LLW MANAGEMENT BY FINNISH POWER COMPANIES

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ABSTRACT

In Finland, the nuclear power companies are responsible for the radioactive waste management including final disposal. Today, all the LLW accumulated is stored at the two power plant sites. The storage capacity is adequate till the mid-'90s. Development of underground LLW repositories at both sites is in progress. Final disposal of LLW will start in the early 1990s.

INTRODUCTION

There are four nuclear power plant units in operation in Finland today. Imatran Voima Oy (IVO) operates two 465 MW(e) PWR units at its Loviisa Power Station. The Industrial Power Company Ltd. (TVO) operates two 710 MW(e) BWR units at its Olkiluoto Power Plant.

All the LLW accumulated in the operation of the power plants is currently conditioned and stored at the sites. No disposal facility is in operation. Development of underground LLW repositories at both sites is in progress. Preliminary Safety Analysis Reports were submitted to the regulatory authorities in December 1986. The aim is to implement complete on-site LLW management at both sites.

EXPERIENCE IN LLW CONDITIONING

Loviisa Power Station

In Loviisa Power Station, liquid wastes mainly consist of evaporator concentrates. At present, the liquid wastes accumulated are stored in liquid form in a large tank storage facility. The annual accumulation is presented in Table I. The low accumulation rate of evaporator concentrates in recent years is due to improvements made in the evaporator operation and to low radioactivity content of the wastes. Considerable amounts of low level evaporator concentrates from previous years have been released into the sea. During 1986, this resulted in an actual decrease in the amount of stored wastes.

IVO has designed and licensed a solidification plant based on the cementation process. Due to ample storage capacity for liquid wastes, construction of the solidification plant has not been started.

TABLE I

Annual accumulation (m^3) of LLW at Loviisa Power Station

Year	Liquid wastes		Solid wastes
	Spent resins	Evaporator concentrates	
1977	-	311	-
1978	3,6	204	19
1979	2,7	116	15
1980	2,9	184	17
1981	6,0	175	76
1982	13,1	223	73
1983	15,0	120	103
1984	16,2	170	87
1985	14,0	114	84
1986	14,2	51	32
Totally	87,7	1668	506

Low level trash waste is compacted into 200 l drums. Annual accumulation is shown in Table I. A more detailed description of the LLW treatment at the Loviisa Power Station is given in Ref. 1.

The estimated volume of LLW accumulated during 30 years' power plant operation is 10 000 m^3.

Two major R&D projects concerning LLW volume reduction are in progress. One deals with the separation of cesium from low level evaporator concentrates, the other with biological degradation of low level trash waste. Pilot plant experiments of both processes will be completed in the near future.

Olkiluoto Power Plant

Liquid wastes at the Olkiluoto Power Plant solely consist of spent ion exchange resins. At both power plant units there is a waste building with complete systems for LLW conditioning. Ion exchange resins are solidified with bitumen and packed into 200 l steel drums. The annual accumulation of bituminized waste is shown in Table II.

Compressible trash waste is compacted into 200 l drums by a light-weight hydraulic press. Non-compressible scrap is packed into drums or into 1.3 m^3 steel containers. The annual accumulation of conditioned trash and scrap is shown in Table II.

TABLE II

Annual accumulation (m^3) of LLW at Olkiluoto Power Plant

Year	Bituminized waste	Trash & scrap
1979	40	21
1980	58	35
1981	80	50
1982	78	102
1983	70	80
1984	76	94
1985	101	83
1986	68	70
Totally	571	535

In 1984, the Finnish Centre for Radiation and Nuclear Safety established radioactivity limits for restricted releases of low level trash waste. Waste bags with low specific activity can be disposed of at the dumping area at the power plant site. In 1984-1986, more than 60% of the low level trash waste was disposed of at the dump.

About 2600 m^3 of bituminized waste and 4300 m^3 of trash and scrap are estimated to accumulate during 30 years' operation of the Olkiluoto Power Plant.

LLW STORAGE FACILITIES

The tank storage facility in the Loviisa Power Station has a capacity of 2400 m^3 in 8 tanks. Four tanks (1200 m^3) are reserved for evaporator concentrates, three (900 m^3) for spent resins and one 300 m^3 tank is held in reserve. The capacity of the resin tanks is adequate for the whole operation life of the power plant. For evaporator concentrates the storage capacity is adequate till the mid-'90s. Dry waste is stored in facilities inside the power plant and in a separate storage hall for very low level wastes. These stores provide storage capacity till the late '90s.

In Olkiluoto LLW is stored in the waste buildings of the plant units and in two separate storage facilities. The waste buildings can accommodate 1500 drums each. A separate storage facility for low level trash and scrap was commissioned in 1981. Its capacity is 5000 drums. The store has reinforced concrete walls 35 cm thick. This enables free emplacement of drums with a surface dose rate up to 0.75 mSv/h. The construction costs of the facility were USD 330 000.

The separate storage facility for bituminized wastes (Fig. 1) was commissioned in 1986. It can accommodate 6000 drums. The design basis for surface dose rate of the drums is 200 mSv/h. The store is provided with concrete walls 75 cm thick. The construction costs of the facility were USD 1.2 million. The storage facility at the Olkiluoto Power Plant will meet the storage requirements till the mid-'90s.

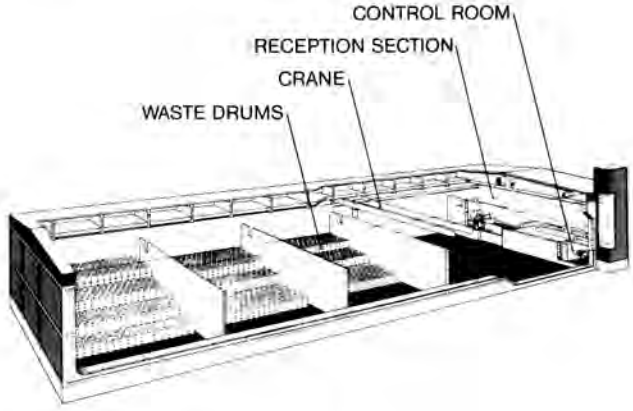

Fig. 1. Interim storage facility for bituminized wastes at Olkiluoto Power Plant.

PLANS FOR LLW DISPOSAL

General

The geological conditions in Finland are not suitable for shallow land burial of LLW. The most feasible alternative is disposal into caverns excavated in the bedrock. In the late '70s, the power companies decided to study the suitability of the bedrock at the two power plant sites for LLW disposal. An evaluation was made concerning the alternatives of two on-site repositories or one common repository at either site. Local acceptance was deemed the most important factor in the evaluation, and the decision was made to continue the development of two separate LLW repositories.

In 1983 the Finnish Government made a decision in principle on the objectives of development of nuclear waste management in Finland. According to the decision, the power companies submitted Preliminary Safety Analysis Reports of the LLW repositories to the regulatory authorities in December 1986. The decision further states that the repositories should be in operation by the end of 1992, if needed.

Loviisa repository

The Loviisa Nuclear Power Station lies on the island of Hästholmen on the southern coast of Finland. Bedrock investigations have been performed at the site since 1979. Planned location of the repository is shown in Fig. 2. The host medium of the site consists of homogeneous rapakivi granite with two almost horizontal, fractured zones.

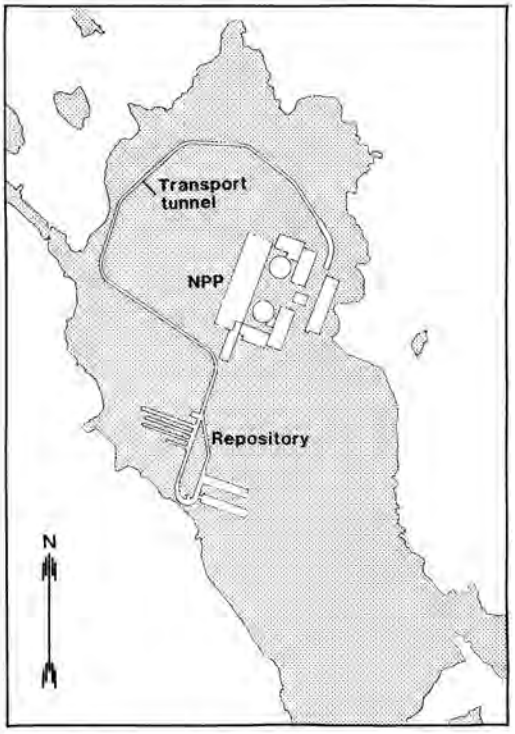

Fig. 2. Planned location of LLW repository at Loviisa power plant site.

There are two different groundwater zones in the bedrock of the site. The boundary between the upper lens-like zone of fresh, flowing groundwater and the lower zone of stagnant saline groundwater is in the upper fractured zone, between the -60 m and -140 m levels. The repository will be constructed at a location suitable with respect to the groundwater flow. It will lie at a depth of approximately 120 m, Fig. 3.

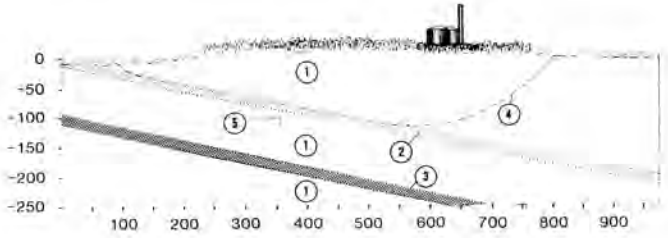

Fig. 3. The hydrogeological model of the bedrock at Loviisa.

The repository comprises a cavern for solidified wastes, tunnels for dry maintenance wastes and all necessary auxiliary facilities, Fig. 4.

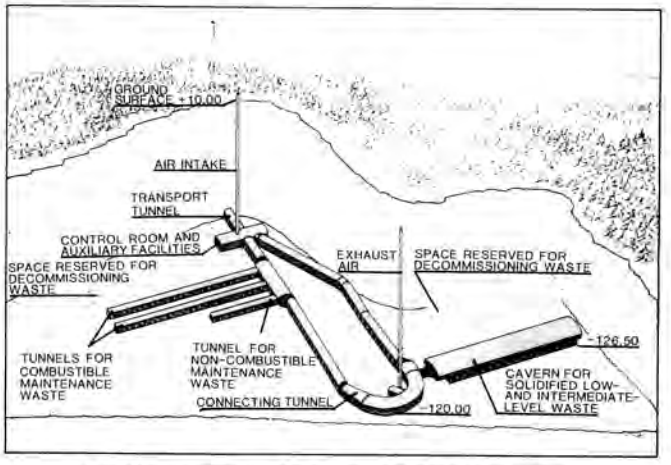

Fig. 4. Layout of the Loviisa repository.

The cavern for solidified wastes is 100 meters long and its cross-section is 300 m^2. The solidified wastes in concrete containers will be placed in the cavern inside the concrete walls. The waste containers are transferred with a remote-control bridge crane. All empty space between the containers is filled with flowing concrete. The space between the walls and the bedrock is filled with crushed rock, when the repository is closed.

Maintenance wastes are transferred from the lorries into the tunnels by a fork lift truck. The tunnels are 100 meters long with a cross-section of 30 m^2. No filling material is used in these tunnels. During the operation period, the air moisture is limited to 60% to avoid corrosion of the steel containers.

The excavation volume of the repository is 100 000 m^3. The estimated construction costs are FIM 53 million.

Olkiluoto repository

The Olkiluoto Power Plant is located on the island of Olkiluoto on the western coast of Finland. The planned location of the LLW repository at the site is shown in Fig. 5. During 1980 to 1986, detailed geological investigations were performed at the site. The bedrock consists of an intact tonalite rock body surrounded by more fractured micaceous gneiss. The results of the geological investigations were applied in repository design and safety analyses.

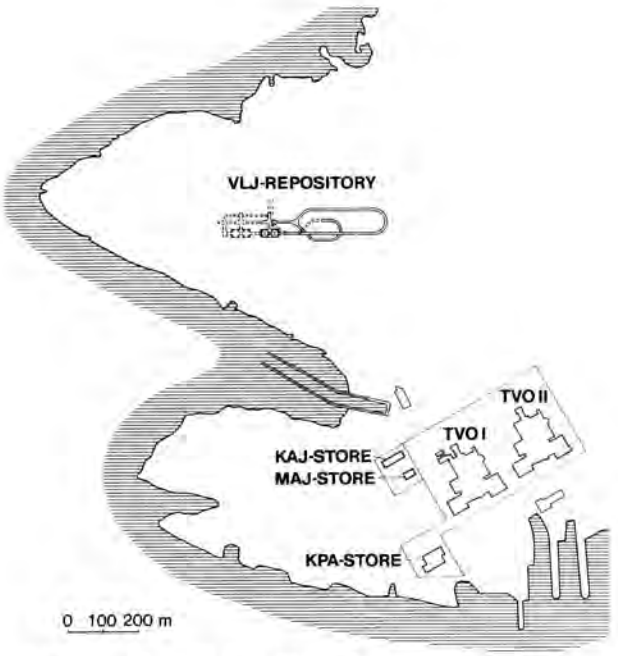

Fig. 5. Planned location of the LLW repository at the Olkiluoto site. The MAJ- and KAJ-stores are interim storage facilities for low level trash waste and bituminized waste. The KPA-store is the interim storage facility for spent fuel.

The repository comprises the control building at the ground level, the access tunnel and the vault at a depth of 60 m, Fig. 6. Two silos will be excavated at the floor of the vault, one for low level wastes and the other for intermediate level wastes. The silos are 20 m and 22 m in diameter and 33 m and 26 m high, respectively. To improve isolation, the facility for intermediate level wastes will be cased with a separate, reinforced concrete silo with an inner diameter of 19 m and walls 0.5 m thick.

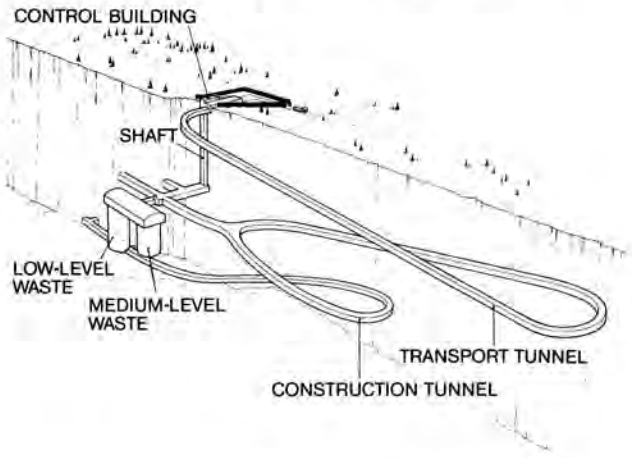

Fig. 6. Layout of the Olkiluoto repository.

The excavation volume of the repository is 66 000 m^3. The estimated construction costs are FIM 33 million.

Disposal of decommissioning wastes

According to the operating licenses, the power companies shall submit a preliminary decommissioning plan to the regulatory authorities by the end of 1987. The Loviisa Power Station will be decommissioned immediately after the operation period. After a cooling period of one year, all the radioactive components of the plant can be dismantled. According to preliminary plans, the plant will be decommissioned by the end of 2016.

At Olkiluoto, once power plant operations have ceased, storage of spent nuclear fuel will continue 30-40 years. According to the preliminary decommissioning plan, the power plant units will be kept 'in mothballs' during this period. Dismantling will be completed in the 2050s.

All LLW from the decommissioning of the nuclear power plant units will be packed and disposed of at the power plant sites. The volume of packed decommissioning wastes amounts to 10 000 m^3 at Loviisa and to 18 000 m^3 at Olkiluoto. When the time for decommissioning has come, the repositories will be enlarged for the disposal of decommissioning wastes.

Shutdown and sealing of the repositories

The safe disposal of LLW is based on the principle of multiple barriers. Some of the barriers will be realized in connection with construction of the repository, and some during the disposal. The system will be completed when the repository is shutdown and sealed. The general idea in the shutdown and sealing is that only the tunnels and vaults in the immediate vicinity of the intermediate level waste vaults will be totally backfilled. Other parts of the repository including vaults for low level waste will be separated from each other with tight plugs. Tunnel openings at ground level are plugged efficiently to prevent inadvertent instrusion later.

When the Loviisa repository is shutdown and sealed, the cavern for solidified waste will be backfilled with crushed rock.

The preliminary plan for the sealing of the intermediate level waste vault in Olkiluoto repository is shown in Fig. 7. The annulus around the concrete silo will be backfilled with crushed rock. A tight reinforced concrete cover will be cast on the silo. A small opening will be made in the cover to avoid development of overpressure due to eventual corrosion gas generation in the silo. The vault above the silos will be backfilled with crushed rock and boulders.

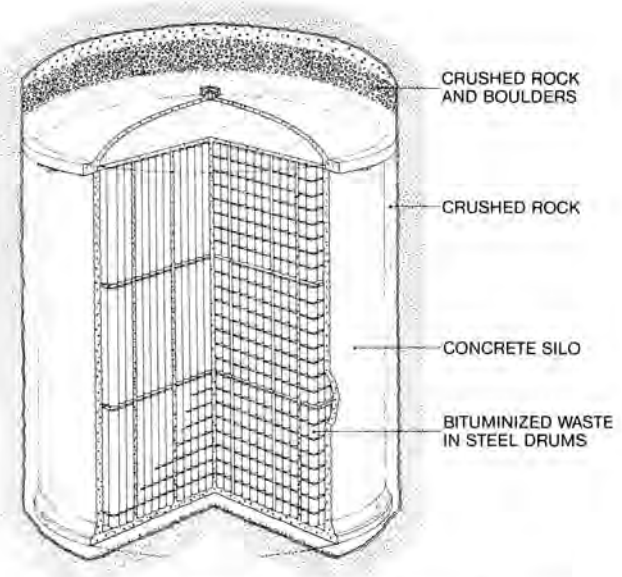

Fig. 7. Shutdown and sealing of the intermediate level waste silo in the Olkiluoto repository.

Safety of LLW disposal

Post-closure safety analyses form an essential part of the Preliminary Safety Analysis Reports. The performance of the disposal system was analyzed using scenario technique. The scenarios employed cover the whole spectrum of repository development alternatives from the anticipated sequence of events to the most extreme disturbed evolution scenarios.

In the anticipated conditions, radionuclides are released from the repository into the biosphere by gradual dissolution into and transport along with the groundwater. The dose pathways analyzed include the present marine environment, a lake environment possibly developed as a result of the continuing land uplift on the Finnish coast, and a well sunk in the immediate vicinity of the repository. The maximum annual dose via the well pathway is 1×10^{-5} Sv. The doses received through the marine and lake environment are negligible.

The safety margin of the repository systems were analyzed by using disturbed evolution scenarios assuming severe impairment of the engineered barriers. Even in the most extreme cases, the annual doses remain well below the level caused by natural background radiation in Finland.

FUNDING OF NUCLEAR WASTE MANAGEMENT

In Finland, the nuclear power companies are responsible for all costs for the nuclear waste management. The operating licenses of the power plant units include stipulations concerning funds for future waste management investments. So far, the companies have submitted to the regulatory authorities cost estimates for future waste management activities each year. After approval of these cost estimates, the authorities confirm the amount of the nuclear waste management reserve that the companies must make when annually closing the accounts.

The total cost estimates for the future waste management are FIM 4100 million for TVO and FIM 620 million for IVO. TVO's cost estimate includes costs of the spent fuel management. At the end of 1986, TVO's reserve for nuclear waste management stood at FIM 1038 million and IVO's at FIM 174 million.

The new nuclear energy law is waiting for approval by the next parliament to be elected in 1987. The new law will bring about fundamental changes in the funding of the nuclear waste management. According to the new law, the funds will be collected and governed by the Ministry of Trade and Industry.

CONCLUSIONS

The Finnish power companies have well established methods to treat and condition LLW accumulated in power plant operations. The existing storage facilities at the power plant sites meet the demand till the mid-'90s. Development of underground LLW repositories is well under way. Current experience and R&D work done indicate that complete on-site LLW management can be implemented at both power plant sites in a technically feasible, economical and safe way.

REFERENCE

1. E. H. TUSA and B. G. WAHLSTRÖM, "Practice to Minimize Nuclear Waste Amounts in Loviisa NPS", Waste Management '87, Tucson, United States, March 1-5, 1987.