Disposal of reactor waste

This Guide is in force as of 1 Nov. 1991 until further notice.

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Authorisation

The Finnish Centre for Radiation and Nuclear Safety (STUK) issues detailed regulations concerning the safety of the use of nuclear energy by virtue of Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/87) and Section 8 of the Decision of the Council of State on the general regulations for the safety of a disposal facility for reactor waste (398/91).

The YVL guides are rules an individual licensee or any other organization concerned shall comply with unless some other acceptable procedure or solution is presented to STUK by which the safety level laid down in an YVL guide is achieved.

Translation. Original text in Finnish.

1 General

The licencing procedure for the disposal of reactor waste is presented in the Nuclear Energy Act (990/87) and Decree (161/88). The general safety requirements are presented in the Decision of the Council of State on the general regulations for the safety of a disposal facility for reactor waste /1/ and in some respects also in the radiation protection legislation and in the Decisions of the Council of State on the general regulations for the safety, physical protection and emergency preparedness of nuclear power plants /2, 3, 4/.

This guide specifies the provisions of the regulations referred to above. This guide applies to the planning, construction, operation, and the post-operational phase of a disposal facility for reactor waste to be located in the bedrock of a nuclear power plant site. This guide assumes that the waste amounts to be emplaced in the facility exceed the limits presented in Section 6, paragraph 1 of the Nuclear Energy Decree, in which case the disposal facility is, by virtue of Sections 3 and 11 of the Nuclear Energy Act, a nuclear facility of considerable general significance.

2 Radiation protection

In accordance with Section 3 of the Decision of the Council of State /1/, the radiation exposure arising from the disposed waste shall be kept as low as reasonably achievable. As disposal in the bedrock of a nuclear power plant site is assumed, the optimization analyses may be confined to comparisons between alternative technical concepts differing from each other with respect to e.g. the disposal depth, technical design or materials used as barriers.

In accordance with Section 3 of the Decision /1/, the expectation value of the annual dose to any member of the public is constrained to 0.1 mSv.

The expectation value of the annual individual dose, $\hat{E}$, at the time t is defined as

$$\hat{E}(t) = E_e(t) + \sum_i \int_0^t E_i(t,T) \cdot p_i(T) dT$$

where

$E_e(t)$ is the annual effective individual dose in the year t, arising from anticipated conditions and from such situations as are not due to unlikely random events,

$p_i(t)dT$ is the probability that within a time interval (T, T+dT), random event (see the fifth paragraph of Section 4) occurs causing increased radiation exposure and

$E_i(t)$ is the annual effective individual dose in the year t, arising from an event i occurring at the time T.

In accordance with Section 3 of the Decision /1/, the annual dose to any member of the public, arising from accident conditions which are caused by natural events or human actions and which are considered possible, is constrained to 5 mSv. The accidents to be considered are addressed in paragraph 5 of Section 4.

In accordance with Section 3 of the Decision /1/, the increase in the total activity concentration of radioactive substances in the environment, arising from the disposed waste, shall remain insignificant in any part of the biosphere. This shall be demonstrated by comparing the calculated activity concentrations arising from the disposed wastes, in surface waters, soil and air to the respective activity concentrations typically arising from natural radioactive substances, such as tritium, carbon-14, potassium-40, and uranium and thorium with their decay products.

In Sections 9 and 10 of the general regulations for the safety of nuclear power plants /2/, constraints for the radiation exposure arising from normal operation and anticipated operational transients at nuclear power plants are given. These constraints apply to the whole nuclear power plant site, including the on-site disposal facility for reactor wastes.

Radiation exposure of the employees of the disposal facility shall be limited as separately

enacted. Radiation protection arrangements shall comply with Guides YVL 7.9 and 7.10.

3 Performance of barriers

In accordance with the Decision of the Council of State /1/, the radiological safety of disposal shall be based on multiple natural and engineered barriers. Thus the design target shall be such an overall disposal system that e.g. deficiencies in the performance of one of the barriers or potential geologic changes will not decisively impair the safety of disposal.

In accordance with Section 4 of the Decision /1/, the disposal facility shall be designed so that such interactions are excluded as might, within a short period of time, substantially impair the performance of any barrier. Such potential, rapidly evolving interactions to be considered include at least the effects arising from swelling of the wastes, gas generation in the repository and chemically aggressive substances in the wastes.

In accordance with Section 4 of the Decision /1/, engineered barriers shall effectively limit the release of radioactive substances from the waste emplacement rooms for at least 500 years. The choice of engineered barriers shall be based on technical designs considered reliable and on materials having experimental or other reliable evidence of long-term stability.

In the long-term the isolation capability of the structures and the capability to retard radionuclides of the materials used as engineered barriers may be impaired. Thus, pursuant to Section 4 of the Decision /1/, after a period of 500 years natural barriers in the first place shall be able to limit the release of radioactive substances to the biosphere at a level which is in compliance with the radiation protection requirements. In evaluating compliance with this requirement, such characteristics of the engineered barriers as have assured long-term stability, can be taken into account in a realistic way.

4 Safety assessments

In accordance with Section 5 of the Decision of the Council of State, compliance with the requirements concerning radiation protection and performance of barriers shall be demonstrated by means of safety analyses. These analyses shall be specific to the disposal facility and site and they shall cover both the operational and the post-operational period. Such safety analyses shall be presented in connection with the preliminary safety analysis report (Section 35 of the Nuclear Energy Act), the final safety analysis report (Section 36 of the Nuclear Energy Act) and the final closure plan (Section 6 of the Decision of the Council of State /1/). In addition, the safety analyses shall be revised in case such new data have been obtained as might decisively alter the the results of the safety analyses with respect of the safety requirements.

The analysis of radiation doses incurred during the operational period shall cover planned disposal operations as well as the disturbances and accidents considered possible, such as fires and failures in waste package handling. In the definition of the scenarios for disturbances and accidents, the important factors to be considered include the properties of waste packages, operational radiation protection arrangements and safety arrangements for exceptional situations.

The analysis of the long-term radiation exposure from the disposed wastes shall be based on the performance of the engineered barriers according to their design bases and the properties of the host rock according to the geologic investigations carried out. Furthermore, it shall be taken into account that

— engineered barriers gradually deteriorate e.g. due to groundwater and interactions evolving in the repository,
— surface waters and the quality and flow of groundwater may change due to e.g. land uplift and sea level variations, and that
— residential, agricultural and industrial conditions at the disposal site and in its environs may change.

The performance of the engineered barriers shall be demonstrated by analyses, in which at least the effects of groundwater and the interactions referred to in paragraph 2 of Section 3 are considered.

Analyses of the accidental events that might occur after the closure of the repository shall include at least
— failure of barriers due to rock movements considered possible,
— making a bore well close to the repository, and
— human intrusion of short duration into the repository.

Technical post-closure surveillance, if any, shall not be taken into account in the safety analyses. It can be assumed that human activities affecting the repository or the nearby host rock are precluded for 200 years at the most by means of administrative post-closure surveillance.

The analysis of the radiation dose to an individual of the public shall be based on the average dose to the members of the so called critical group. The critical group stands for members of the public, who can be foreseen to receive the highest radiation doses due to their place of residence and way of living. For the analysis of radiation exposures in the distant future, a hypothetical critical group shall be defined to represent the people who will be living in the environs of the disposal site. Their nutritional habits and way of living can be assumed to be similar to those of people living today.

The safety analyses shall be based on carefully verified calculational methods and on models that are validated as far as practicable. Except for the optimization analyses referred to below, the safety analyses shall be based on such input data and assumptions that the results of the calculations are, with a high certainty, more unfavourable with respect to safety than the real values.

As an optimization method, e.g. a cost-effectiveness analysis based on collective radiation exposure may be used. In these analyses, best-estimate input data and assumptions can be applied. Extensive optimization analyses are not necessary if the collective effective dose from disposal, extended to 10 000 years, is of the order of 1 manSv at the most.

5 Geologic investigations

In accordance with Section 5 of the Decision of the Council of State /1/, bedrock characteristics at the disposal site shall be experimentally investigated to ensure the suitability of the site and the repository and to acquire the data needed for safety analyses. For this purpose, investigations of e.g. geologic structures, hydrogeology and the quality of groundwater are needed. In the preliminary safety analysis report, a summary of these geologic investigations shall be presented. In connection with the preliminary safety analysis report, also a plan for the investigations to be performed during the construction of the disposal facility shall be performed. These investigations shall include
— investigations for ensuring the suitability of the waste emplacement rooms,
— geologic mappings,
— observations of movements and transformations in the host rock surrounding the waste emplacement rooms,
— analyses of groundwater quality and
— hydrogeologic observations of the host rock surrounding the waste emplacement rooms.

In the final safety analysis report, a summary of the investigations performed during the construction of the disposal facility shall be presented. In connection with the final safety analysis report, also a plan for the investigations to be performed during the operational period shall be presented. These investigations shall include at least
— observations of movements and transformations in the host rock surrounding the waste emplacement rooms,

— analyses of groundwater quality and
— hydrogeologic observations of the host rock surrounding the waste emplacement rooms.

In the final closure plan, a summary of the investigations performed during the operational period shall be presented.

6 Records of the disposed wastes

The final safety analysis report shall include an adequately detailed description of the characteristics of the wastes to be disposed of. For this purpose, the waste packages shall be classified into categories. A description of each waste category shall include at least
— waste type,
— conditioning method,
— upper bound for the surface dose rate,
— upper bounds for the activities of the most significant nuclides and
— other properties relevant to safety expressed in average values (e.g. flammability, swelling capability, gas generation potential, concentrations of chemically aggressive substances).

A record shall be kept of the disposed wastes. This record shall include waste package specific data of at least
— waste type,
— conditioning method,
— location in the waste emplacement room and
— activities of the most significant nuclides estimated in such a way that the upper bounds for their total activities in each waste emplacement room are obtained.

During the operational period, the record referred to above shall be annually complemented and submitted to the Finnish Centre for Radiation and Nuclear Safety.

7 Safety control

The licensing of a disposal facility, in which the amount of wastes to be disposed of exceeds the limits presented in Section 6, paragraph 1 of the Nuclear Energy Decree, shall comply with the procedures presented in Sections 23–40 of the Nuclear Energy Decree. In connection with the licensing, the documents referred to in Sections 35 and 36 of the Nuclear Energy Decree shall be submitted to the Finnish Centre for Radiation and Nuclear Safety taking into account that
— the safety analyses referred to in Section 4 of this guide correspond to the probabilistic safety analysis,
— the plans for and descriptions of nuclear material control need not be presented whenever the wastes do not contain nuclear materials or other such materials that have bearing on Finland's international treaties in the nuclear energy field and that
— the quality assurance programme, the description of the arrangements for physical protection and emergency response, the administrative rules and the programme for radiation monitoring in the environment can be submitted as supplements to the respective documents of the nuclear power plant.

The Finnish Centre for Radiation and Nuclear Safety controls the construction and operation of a disposal facility for reactor waste in accordance with Sections 108–113 and 115–121 of the Nuclear Energy Act. The essential targets for regulatory control include
— structures that are important to long-term safety,
— the host rock surrounding the repository and the transformations in that host rock,
— systems that are important to operational safety, such as the radiation surveillance system, hoisting and transfer equipment for waste packages, ventilation and sewer system of the controlled area and fire detection and extinguishing system, and
— radiation protection of disposal operations.

In accordance with Section 6 of the Decision of the Council of State /1/, the closure of a waste emplacement room may be commenced after the Finnish Centre of Radiation and Nuclear Safety has approved the closure plan for that room. The closure plan shall include

— description of the technical realization of the closure of the repository,
— safety analyses as referred to in Section 4 of this guide,
— summary of geologic investigations, performed during the operational period, as referred to in Section 6 of this guide, and
— plan for post-closure surveillance, taking into account the requirements included in Section 7 of the Decision of the Council of State.

When all the measures needed for closing the repository have been completed, when the Finnish Centre for Radiation and Nuclear Safety has, in accordance with Section 33 of the Nuclear Energy Act, confirmed the nuclear wastes to have been permanently disposed of in an approved manner, and when other actions as referred to in Section 32 of the Nuclear Energy Act have been completed, the licencee with a waste management obligation shall, in accordance with Section 84 of the Nuclear Energy Decree, apply for an order on the expiry of his waste management obligation.

8 References

1 Decision of the Council of State on the general regulations for the safety of a disposal facility for reactor waste (398/91), 14.2.1991

2 Decision of the Council of State on the general regulations for the safety of nuclear power plants (395/91), 14.2.1991

3 Decision of the Council of State on the general regulations for emergency planning at nuclear power plants (397/91), 14.2.1991

4 Decision of the Council of State on the general regulations for physical protection at nuclear power plants (396/91), 14.2.1991