Management of Low- and Intermediate Level Waste in Sweden[1]

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Introduction

Sweden's nuclear waste management program dates from 1976, when a committee on the future treatment of nuclear waste, composed of members of Parliament, civil servants, experts and representatives of interested bodies, made its report to the government. This report has become a cornerstone of Sweden's radioactive waste management system.

Swedish law places responsibility for nuclear waste management with the waste generators. Sweden's four nuclear utilities have formed a joint company, the Swedish Nuclear Fuel and Waste Management Co. (SKB), to handle the nuclear waste.

SKB's activities are regulated by various statutes, and are overseen by the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Institute (SSI), which also oversee the operation of the nuclear power plants.

The Swedish waste management system today includes a final repository for short-lived LLW and ILW, and an interim storage facility for spent nuclear fuel and long-lived waste. Sweden plans to dispose off the spent fuel as it is, without reprocessing. An encapsulation plant for spent fuel and a deep repository for the final disposal of the fuel and other long-lived waste are planned but have not yet been built. A sea-based transportation system is in place to service the waste facilities.

LLW/ILW Disposal

Some very low-level, short-lived waste is disposed of in shallow-land repositories at the nuclear power stations. These wastes, primarily compacted trash, but also some metal scraps, are packaged in bales, drums, boxes, and ISO-containers. The containers are limited to a surface dose rate of 0.5 mSv/hr and a specific activity of 300 kBq/kg. The landfills are limited to a maximum content of 100 GBq each at any given time. Each facility is estimated to be able to hold between 5000 and 10 000 m^3 of such waste.

The Final Repository for Radioactive Operational Waste (SFR) is situated in underground rock caverns close to the Forsmark nuclear power plant. The rock caverns have been excavated to a depth of more than 50 meters beneath the Baltic Sea floor. The entrance to the disposal caverns is via tunnels starting at the shoreline. The location ensures a very small hydraulic gradient, and the groundwater is almost stagnant. The location also makes it unlikely that anyone will drill for drinking water in the area for at least 500 years. After that time, land uplift may raise the shallowest seabed formations above sea level.

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[1] *) *Based on an article in RADWASTE Magazine, Nov/Dec 1998*

The total activity of the operational (low-level) waste deposited in the SFR is less than one percent of that present in spent fuel. The wastes contain only trace quantities of such long-lived radionuclides as plutonium and americium. The primary activity comes from cobalt-60 and cesium-137, which decay at a rate such that the waste activity will be equal to natural background activity in the granite rock of the repository within a few hundred years.

LLW is compacted into bales or packaged in metal drums or cases that can then be transported in standard freight containers (20–40 m^3). Some LLW is taken to the Studsvik research centre for incineration or melting. The incineration ash is then disposed of at SFR. Metal waste, after melting, usually has a nuclide content that allows it to be exempt from disposal requirements. Metal that does not meet these requirements is disposed of at SFR.

Radioactive materials used in various other sectors of society, for example, at hospitals, in industry, in research, and in consumer items such as smoke detectors, are collected and packaged at Studsvik. Studsvik also produces radioactive waste in its own research activities. The waste collected and packaged at Studsvik is disposed of in SFR if it is low- or intermediate-level and short-lived waste. Other waste is stored onsite for later disposal in the deep repository.

ILW, especially filters and ion-exchange resins, is mixed with cement or bitumen (asphalt) and cast in cement or 1.7 m^3 steel boxes or 200-litre metal drums. The cement and bitumen immobilise the waste, and the box or drum provides radiation shielding and uniform packaging for ease of handling. (Some filter and ion-exchange resins with lower activity levels are packed in 10 m^3concrete containers and dewatered.)

SFR has different disposal chambers for different kinds of waste. The most active waste is disposed of in a 50-m-high and 25-m-diameter concrete silo surrounded by a bentonite clay barrier. About 90 percent of the activity in the repository will be allocated to this silo. The remaining 10 percent of the activity will be disposed of in more rudimentary 160-m-long rock caverns.

The environmental impact of the repository is negligible during operation. The annual collective dose to the workforce is around 0.002 person-Sv. Analyses indicate that after sealing, the dose level will be well below the design goal of 0.1 mSv per year to any individual, based on a total activity content of 10^{16} Bq at the time of closure.

The capacity of the repository today is 63 000 m^3, and an extension to a total of 90 000 m^3 is planned. By the end of 1997, 23 000 m^3 of waste had been deposited in SFR since the facility opened in 1988. Originally, it was thought that the extension would be needed by the end of the 1990s, but to reduce disposal costs, waste producers have begun reducing their waste volumes through better waste segregation, onsite disposal of very low-level waste, and more efficient waste conditioning. As a result, it now appears that construction of the extension can be delayed until 2015.

When the SFR is sealed, some years into the next century, it will require no additional supervision. The classification of waste is such that, after about 500 years, the radioactivity in the waste in SFR will be no more dangerous than the natural background radiation in the surrounding rock. That includes the radioactivity of future decommissioning wastes, which will probably be disposed of in a 100 000 m^3 extension to SFR.

Wastes with significant amounts of long-lived radionuclides, for example, core components and other reactor international with neutron-activated metal, will be disposed of at a depth of about 300 meters in the same facility as the spent fuel but in separate caverns. This part of the repository is scheduled to start operating in around 2020. Until then, these wastes will be stored.

At present, feasibility studies are in progress to allow for site characterisation at two sites some years into the next century.

Because the deep repository has not yet received formal government assessment and approval, all wastes intended for that facility must be packaged in such a way that the wastes can be reconditioned before disposal. In principle, however, the deep repository will accept the same type of containers as the SFR. Preliminary design and long-term safety studies have been performed, but no formal license application has been filed for the deep repository. This will be done when a site has been selected and final design and performance assessments have been made.

Transport

Because Sweden's nuclear power plants and SKB's facilities are all located on the Swedish coast, all waste transport can be conducted by sea. ILW is transported in thick-walled containers, which provide the necessary shielding in compliance with International Atomic Energy Agency recommendations. These containers weigh up to 120 tonnes when filled with waste packages. To move the container to and from the ship, specially built transport vehicles are used. Waste packages having a maximum surface dose rate of 100 mSv/hr can be transported today. A new transport container, which will allow for a surface dose rate of 500 mSv/hr, is under construction. That container will meet IAEA requirements for a Type B container. LLW that does not required radiation shielding during transport can be transported in standard freight containers (ISO containers).

Costs and financing

The costs of managing and disposing of Sweden's nuclear waste are small compared to the price of electricity. All costs for spent fuel and nuclear waste management and disposal are being covered by the owners of the nuclear power plants. The owners will also be responsible for the costs of decommissioning the nuclear plants and disposing of the decommissioning waste. Funds to cover these costs are being raised by a special levy on nuclear power production (0.01 – 0.02 SEK/kWh). In addition, a little less than 0.002 SEK/kWh is set aside internally by the utilities for the costs of LLW/ILW disposal, which are not covered by the funding system.