Status of radioactive waste and spent nuclear fuel management in Finland

Dr. Jari Tuunanen

Fortum Power and Heat Oy, Loviisa NPP

Loviisa NPP, P.O.Box 23, 07901 Loviisa, Finland

Key words; spent nuclear fuel, radioactive waste, decommissioning

Abstract

The main principles of the Finnish radioactive waste management program were fixed already in 1983 in a decision in principle (DiP) of the ministry of trade and industry. This DiP fixed the overall responsibilities, schedule and reporting principles of the radioactive waste producers covering the operational waste, spent nuclear fuel and decommissioning. One key principle of the decision was that the waste producers are themselves responsible for management of all the radioactive waste they produce, including the costs.

The status of the program today is such that all the facilities are ready on site of the Nuclear Power Plants (NPPs) in Olkiluoto and Loviisa for management of the operational radioactive waste. Both nuclear power plant operators have their own waste treatment and storage facilities as well as own Low and Intermediate Level Waste (LILW) repositories in operation. The spent nuclear fuel is stored at the NPP sites as well. The spent fuel management program is organized through Posiva, a private company owned by the NPP operators Fortum and TVO. Just recently Posiva got a construction license for spent fuel encapsulation and final disposal facility.

Decommissioning plans have also been prepared as requested by the DiP. Money for decommissioning is reserved in the radioactive waste fund and the aim is to dispose all decommissioning waste to the existing LILW repositories on site of the NPPs. In Finland the decommissioning plans cover only the radioactive parts of the NPPs.

This paper summarizes the status of the radioactive waste management program in Finland, with the main focus on the radioactive waste and spent fuel produced at Loviisa NPP. It also presents some highlights of research and development program on radioactive waste management and gives an overview of the plans for the future decommissioning.

Contents

1. Introduction

There are four operating nuclear reactors in Finland: two Asea Atom BWR's of 880 MWe each in Olkiluoto site in the west-coast of Finland, and two Russian designed VVER-440 reactors of about 500 MWe each in the Loviisa site, about 100 km east from the capital Helsinki. The BWRs were taken into operation early 1980's and the operator has just recently applied for a 20 years prolongation of the operational license until the end of 2038. The VVERs started operation in 1987 and 1980, and they have a license for 50 years of operation.

There is also one EPR-type PWR of 1600 MWe under construction in Olkiluoto site, and one Russian designed AES-2006 type PWR has a construction license application under evaluation for a new Hanhikivi site.

The main principles of the Finnish radioactive waste management program were fixed in 1983 in the decision in principle (DiP) of the Ministry of Trade and Industry (MTI). The DiP determined that the license holders are themselves responsible for planning and financing the management of their own radioactive waste. Hence, there is no governmental or other national radioactive waste management organization in Finland, like in some other countries.

After this introduction the second chapter describes the status of the spent fuel management program in Finland. The focus of the third chapter is on the operational waste management. The fourth chapter presents the status of the plans for the future decommissioning of the reactors and the fifth one

discusses the management of institutional radioactive waste in Finland, such as radiation sources from the industry, hospitals and universities. The last chapter presents a summary and conclusions. Along the paper some highlights of the R&D work are also presented.

2. SPENT NUCLEAR FUEL MANAGEMENT

The main aim of the DiP of MTI from 1983 was that the operators shall try to find an international solution for the spent fuel management, in such a way that the spent fuel, after reprosessing or directly, would have been disposed of abroad. Direct disposal in Finland was only the second option that time. The deadline for the plans of interim storage of spent fuel was 1984, the timeline for the selection of the site for spent fuel disposal facility was set to the year 2000 and the spent fuel disposal facility was requested to start operation around 2020, if the operators had decided to follow the second option.

During the early years of operation the spent fuel from Loviisa NPP was returned back to Russia (Soviet-Union). This activity was terminated in 1995 when the Finnish government decided to prohibit export and import of spent nuclear fuel. At the same time TVO had its own research program for finding solution for their spent fuel management.

TVO decided to build an own wet spent fuel storage, which gave them time to develop solution for their spent fuel management. The original wet spent fuel storage at Loviisa NPP was designed assuming that all the fuel is returned to Russia soon after it is removed from the reactors. Later the storage has been expanded twice, first allowing more cooling time for the spent fuel before returning it to Russia, and later to make it possible to store all the spent fuel on site after it was not possible to return it to Russia any more. The capacity of the storage has later been further expanded using high density racks, which are of Fortum's own design, allowing storage of all the spent fuel on site produced during 50 years of operation of the plant.

After it was not possible to return the spent fuel from Loviisa NPP to Russia Fortum and TVO started to negotiate of co-operation. In 1995 the companies reached an agreement which gave Posiva the responsibility for planning the management and final disposal of the spent fuel of these companies. Based on this agreement TVO owns 60% and Fortum 40% of Posiva.

Posiva's programme on owners spent fuel management has progressed well according to the DiP. Posiva selected Olkiluoto site for its final disposal facility in the year 2000 and the site was approved by the parliament in 2001. Construction license application for the spent fuel encapsulation and final disposal facility was left 2012 and the license was granted 2015. Now Posiva is working with the operating license application, at the same time with closing the remaining open issues from the construction license. The operating license application shall be left around 2020, making it possible to start final disposal of the spent fuel early 2020's. Hence, about 40 years will be needed from DiP to the operation of a spent fuel disposal facility. This long journey is illustrated in Fig. 1 below.

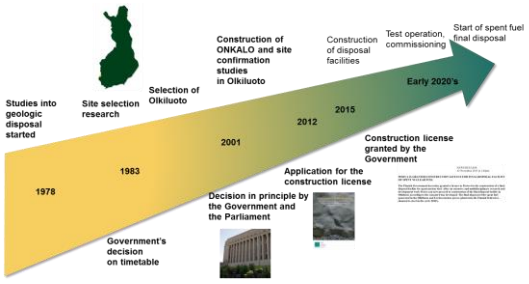

Fig. 1: The main steps of Posiva's spent fuel management program (source: Posiva).

The research and development work on spent nuclear fuel disposal started already more than 40 years ago in Finland. After Posiva selected the Olkiluoto site the research focused more on the site issues, both above and below the ground. In addition, Posiva has had a program for developing technology for encapsulating the fuel, manufacturing the copper canisters for the fuel, and the machines needed to dispose it. An example of the machines developed is the boring machine for disposal holes (Fig. 2).

Fig. 2: Posiva's machine for boring disposal hole (source: Posiva).

3. OPERATIONAL WASTE MANAGEMENT

The objective of the DiP for operational waste management was, that all the operational waste produced shall be treated, stored and disposed of in Finland. The deadline for taking disposal facilities in operation was set to 1992.

The power companies Fortum and TVO had some discussions about co-operation in the management of their operational waste too, but they decided to build their own final disposal facilities to the NPP sites. TVO took its repository into operation in 1992 and Fortum later in 1999. Hence, the targets of the DiP have been fulfilled.

In Loviisa NPP, dry operational waste is packed in 200 l drums. The evaporate concentrates are cleaned using Fortum's selective NURES inorganic ion exchange materials. Several campaigns have been carried out to treat concentrates with NURES and CsTreat. About 200 m^3 have been treated during each campaign and until the end of 2013 totally 1460 m^3 had been treated. As a result of this treatment there are only 0,272 m^3 of CsTreat left as waste. In Loviisa CsTreat is used in 8 liter columns. Thus there are 34 spent columns left as waste, and they can be disposed of in three concrete containers, with outer volume of about 1,7 m^3, each. In this way Fortum has saved about 55 million euros in solidification and final disposal costs at Loviisa NPP.

The wet operational waste, ion exchange resins and those evaporate concentrates that can't be cleaned, are treated in the solidification plant at Loviisa NPP site. In the solidification process the waste is mixed with cements, blast furnace slag and additives in a concrete waste container. The cementation plant is very effective: 400-500 l of waste can be solidified into a 1 m^3 (inner volume) concrete container. The cementation recipes are based on Fortum's own R&D work, which still continues for further optimization of the solidification process. See Fig. 3 for the main principle of the solidification plant operation.

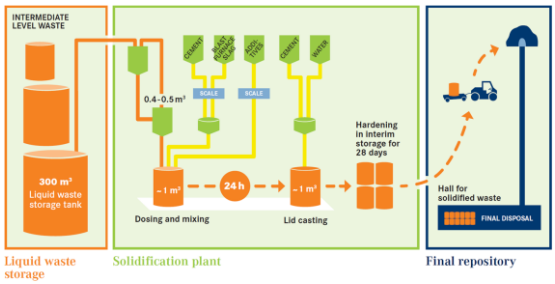

Fig. 3: Operation principle of Loviisa NPP solidification plant.

The radioactive waste produced at Loviisa NPP is disposed of to a disposal facility on site, located about 100 m underground. At the moment there are two waste caverns for operational waste in operation, one for storing operational waste, and one for disposing of the solidified waste constructed. There is enough space for disposal of all the waste produced during the 50 year operational life of Loviisa NPP. If needed, more space can be built.

The safety of final disposal of the waste is evaluated in a long term safety case of the repository. Currently Fortum is updating it as a part of a periodic safety review of the repository.

4. PREPARATION FOR THE FUTURE DECOMMISSIONING

In the decommissioning area the DiP determined the time schedule for the operators for developing decommissioning plans of their reactors. Every 5 years the operators were requested to present their updated plans for decommissioning the reactors. The DiP also required that the waste from the decommissioning shall be disposed of either to the LILW repositories or to the spent fuel repository.

The operators have followed the DiP and presented their decommissioning plans to the ministry ever since 1980's. Today the plans need to be updated every 6 years. In the case of Loviisa NPP, the next update will be submitted at the end of 2018.

Fortum is planning to dispose of all the radioactive decommissioning waste from the Loviisa NPP to the on-site LILW repository. The inventory of the decommissioning waste has been estimated based on plant measurements, operation experience and MCNP simulations, and a conceptual design of the repository extension for the decommissioning waste is available. Fig. 4 shows the repository extension for the decommissioning waste packages and for the large components (e.g reactor pressure vessels, steam generators).

When the Loviisa LILW repository was built the future decommissioning was taken into account. For example the entrance tunnel is so large that all the big components, such as reactor pressure vessel and steam generators, can be transported to the repository without cutting them into smaller peaces. This allows cost-effective dismantling and disposal of the waste.

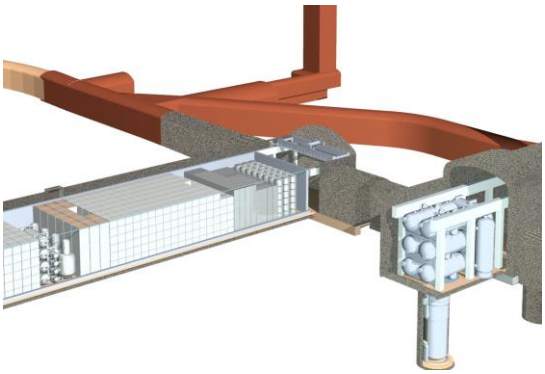

Fig. 4: A view of the Loviisa LILW repository extension for decommissioning waste.

The long term safety case for final disposal of the radioactive waste takes into account the disposal of the decommissioning waste to the repository.

If the Loviisa NPP operation will end after 50 years of operation, the licensing of the decommissioning shall start early 2020's. The licensing process for decommissioning starts with an environmental impact assessment for the decommissioning and the disposal of the decommissioning waste. In addition, the extension of the repository needs to be licensed. The repository extension may also need a political approval through decision in principle process in the parliament. It also has to get a construction license and an new operating license. For the decommissioning, also a decommissioning license will be needed in the future.

5. MANAGEMENT OF INDUSTRIAL RADIOACTIVE WASTE

One area which was not covered by the old DiP is the institutional radioactive waste. This waste is typically produced in hospitals, universities and by the research organizations. At the moment a part of this waste is stored and disposed of to TVO's LILW repository at Olkiluoto NPP site through an agreement between TVO and the Ministry of Social Affairs and Health. The disposal of this type of waste to Olkiluoto LILW repository became possible after TVO got an updated operating license for the repository, allowing also disposal of the waste from the new Olkiluoto 3 NPP unit.

The operating license of the Loviisa LILW repository also allows disposal of small amount of industrial waste to the repository. So far, this option has not been used. Otherwise, the repository is licensed for the waste produced at the Loviisa NPP only.

6. SUMMARY AND CONCLUSIONS

The Finnish radioactive waste management program has progressed well according to the old DiP from 1983. Only the last step of the spent fuel disposal remains to be completed: the beginning of spent fuel disposal.

The operational waste from the existing reactors can be handled with the existing infrastructure on the Loviisa and Olkiluoto NPP sites, even in the situation that the operational life of the reactors is prolonged. If the operation continues after the current operating licenses, the repositories and the spent fuel storages can be expanded. The time and scope of the expansions of the spent fuel storages depend e.g on the schedule of Posiva. The expansion of LILW repositories for more operational waste is possible provided the long term safety case shows the dose rate limits for the population living in the repository area in the future are met.

Preliminary decommissioning plans, including the cost estimates, are available for the existing NPPs. About 5-10 years will be needed for licensing the decommissioning and for the expansion of the LILW repository for decommissioning waste before dismantling works can begin. During this time also the detailed dismantling plans shall be made and decommissioning license application shall be left. The disposal of the decommissioning waste to the Loviisa LILW repository has already been taken into account in the long term safety case of the repository, as well as in the design of it.

Fortum's R&D efforts have supported the management of radioactive waste from Loviisa NPP. The main outcome of this effort are the NURES products for cleaning radioactive water. In addition to that, development of recipes for cementation of the liquid radioactive waste have led to very effective cementation solutions for the wet radioactive waste. These efforts still continue for further optimization of the waste management processes.