EXCHANGE RESINS

The reactor coolant is purified with ion-exchangers. The purification flow is 11-16 kg/s. The entire primary circuit volume thus is purified in 4-5 hours. The accumulated amount of spent ion exchange resins is less than 90 m^3, which corresponds to the accumulation rate of 6 m^3 per reactor year (Table I). Regeneration of spent resins is no longer used, because it would increase the radioactivity in the evaporator concentrates.

TABLE I

Total Amount (m^3) of Spent Ion Exchange Resins Accumulated in the Loviisa NPS

Year	Lo1 m^3	Lo2 m^3	Total annual amount m^3	Total amount accumulated m^3
1977	-		-	-
1978	3.6		3.6	3.6
1979	2.7		2.7	6.3
1980	2.9		2.9	9.2
1981	3.0	3.0	6.0	15.2
1982	8.1	5.0	13.1	28.3
1983	6.0	9.0	15.0	43.3
1984	9.8	6.4	16.2	59.5
1985	8.0	6.0	14.0	73.5
1986	3.0	11.2	14.2	87.7

All wet wastes at the Loviisa NPS are stored in a tank storage facility consisting of eight tanks, 300 m^3 each. Four tanks are reserved for evaporator concentrates, three tanks for spent resins and one tank is kept in reserve. Spent ion exchange resins are stored in one tank thus occupying less than 10% of the capacity of the resin tanks today.

The accumulated radioactivity in the resins is 4.2 TBq. Most of these radionuclides have a half life less than 5 years (Table II).

TABLE II

The Amount of Radioactivity in Spent Ion Exchange Resins Accumulated by 1 January 1987

Nuclide	Radioactivity GBq
Mn-54	700
Co-60	400
Ag-110m	1200
Sb-124	200
Cs-134	500
Cs-137	1200
Totally	4200

Only minute amounts of corrosion products are accumulated, and the main reason for that is that all primary circuit surfaces in contact with the coolant are made of high quality titan stabilized austenitic stainless steel, which has a very low corrosion rate. No stellite has been used, and the cobalt content of the stainless steel by analysis was found to be 0.002 to 0.004%. The fuel cladding is zirconium/niobium alloy (99/1).

Fission products, to some degree, are produced on the surface of the fuel elements through fission of uranium contamination, but most of the fission products in the coolant are caused by fuel leakages. As the fuel rods are very clean and tight, very small amounts of fission products appear in the wet wastes at the Loviisa NPS. Not more than six minor leakages have occurred during 16 reactor years. This is partly due to good operation practices. There are very few transients in the reactor annually and un-planned reactor trips have been very rare after the start-up period (Table III).

HANDLING OF EVAPORATOR CONCENTRATES

Evaporation is used for purification of controlled leakages, drainage from processes and water from the decontamination, the laundry, the washing and the floor drainage. Some 20 000 m^3 is evaporated each year. Evaporated water returns back to the process, or it is released into the sea. Evaporator concentrates are transported by pipelines to the tank storage facility of wet wastes.

TABLE III

Total Number of Fuel Rods with Leakages and Number of Un-planned Reactor Trips in the Loviisa NPS

Year	Number of fuel rods with leakages		Number of un-planned reactor trips	
	Loviisa 1	Loviisa 2	Loviisa 1	Loviisa 2
1977	-		9	
1978	-		2	
1979	-		-	
1980	-	-	2	5
1981	1	-	-	1
1982	-	-	-	1
1983	2	3	-	1
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-

On 1 January 1987, the total amount of evaporator concentrates was not more than 423 m^3, which is about 35% of the storage capacity (Table IV). This volume was not much larger than that of 1983, and its radioactivity content was less than that of 1981.

TABLE IV

Total Amounts (m^3) of Evaporator Concentrates Accumulated and Released in the Loviisa NPS

Year	Evaporator concentrates accumulated	Amounts released	Radioactivity released		In the storage on 31 Dec.	
	m^3	m^3	corr. GBq	H-3 TBq	m^3	GBq
1977	311	-	-		311	-
1978	204	300	17.8	4.9	215	4
1979	116	295	15.1	3.4	36	31
1980	184	155	17.9	3.7	75	85
1981	175	69	2.7	10.4	181	636
1982	223	55	13.4	9.6	349	429
1983	120	81	22.2	7.4	388	350
1984	170	82	20.5	8.9	476	359
1985	114	116	17.8	9.3	474	290
1986	51	102	16.9	13.3	423	269

Evaporator concentrates are normally collected into one tank at a time. When an amount of 150 to 200 m^3 has accumulated into one tank, it is isolated from the process. After that, all movement in the tank stops, and the solid radioactive substances settle to the bottom of the tank. At the end of the year a remarkable volume can be released from one of the tanks being isolated. At that time its activity content is not more than 10-20 GBq of the corrosion and fission products, and less than 10 TBq of tritium (some 2% and 6%, respectively, of the release limits).

In the use of evaporators, special emphasis has been laid on the waste amounts produced. In previous years, the salt content of the concentrates was about 250 g/l. The structure of evaporators did not allow higher salt contents, although that was desired. A higher salt content would not cause problems in the storage tanks or in the solidification process. During the last two years, technical innovations have given promising results. The evaporators have now been modified a little. At present they produce wastes, the salt content of which is about 400 g/l. The effect of modifications of the evaporators can be seen in Table IV.

It must be emphasized that the total amount of radioactivity, 269 GBq, is less than one-third of the annual release limit (890 GBq/a). The entire inventory of evaporator concentrates could be released, if so desired, but there is no need to do so. Neither is there any need for a solidification plant for the time being.

If the radioactivity inventory grows large in relation to the release limits, it will still be possible to release the concentrates after a certain aging period, if the content of long-lived nuclides, i.e. Cs-137, is insignificant. For this reason a new unique method to extract cesium from the evaporator concentrates has been developed for the Loviisa NPS. Several laboratory tests were carried out during a few years. Pilot plant tests of the method began in 1985. This method allows the separation of cesium by inorganic ion exchangers.

The pilot plant tests of the cesium separation method have given promising results. One liter of ion-exchange mass can separate cesium from several thousand liters of original concentrates. The decontamination factor for cesium has proved to be several thousands. According to this practice, the evaporator concentrates of the Loviisa NPS may never need a solidification plant. All these wastes could be treated together with the decommissioning wastes.

CONDITIONING OF LOW LEVEL SOLID WASTES

All dry wastes are compressed into standard 200 l steel drums after a brief separation into four categories, i.e.:

I combustible/compressible
II non-combustible/compressible
III non-combustible/non-compressible
IV combustible/non-compressible

This separation is done at the spot where the wastes are produced. After the compacting, the nuclide content of each drum is measured. According to the classifications in Loviisa, the drums contain insignificant amounts of radioactivity, if the limits in Table V are not exceeded. The aim is to find a cheap way of disposing of these wastes, for example, a particular dump.

TABLE V

Activity Limits for Drums Which Can Be Handled Without Radiation Protection Restrictions

Nuclide	Radioactivity/drum
Cr-51	10 MBq
Co-60	1 MBq
Cs-137	0.1 MBq
others	3 MBq

All dry wastes are stored at the power plant site. Drums containing an insignificant amount of radioactivity are stored in a non-heated, non-ventilated and non-drained cheap hall at the power plant site. The amount of these wastes is about 327 m^3 (Table VI).

The drums exceeding the limits of Table V are stored inside the power plant. Radioactive combustible and radioactive non-combustible wastes are stored in their respective rooms. The amounts of dry wastes collected by 1 January 1987 are shown in Table VI. The volumes given are without supercompaction or incineration. The total radioactivity content of dry wastes is 22 GBq.

TABLE VI

Accumulated Amounts of Low Level Dry Waste

Radioactivity exceeds the limits of Table V class	volume	Radioactivity below the limits of Table V class	volume
I	115.6 m^3	I	143.4 m^3
II	34.0 m^3	II	106.4 m^3
III	29.4 m^3	III	52.0 m^3
IV	1.8 m^3	IV	24.6 m^3
Totally	180.8 m^3		326.4 m^3

The small volume of low level solid wastes is a result of stringent rules in the use of package materials, disposable insulating materials, scaffoldings, etc. Normally it is prohibited to take any packages (paper, boxes, plastic foils, truck lavetts, etc.) into the controlled area. This practice was adopted in 1983. There are only a few exceptions from this rule. Packages should be opened and stripped off outside the controlled area. Disposable insulating wool has been replaced by reusable material. A slight contaminaton level in the scaffolding material is accepted. The use of plastic foils as contamination protection is strongly restricted. Paper or cleaning up is preferred. Certain materials, for example, spent oil, scrap metal and fluorescent lamps,may be released according to the rules agreed on with the authorities.

STORAGE OF ACTIVATED METAL WASTES

Activated metal components, e.g., interior parts of the reactor structures and control rod mechanisms, are placed in special 'storage holes' inside the reactor buildings and in the intermediate storage facility for spent fuel. The holes have been designed for this purpose. Activated metal wastes will be treated together with decommissioning wastes. At the time of treatment they will not significantly add to the radioactivity of the decommissioning wastes.

FUTURE PLANS AND CONCLUSION

The amount of evaporator concentrates will be reduced by efficient use of the evaporators and, if needed, by separating long-lived nuclides from the concentrates. The separation of other nuclides than cesium has also been studied. The accumulation rate of spent ion exchange resins seems to stay at the same low value also in future. No need for alteration of the present practice thus is anticipated.

The volume of low level solid wastes is still under consideration. Research on the microbiological degradation of organic wastes is being done. Pilot plant tests of the studies have been going on during 1986 and the results have been promising. The wastes that contain paper, board, wood, cloth, rubbers, small amounts of plastics, etc., have almost totally decomposed in 7-10 days. The volume and mass of the wastes are tenfold reduced compared with the volume of the same wastes when compressed into steel drums.

Ion exchange resins are also organic material. They might also be decomposed as a result of bacterial action. A contract for laboratory studies has been drawn up between Imatran Voima Oy and a consulting firm, and a pilot plant is being planned.

In any case, there certainly will be some amounts of wastes to be disposed of, at least in the phase of decommissioning the power plant. Due to that fact, a final repository is being projected into the granitic bedrock of the power plant site (Ref. 1). According to the operating licenses of the power plant units, the repository should be taken into use in 1992, if necessary.

The site has been investigated since 1979. The results of the investigations show that the granitic bedrock of the power plant site is suitable for final disposal of low and intermediate level wastes.

The repository has been planned for all low and intermediate level wastes accumulated during the operation of the Loviisa NPS. The plans are based on

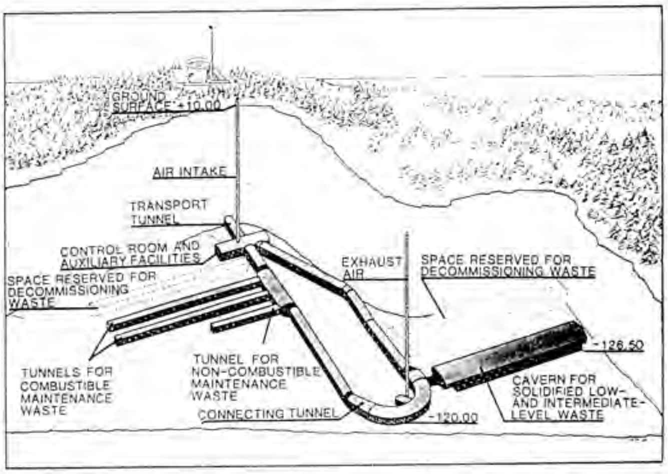

Fig. 1. Final Repository at Loviisa Hästholmen

conservative estimates of the waste amounts that will accumulate during 30 years. The repository will be built at the -120 m level, Fig. 1. The repository comprises different rooms for different waste types.

Efficient treatment of wastes will reduce the volume of the repository. Certain halls or caverns of the repository might not necessarily be needed at all. Research may save a lot of work in the treatment and final disposal of the wastes.

Our experience has shown that the problem of handling nuclear wastes can be very much reduced by means of the following measures:

- use of high quality non-corrosive low cobalt materials in all surfaces in contact with the reactor coolant
- gentle operating of the reactor to avoid transients, which cause fuel leakages
- installation of a large tank storage facility for interim storage of wet wastes in order to benefit from the natural decay of radioactivity during the entire operation period of the plant
- introduction of stringent rules for the use of such materials in the controlled area that will be defined as wastes
- construction of interim graveyards where the radioactivity of strongly activated material may decay for several decades before final conditioning and disposal.

Reference

1. E. H. Tusa, P. T. Anttila, H. Härkönen, E. K. Peltonen, "Final Disposal of Low and Intermediate Level Wastes from Nuclear Power Plants in Finland", IAEA-SM-289/18, *Proc. of Int. Symp. on the Siting, Design and Construction of Underground Repositories for Radioactive Wastes*, Hannover, FRG, 3 - 7 March 1986, p.231, IAEA (1986).