STUK

GUIDE **YVL 8.1** / 10 SEPTEMBER 2003

DISPOSAL OF LOW AND INTERMEDIATE LEVEL WASTE FROM THE OPERATION OF NUCLEAR POWER PLANTS

This Guide remains in force as of 1 March 2004 until further notice.
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Authorisation

By virtue of the below acts and regulations, the Radiation and Nuclear Safety Authority (STUK) issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards:

- Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987)
- Section 29 of the Government Resolution (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Government Resolution (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Government Resolution (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Government Resolution (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Government Resolution (478/1999) on the Safety of Disposal of Spent Nuclear Fuel.

Rules for application

The publication of a YVL guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear power plants, or to those under construction, and to licensees' operational activities. The guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into account section 27 of the Government Resolution (395/1991), which prescribes that *for further safety enhancement, measures shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.*

If deviations are made from the requirements of a YVL guide, STUK shall be presented with some other acceptable procedure or solution by which the safety level set forth in the guide is achieved.

Translation. Original text in Finnish.

1 General

This Guide specifies the requirements given in the Government Resolution 398/1991 on the general regulations for the safety of a disposal facility for reactor waste. The licensing procedure for a disposal facility is presented in the Nuclear Energy Act and Decree. Some aspects of disposal of reactor waste are also addressed in the Radiation Act and Decree and in the Government Resolutions on the general regulations for the safety, physical protection and emergency preparedness of nuclear power plants (Government Resolutions 395/1991, 396/1991 and 397/1991).

In Finland, the management of operational low and intermediate level wastes from nuclear power plants, so called reactor wastes, is based on the disposal of such waste in facilities located in the bedrocks of the nuclear power plant sites. This Guide applies to the design, construction, operation, and the post-operational phase of such disposal facilities. The Guide addresses disposal facilities which, as defined in Section 11 of the Nuclear Energy Act, are nuclear facilities of considerable general significance.

2 Radiation protection

In accordance with Section 3, Paragraph 1 of the Government Resolution 398/1991, *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, materials used as barriers or radiation protection arrangements. The aim of the optimization analyses is to indicate, that either the radiation exposure of the members of the public as a whole, arising form the selected disposal concept, is small (only a confined critical group receives annual doses above 0,01 mSv), or that alternative concepts are not essentially preferable with regard to the reduction in radiation exposure and to the arising costs.

In accordance with Section 3, Paragraph 2 of the Government Resolution 398/1991, *the expectation value of the annual effective dose to any member of the public is constrained to 0.1 mSv. The annual effective dose to any member of the public, arising from plausible accidental conditions caused by natural events or human actions, is constrained to 5 mSv.*

The expectation value of annual individual dose is defined as a potential radiation exposure of an individual in a given year, multiplied with its probability of occurrence. The total dose is calculated by summing up the exposure contributions from different exposure situations to a given individual. The anticipated and accidental situations giving rise to potential radiation exposure are addressed in Section 4. The probability of occurrence for the radiation exposure from an anticipated situation is assumed to be unity. The probability of occurrence may be quantified for such incidents causing elevated radiation exposure, which have a small probability to occur during the period to be assessed.

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, arising from the operation of the disposal facility or from the disposed waste, due to their place of residence and way of living. For the analysis of radiation exposures in the distant future, hypothetical critical groups shall be defined to represent the people who will be living in the vicinity of the disposal site. The nutritional habits and way of living of these groups can be assumed to be similar to those of people living today.

In accordance with Section 3, Paragraph 3 of the Government Resolution 398/1991, *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.*

Compliance with the environmental radiation protection requirement shall be demonstrated by comparing the calculated activity concentrations in surface waters, soil and air, arising from the disposed waste, 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 Government Resolution 395/1991, 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 enacted in Section 9 of the Radiation Act and Section 2 of the Radiation Decree. Radiation protection arrangements shall comply with Guides YVL 7.9 and 7.10.

The occupational exposure due to natural radioactivity shall be considered in the design, construction and operation of the underground rooms in the disposal facility. Limitation of exposure to natural radioactivity is addressed in Guide ST 12.1.

3 Performance of barriers

In accordance with Section 4 of the Government Resolution 398/1991, *the radiation safety of disposal shall be based on multiple natural and engineered barriers. The engineered barriers shall effectively limit the release of radioactive substances from the waste emplacement rooms for at least 500 years. Thereafter, 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.*

The choice and design of the system of barriers shall aim at such an overall disposal concept that deficiencies in the performance of a single barrier or potential geologic changes will not crucially impair the safety of disposal. The choice of engineered barriers shall be based on technical designs considered reliable and on materials to which experimental or other reliable evidence of long-term stability can be attributed. In the assessment of the isolation capability of the disposal system over 500 years, characteristics of the engineered barriers that have assured long-term stability, can be taken into account in addition to the natural barriers.

In accordance with Section 4 of the Government Resolution 398/1991, *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.*

Consideration shall be given at least to the following rapidly evolving interactions which might impair the performance of barriers

- swelling of waste packages due to e.g. radiolysis, hygroscopic interactions or chemical reactions caused by sulphates
- early deterioration of structures in the waste emplacement rooms due to e.g. corrosion of rebars in concrete structures or swelling reactions caused by sulphates
- effects of gas generation in the waste emplacement rooms due to e.g. corrosion of metals or degradation of organic substances.

4 Safety assessments

In accordance with Section 5 of the Government Resolution 398/1991, *compliance with the regulations for radiation protection and the performance of barriers shall be demonstrated by safety analyses. Such analyses shall cover expected conditions and events as well as disturbances and accidents significant to radiation safety. Technical post-closure surveillance measures to be potentially implemented are not taken into account in the safety analyses.*

The safety analyses shall be specific to the disposal facility and site and they shall cover the operational and post-closure periods. Such safety analyses shall be presented in connection with the preliminary safety analysis report, the final safety analysis report and the final closure plan. An application for Government's decision-in-principle shall include comparable general safety evaluations. Furthermore, the safety analyses shall be revised in case such new data have been obtained as might decisively alter the results of the safety analyses with respect of the safety requirements.

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

The definition of scenarios for analysing the long-term safety of disposal shall be based on the performance of the engineered barriers according to their design bases and on the properties of the host rock according to the geologic investigations carried out. The analyses shall also address the following transitions

- engineered barriers gradually deteriorate due to e.g. reactions with groundwater and interactions evolving in the repository
- water systems on ground surface and the quality and flow of groundwater may change due to e.g. land uplift and sea level variations
- residential, agricultural and industrial conditions in the vicinity of the disposal site may change.

Analyses of the accidental events that might occur after the closure of the repository shall include at least

- failure of barriers due to potential rock movements
- boring a water well close to the waste emplacement area or penetrating it by drilling.

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 safety analyses shall be based on carefully verified calculational methods and on models that are validated as far as practicable. The safety analyses shall be based on such input data and assumptions that the calculated radiation exposure, with a high certainty, exceeds the exposure likely to occur. An analysis aiming at the optimization of radiation protection shall be based on realistic input data and assumptions.

5 Geologic investigations

In accordance with Section 5 of the Government Resolution 398/1991, *bedrock characteristics at the disposal site shall be experimentally investigated to ensure the suitability of the disposal site and facility and to acquire the data needed for safety analyses.*

Prior to the start of construction of the disposal facility, investigations of i.a. structural geology, hydrogeology and the characteristics of groundwater are needed. The preliminary safety analysis report shall include a summary of these geologic investigations. The preliminary safety analysis report shall also be appended by a plan for the investigations to be performed during the construction of the disposal facility. These investigations shall include at least

- investigations for ensuring the suitability of the waste emplacement rooms
- geologic mappings
- periodic measurements of the stresses, movements and deformations in the rock surrounding the waste emplacement rooms
- analyses of groundwater characteristics
- hydrogeologic observations of the host rock surrounding the waste emplacement rooms.

The final safety analysis report shall include a summary of the investigations performed during the construction of the disposal facility. The final safety analysis report shall also be appended by a plan for the investigations to be performed during the operational period. These investigations shall include at least

- periodic measurements of the movements and deformations in the rock surrounding the waste emplacement rooms
- analyses of groundwater characteristics
- hydrogeologic observations of the host rock surrounding the waste emplacement rooms.

The final closure plan shall include a summary of the investigations performed during the operational period.

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 and its material characteristics
- conditioning and packaging method
- maximum surface dose rate of the package
- upper bounds for the activities of the most significant nuclides
- other properties relevant to safety expressed in average values, e.g. flammability, swelling capability, gas generation potential, concentrations of chemically aggressive substances.

A record of the disposed wastes shall be maintained, including waste package specific data of at least

- waste type
- conditioning and packaging method
- location in the waste emplacement room
- activity inventories of the most significant nuclides estimated in such a way that the upper bounds for their total activities in each waste emplacement room can be obtained.

During the operational period, the record referred to above shall be annually updated and submitted to the Radiation and Nuclear Safety Authority in electronic and hard copy form.

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 the Nuclear Energy Decree, shall comply with the procedures presented in Sections 23–40 of the Nuclear Energy Decree. In connection with the construction and operating license applications, the documents referred to in Sections 35 and 36 of the Nuclear Energy Decree, respectively, shall be submitted to the Radiation and Nuclear Safety Authority 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 to be presented only if the waste contains nuclear materials or other materials referred to in Section 1, point 8 of the Nuclear Energy Decree
- 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.

Whenever a disposal facility is intended to be enlarged by virtue of the conditions of the operating licence, amendments to the documents given above shall be submitted. In addition, an evalution of the impacts of the enlargement works on the safety of the existing disposal facility shall be submitted to the Radiation and Nuclear Safety Authority for approval.

The Radiation and Nuclear Safety Authority controls the construction and operation of a disposal facility for reactor waste in accordance with Sections 108–121 of the Nuclear Energy Act. The major targets for regulatory control include

- systems that are important to operational safety, such as the radiation surveillance system, hoisting and transfer equipment for waste packages, ventilation and sewer system at the controlled area and fire detection and extinguishing system
- radiation protection of disposal operations
- structures that are important to long-term safety
- deformations in the rock surrounding the waste emplacement rooms.

Any modifications important to safety to the systems, structures or operational procedures of the disposal facility are subject an advance approval by the Radiation and Nuclear Safety Authority in accordance with Section 112 of the Nuclear Energy Decree.

In accordance with Section 6 of the Government Resolution 398/1991*, the closure of a waste*

emplacement room may be commenced after the Radiation and Nuclear Safety Authority has approved the closure plan for that room.

The closure plan shall include

- description of the technical implementation 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 5 of this Guide
- plan for post-closure surveillance, taking into account the requirements included in Section 7 of the Government Resolution 398/1991.

When all the measures needed for closing the repository have been completed, when the Radiation and Nuclear Safety Authority 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 licensee 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.