STUK

GUIDE **YVL D.5** / 15 NOVEMBER 2013

DISPOSAL OF NUCLEAR WASTE

continues

With regard to new nuclear facilities, this Guide shall apply as of 1 December 2013 until further notice. With regard to operating nuclear facilities and those under construction, this Guide shall be enforced through a separate decision to be taken by STUK. This Guide replaces Guides YVL 8.1, YVL 8.4 and YVL 8.5.

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Authorisation

According to Section 7 r of the Nuclear Energy Act (990/1987), *the Radiation and Nuclear Safety Authority (STUK) shall specify detailed safety requirements for the implementation of the safety level in accordance with the Nuclear Energy Act.*

Rules for application

The publication of a YVL Guide shall not, as such, alter any previous decisions made by STUK. After having heard the parties concerned STUK will issue a separate decision as to how a new or revised YVL Guide is to be applied to operating nuclear facilities or those under construction, and to licensees' operational activities. The Guide shall apply as it stands to new nuclear facilities.

When considering how the new safety requirements presented in the YVL Guides shall be applied to the operating nuclear facilities, or to those under construction, STUK will take due account of the principles laid down in Section 7 a of the Nuclear Energy Act (990/1987): *The safety of nuclear energy use shall be maintained at as high a level as practically possible. For the further development of safety, measures shall be implemented that can be considered justified considering operating experience, safety research and advances in science and technology.*

According to Section 7 r(3) of the Nuclear Energy Act, *the safety requirements of the Radiation and Nuclear Safety Authority (STUK) are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the regulations. If the licensee can convincingly demonstrate that the proposed procedure or solution will implement safety standards in accordance with this Act, the Radiation and Nuclear Safety Authority (STUK) may approve a procedure or solution by which the safety level set forth is achieved.*

1 Introduction

101. Spent nuclear fuel and low and intermediate level waste are accumulated during the operation and decommissioning of nuclear power plants. The spent nuclear fuel originating from Finnish nuclear power plants is intended to be encapsulated and disposed of in repositories constructed deep inside the bedrock. Low and intermediate level waste arising from the operation of nuclear power plants and other nuclear facilities are to be processed and disposed of in bedrock repositories constructed at an intermediate depth. The waste arising from the eventual decommissioning of nuclear power plants and other nuclear facilities is also envisaged to be disposed of in repositories constructed at an intermediate depth.

102. The preparations for the disposal of nuclear waste comprise selecting and characterising the disposal site, developing the disposal method and technology, and developing the methods and collecting the data necessary for assessing the operational and long-term safety of the facilities. The implementation of the disposal involves the excavation of rock caverns and other construction works, packing the waste for disposal, transferring the waste packages into the emplacement rooms, the installation of other engineered barriers, if any, and the backfilling and closure of the excavated rooms.

103. This Guide addresses the facilities and actions referred to above. Chapters 3–7 of the Guide contain requirements pertaining to the disposal facility and disposal methods of nuclear waste as well as obligations pertaining to a licence applicant or licensee, and a licensee under a waste management obligation. Chapter 8 describes regulatory oversight.

104. The basic requirements concerning the safe use of nuclear energy are set out in the Nuclear Energy Act (990/1987). The general principles for radiation protection and provisions concerning radiation work are set out in the Radiation Act (592/1991).

105. According to Section 7 h of the Nuclear Energy Act, *nuclear waste shall be managed so that after disposal of the waste no radiation exposure is caused, which would exceed the level considered acceptable at the time the final disposal is implemented. The disposal of nuclear waste in a manner intended as permanent shall be planned giving priority to safety and so that ensuring long-term safety does not require the surveillance of the final disposal site.*

106. The disposal of nuclear waste is governed by the Government Decree on the Safety of Disposal of Nuclear Waste (736/2008). The Government Decrees on the Security in the Use of Nuclear Energy (734/2008) and Emergency Response Arrangements at Nuclear Power Plants (716/2013) also pertain to the disposal of nuclear waste where applicable.

107. The handling and encapsulation of spent nuclear fuel for disposal are addressed in Guide YVL D.3, Handling and storage of nuclear fuel, and the processing and packaging of other nuclear waste for disposal is addressed in Guide YVL D.4, Predisposal management of low and intermediate level nuclear waste and decommissioning of a nuclear facility. Several other YVL Guides issued by STUK are also applicable to the disposal of nuclear waste. This Guide contains references to the applicable Guides; the relevant paragraphs are specified where practicable.

2 Scope of application

201. This Guide addresses the large-scale disposal of nuclear waste in repositories constructed inside the bedrock. The types of nuclear waste within the scope of the present Guide include spent nuclear fuel, radioactive waste arising from the operation of a nuclear facility, radioactive waste arising from the dismantling of a nuclear facility, and other radioactive waste to be disposed of in repositories designed for nuclear waste. The Guide covers the whole life cycle of a disposal facility (site investigations, design, construction, operation and closure), and it addresses both the operational safety of disposal facilities and the demonstration of the long-term safety of disposal.

3 Nuclear and radiation safety

3.1 Operation of a disposal facility

301. A disposal facility and its operation shall be so designed that *as a consequence of undisturbed operation of the facility, releases of radioactive materials into the environment remain insignificantly low* (Government Decree 736/2008, Section 3).

302. Pursuant to Section 3 of Government Decree 736/2008 and the optimisation principle of Section 2 of the Radiation Act, the disposal facility shall be so designed that the average annual dose to the most exposed individuals of the population, arising from normal operation of the facility, does not exceed the 0.01 mSv constraint.

303. The disposal facility and its operation shall be so designed that the annual dose to the most exposed individuals of the population remains below the values indicated below (Government Decree 736/2008, Section 3):

a. 0.1 mSv as a result of an anticipated operational occurrence;
b. 1 mSv in the event of a Class 1 postulated accident; and
c. 5 mSv in the event of a Class 2 postulated accident.

304. The dispersion analyses of radioactive releases to the environment and the analyses of the radiation doses arising from the releases shall be conducted in compliance with Guide YVL C.4, Assessment of radiation doses to the public in the vicinity of a nuclear facility, where applicable. This applies to normal operation, operational occurrences and accidents.

305. The anticipated operational occurrences to be considered shall be defined as events that have a high probability to occur during the lifetime of the facility (on average at least once over a span of one hundred operating years). At least the following shall be considered as operational occurrences:

a. a waste package handling error;
b. a component failure or malfunction and the resulting non-operability of a non-redundant system;
c. loss of power in a waste package handling system or related safety system;
d. fire in a safety-significant location; and
e. a major water leakage or flood in the disposal facility.

306. The postulated accidents to be considered shall be defined and classified based on their estimated probability so that a Class 1 accident may occur more frequently and a Class 2 accident less frequently than once over a span of one thousand years. At least the following shall be considered as postulated accidents:

a. dropping or other handling errors of the disposal canister;
b. an explosion or tunnel collapse in the disposal facility that incurs damage to the waste packages; and
c. a design basis earthquake.

3.2 Long-term safety

Radiation dose constraints

307. The disposal of nuclear waste shall be so designed that the radiation impacts arising as a consequence of expected evolution:

a. the annual dose to the most exposed individuals remains below the value of 0.1 mSv; and
b. the average annual doses to other individuals remain insignificantly low.

These constraints shall be applied over an assessment period, during which the radiation exposure of humans can be assessed with sufficient reliability, and which shall extend, at a minimum, over several millennia (Government Decree 736/2008, Section 4).

308. In applying the dose constraints, account shall be taken of the changes in the living environment that arise from changes in ground and sea level. The climate type as well as human habits, nutritional needs and metabolism can be assumed to remain unchanged.

309. In applying the dose constraints, the exposure shall be assumed to arise from radioactive

materials released from the repository and migrated to near-surface groundwater bodies and further to above-ground watercourses. At least the following potential exposure pathways shall be considered:

a. the use of contaminated water as household and irrigation water and for animal watering; and
b. the use of contaminated natural or agricultural products originating from terrestrial or aquatic environments.

310. The dose constraint for the most highly exposed individuals, 0.1 mSv per year, stands for the average individual dose in a self-sustaining family or small village community living in the environs of the disposal site, where the highest radiation exposure arises through different exposure pathways. In the living environment of this community, a small lake and a shallow water well, among other things, are assumed to exist.

311. In addition to the community referred to in para. 310, the average annual doses to larger groups of people living in the environs of a large lake or sea coast shall be addressed. The acceptability of these doses depends on the size of the group of people exposed, the maximum dose, however, being in the range of 1 to 10% of the dose constraint for the most highly exposed individuals specified in point a of para. 307 above.

Release constraints of radioactive materials

312. The disposal of nuclear waste shall be so designed that, as a consequence of expected evolution, the average long-term quantities of radioactive materials released into the living environment from disposed nuclear waste remain below the constraints specified separately for each nuclide by the Radiation and Nuclear Safety Authority. These constraints shall be so defined that:

a. at a maximum, the radiation impacts arising from disposal may be equivalent to those caused by natural radioactive materials in the earth's crust; and
b. on a large scale, the radiation impacts remain insignificantly low (Government Decree 736/2008, Section 4).

The constraints shall be applied in limiting the radiation exposures arising beyond the assessment period referred to in para. 307.

313. The nuclide specific constraints for radioactive releases to the living environment (average release of radioactive materials per annum) referred to in para. 312 are as follows:

a. 0.03 GBq/a for long-lived, alpha-emitting radium, thorium, protactinium, plutonium, americium and curium isotopes;
b. 0.1 GBq/a for the nuclides Se-79, Nb-94, I-129 and Np-237;
c. 0.3 GBq/a for the nuclides C-14, Cl-36 and Cs-135 and for long-lived uranium isotopes;
d. 1 GBq/a for the nuclide Sn-126;
e. 3 GBq/a for the nuclide Tc-99;
f. 10 GBq/a for the nuclide Zr-93;
g. 30 GBq/a for the nuclide Ni-59; and
h. 100 GBq/a for the nuclide Pd-107.

314. The constraints of para. 313 shall apply to activity releases that may migrate to the living environment after several thousands of years at the earliest. These activity releases can be averaged over 1,000 years at the most. The sum of the ratios between the nuclide-specific activity releases and the respective constraints shall be less than one.

Unlikely events

315. The significance of unlikely events impairing long-term safety shall be assessed by evaluating the reality, probability and possible consequences of each event. Whenever possible, the radiation impacts caused by such events shall be assessed quantitatively (Government Decree 736/2008, Section 5).

316. The unlikely events potentially impairing long-term safety induced by natural phenomena to be considered shall at least include rock movements jeopardising the integrity of disposal canisters. Unlikely events caused by human actions to be considered shall at least include the boring of a medium-deep water well at the disposal site and core drilling or boring hitting a disposed waste package. In such a case, it is assumed that the existence of the disposed waste is not known and that the incident may only occur 200 years

following the closure of the disposal facility at the earliest.

317. The probability and importance to safety of the incidents referred to in para. 316 as well as the annual radiation doses or activity releases arising from them shall be assessed. Where possible, the expectation values for the radiation effects arising from the incidents shall be assessed and compared against the radiation dose constraint of para. 307 or the release constraint of para. 313. The possibility of such radiation exposure that might imply deterministic effects (dose at least around 0.5 Sv) shall be very low.

Protection of other living species

318. The disposal shall not have detrimental radiation effects on species of flora and fauna. This shall be demonstrated by assessing the typical radiation exposures of terrestrial and aquatic populations in the disposal site environment, assuming the present kind of living populations. The assessed radiation exposures shall remain clearly below the doses that, on the basis of the best available knowledge, would cause significant detriment to any living population.

4 Planning of the disposal method

4.1 Stepwise implementation

401. According to Section 10 of Government Decree 736/2008, *disposal shall be implemented in stages, with particular attention paid to aspects affecting long-term safety. The planning of the construction, operation and closure of a disposal facility shall take into account the reduction of the activity of nuclear waste through interim storage, the utilisation of high-quality technology and scientific data, and the need to ensure long-term safety via investigations and monitoring. However, the implementation of the various stages of disposal shall not be unnecessarily postponed.*

402. The disposal of nuclear waste involves the following implementation stages:

a. selection of the disposal concept;
b. selection and characterisation of the disposal site, which may include the construction of an underground research facility at the site;
c. design of the disposal facility with related research and development work;
d. construction of the disposal facility;
e. waste emplacement activities and other operation of the disposal facility;
f. backfilling and closure of emplacement rooms and other underground rooms; and
g. post-closure monitoring measures of the disposal facility, where required.

These stages may be partly parallel.

403. The various disposal stages shall be scheduled and implemented giving priority to safety. The preparedness for advancing to the next stage shall be assessed as a whole, taking into account the suitability of the disposal concept and site, technical feasibility and, in particular, the outcome and reliability of the long-term safety analyses.

4.2 Barriers and safety functions

404. According to Section 11(1) of Government Degree 736/2008, *the long-term safety of disposal shall be based on safety functions achieved through mutually complementary barriers so that a deficiency of an individual safety function or a predictable geological change will not jeopardise the long-term safety.*

405. Based on the characteristics of the waste to be disposed of, at least the following engineered barriers shall be considered in planning the disposal:

a. the waste matrix;
b. the waste package;
c. the buffer surrounding the waste packages;
d. the backfilling of emplacement rooms; and
e. the closing structures of the disposal facility.

406. At least the following shall be considered as the safety functions provided by means of engineered barriers:

a. the immobilisation of radioactive materials in the waste matrix;
b. the corrosion resistance of the waste package;

c. the mechanical stress endurance of the waste package;
d. the buffer's containment characteristics and yield to minor rock movements; and
e. the characteristics of the buffer, backfill and closing structures that maintain the functionality of the other engineered barriers and limit the migration of radioactive materials through excavated caverns.

407. The bedrock surrounding the emplacement rooms serves as a natural barrier.

408. At least the following shall be considered as the safety functions provided by means of the natural barrier:
a. the stability and water tightness of the rock;
b. low groundwater flow;
c. favourable groundwater chemistry;
d. the retardation of radioactive materials in the rock; and
e. protection against natural phenomena and human actions.

409. Performance targets shall be specified for each safety function based on high-quality scientific knowledge and expert judgement. In doing so, account shall be taken of the factors affecting the disposal conditions during each assessment period as well as their combined effects. In an assessment period extending up to several thousands of years, one can assume that the bedrock of the site remains in its current state, taking account, however, of the changes due to the disposed waste and predictable or foreseable processes such as land uplift and excavations.

410. In defining performance targets for the safety functions provided by means of engineered barriers, account shall be taken of the quantities and half-lives of radioactive materials. The point of departure for the disposal of spent nuclear fuel shall be that the safety functions provided by the engineered barriers will effectively limit the release of radioactive materials into the bedrock at least for about 10,000 years. Respectively, the duration of the effective containment provided by means of engineered barriers shall be at least about 500 years for short-lived waste disposed of in the bedrock.

411. The design of the safety functions shall aim to provide a disposal concept that is not sensitive to changes in the bedrock. Another design objective shall be that the characteristics of the engineered barriers in the disposal facilities will not change over time in a way that may have adverse effect on the safety functions, with due consideration given to the reduction of the importance of engineered barriers over long periods of time.

4.3 Disposal site and repository

412. The bedrock of the disposal site shall, to a sufficient extent, possess natural barrier characteristics that lend support to safety functions as specified in para. 408. Factors indicating the unsuitability of a disposal site include at least the following:
a. the proximity of exploitable natural resources;
b. abnormally high rock stresses with regard to the strength of the rock;
c. anomalously high seismic or tectonic activity; and
d. exceptionally adverse groundwater characteristics, such as the lack of reducing buffering capacity and high concentrations of substances that may impair the safety functions.

413. The characteristics of the bedrock shall be favourable in view of the long-term performance of the engineered barriers. Such conditions in the bedrock that are of importance in terms of long-term safety shall be stable or assessable up to at least several thousands of years. The range of subsequent geological changes, in particular those due to large-scale climate changes, shall also be assessable and taken into account in specifying performance targets for the safety functions.

414. The locations of the emplacement rooms shall be favourable with respect to the groundwater flow regime at the disposal site. The disposal depth shall be selected giving priority to long-term safety, taking into account the geological structures of the bedrock as well as the changes occurring in hydraulic conductivity, groundwater chemistry and mechanical stability of the rock following the increase in depth. The repository for spent nuclear fuel shall be located at the depth of several hundreds of meters so as to adequately mitigate the impacts of above-ground natural phe-

nomena, such as glaciation, and human actions. The repositories for other long-lived waste and those for short-lived waste shall be located at the depth of some tens of meters at a minimum.

5 Planning and design of the disposal facility and disposal operations

5.1 Radiation safety

501. The planning and design of the disposal facility and the operations conducted therein shall take account of the following considerations:

a. The facility shall have in place a classification into radiation protection areas and zones as provided in Guide YVL C.2, Radiation protection and exposure monitoring of nuclear facility workers.
b. The layout design and the design of systems and components shall comply with the requirements of Guide YVL C.1, Structural radiation safety at a nuclear facility, with due consideration given to the special characteristics of underground facilities and the work conducted inside them.
c. The facility shall have radiation monitoring systems in place as specified in Guide YVL C.6, Radiation monitoring at a nuclear facility.
d. The limitation and monitoring of potential radioactive releases shall be conducted in compliance with the requirements of Guide YVL C.3, Limitation and monitoring of radioactive releases from a nuclear facility, where applicable.

502. The operations shall be so planned that the radiation exposure of workers is kept as low as reasonably achievable. Radiation shields or remote control shall be used where necessary.

5.2 Design of systems, structures and functions

Classifications

503. The systems, structures and components of a disposal facility shall be safety-classified according to their functional and structural importance to safety. The classification shall be based not only on the operational safety of the facility, but also on the long-term safety of disposal. The safety class shall be considered in setting requirements for the design, fabrication, installation, testing and inspection of a system, structure or component. Structures and components shall also be classified based on their durability under environmental conditions. The classifications related to the operation of the disposal facility shall comply with Guide YVL B.2, Classification of systems, structures and components of a nuclear facility, where applicable.

504. Any systems, structures and components with a major bearing on the radiation protection of the personnel at the facility or the prevention of radioactive releases shall be classified in terms of the operational safety of the disposal facility. Functions of importance notably include transfers of waste packages, radiation measurements and fire protection in compartments accommodating radioactive materials.

505. Any systems, structures and components with a major bearing on the safety functions specified in paras. 406 and 408 or that may have major adverse effects on long-term safety within the meaning of para. 508 shall be classified in terms of the long-term safety of disposal. Systems, structures and components of importance include waste packages and the buffer materials and containment structures surrounding them, and the host rock surrounding the underground caverns of the disposal facility.

Construction, operation and closure of the disposal facility

506. During the construction and operation of the disposal facility, a research, testing and monitoring programme shall be executed to ensure that the site and the rock to be excavated are suitable for disposal and to collect supplementary information the safety-relevant characteristics of the host rock and the performance of the barriers. This programme shall at least include:

a. the characterisation of the rock volumes intended to be excavated;

b. the monitoring of rock stresses, movements and deformations in rock surrounding the emplacement rooms;
c. the hydrogeological monitoring of the host rock surrounding the emplacement rooms;
d. the monitoring of groundwater chemistry; and
e. the monitoring of the performance of engineered barriers.

507. Any structures and other characteristics of the host rock surrounding the repositories that may be of importance with regard to groundwater flow, rock movements or other factors affecting long-term safety shall be defined and classified. Provision shall be made for modifications to the layout of the underground caverns in the event that the quality of the host rock surrounding the foreseen emplacement rooms turn out to be unfavourable.

508. The construction, operation and closure of the emplacement rooms and other underground caverns shall aim at maintaining the rock characteristics that are favourable to long-term safety. To this end, in particular when the disposal of spent fuel is implemented:
a. such rock construction methods shall be used that limit disturbances in the rock surrounding the emplacement rooms to a level as low as reasonably achievable;
b. reinforcement and injection of the host rock shall be done in such a way that no significant amounts of substances detrimental to the performance of the barriers enter the emplacement rooms;
c. the ingress of organic, oxidising and other potentially detrimental substances into the emplacement rooms shall be minimised; and
d. the emplacement rooms shall be backfilled and closed as soon as practicable with regard to the waste emplacement and related monitoring activities.

509. The layout of the disposal facility shall be so designed that the waste emplacement activities are appropriately separated from the transfers of excavated rock, backfill materials and heavy machinery. Excavation-induced rock collapses or displacements in rooms where disposal canister emplacement is underway or has been completed shall be prevented by means of careful excavation and rock reinforcement, and by keeping these caverns at a sufficient distance from the excavation work.

510. The transfer and installation of the disposal canister along with the installation of buffer and backfill materials shall be so performed as to prevent the occurrence of any damage compromising the performance of engineered barriers.

Design of systems, structures, and components

511. The systems, structures and components of a disposal facility shall be designed with due consideration given to their safety class, foreseen service life and environmental conditions. The design of systems, structures and components shall take account of operational occurrences and postulated accidents. Any structures and components susceptible to wear or damage shall be capable of being repaired or replaced.

512. The design of the structures of a disposal facility shall, where applicable, comply with the requirements set out in Guide YVL E.6, Buildings and structures of a nuclear facility.

513. The design of systems and components shall comply with the general requirements included in Guide YVL B.1, Safety design of a nuclear power plant, and, where applicable, the requirements included in:
a. Guide YVL E.7, Electrical and I&C equipment of a nuclear facility, discussing electrical and I&C equipment; and
b. section 5.5 of Guide YVL B.1, Safety design of a nuclear power plant, discussing air conditioning and ventilation systems.

514. The design of hoisting and transfer equipment shall comply with the requirements set out in Guide YVL E.11, Hoisting and transfer equipment of a nuclear facility.

5.3 Prevention of occurrences and accidents

Functions to be ensured

515. Steps shall be taken to ensure any functions in the disposal facility, the failure of which might induce an accident resulting in a significant release of radioactive materials or radiation exposure of the facility's personnel. In ensuring the functions, the principles of separation and diversity shall be applied whenever practicable. The functions to be ensured for single failure shall be determined based on their safety classification and typically include:

a. braking systems of the transfer elevator or carriage for spent fuel disposal canisters;
b. radiation measurements in rooms where exposure to significant radiation doses is possible;
c. fire alarm and extinguishing systems in areas where a fire could cause a significant radiation hazard or other threat; and
d. power supplies important to the facility's operational safety.

Fires and explosions

516. The prevention of fires and explosions shall primarily be based on room layout planning and fire compartmentation. As a rule, no such materials or equipment that would increase the fire load or pose an ignition or explosion hazard shall be placed within fire compartments important to safety or in their immediate vicinity. The materials used in such compartments shall predominantly be incombustible and heat resistant.

517. The disposal facility shall be equipped with an automatic fire alarm system by means of which any fire can be located. The facility's rooms and systems where a fire could cause a significant radiation hazard or other threat shall be equipped with a suitable fire extinguishing system and with first-response fire fighting equipment suitable for operative fire fighting. The planning and design of fire safety arrangements shall, where applicable, comply with Guide YVL B.8, Fire protection at a nuclear facility, with due consideration given to the special conditions prevailing in underground caverns.

Consideration of external events

518. The natural phenomena to be considered in the design of a disposal facility shall at least include lightning, earthquake and flood. Potential internal events to be considered, besides those discussed above (handling failure, fire and explosion), shall at least include tunnel collapse and flooding due to a failure in the pumping of leaked waters.

519. Security arrangements shall be in place to protect the disposal of nuclear waste against unlawful action, the extent of which shall be commensurate with the threat arising from unlawful action. The planning and design of security arrangements shall, where applicable, comply with the requirements of Guide YVL A.11, Security of a nuclear facility.

Criticality

520. The spent nuclear fuel contained in a disposal canister shall remain subcritical also in the long term. The design shall accommodate conditions where the leak-tightness of the container has been lost and the container has sustained mechanical or corrosion-induced deformations. Criticality safety is covered by the requirements set out in Chapter 5 of Guide YVL B.4, Nuclear fuel and reactor, where applicable.

5.4 Nuclear safeguards

521. In designing and operating a facility intended for the disposal of spent nuclear fuel or other nuclear materials, provisions shall be made for nuclear safeguards arrangements in compliance with Guide YVL D.1, Regulatory control of nuclear safeguards. The facility shall have the necessary rooms and equipment in place. Transport routes, buffer stores and handling processes shall be so designed that the control of material flows to and from the underground rooms is feasible and a continuity of knowledge of nuclear material data is assured. The facility shall not contain any premises, materials or functions of nuclear safeguards relevance that are not included in its design information. The disposed nuclear material shall remain in their declared positions during the operation of the facility and after its closure.

6 Operation of a disposal facility

601. The construction and commissioning of a disposal facility shall, where applicable, comply with Guide YVL A.5, Construction and commissioning of a nuclear facility. The holder of an operating licence for a disposal facility shall have in its possession the documents required under Section 36 of the Nuclear Energy Decree and Section 18 of Government Decree 736/2008. These documents shall be regularly updated to reflect the current structure and state of the facility.

602. The holder of an operating licence for a disposal facility shall have an operating experience feedback programme in place. The licensee shall also have a research, testing and monitoring programme referred to in para. 506 in place. Safety research shall also be followed on a continuous basis. Based on the follow-up programmes and in response to the advancement of construction and disposal methods, the opportunities for enhancing safety shall be considered and any improvements deemed justified shall be implemented.

603. The holder of an operating licence of a disposal facility shall maintain records of the disposed waste, providing at least the following information to an accuracy of an individual waste package:

a. the waste type, its processing and packaging method and structural and material characteristics significant to safety;
b. a waste package identifier and location in the emplacement room;
c. the upper limits for the activities of the dominant nuclides, to an accuracy of an individual disposal canister in case of spent fuel and to an accuracy of an individual emplacement room in case of other waste; and
d. the effective multiplication factor and heat generation calculated for spent fuel disposal canisters.

A summary of the records shall be annually submitted to STUK.

604. In the event that the licensee, following the commissioning of the disposal facility concerned, wishes to modify any system, structure, component or mode of operation of the facility that STUK has previously approved, the modification plan shall be subjected to STUK's approval as provided in Section 112 of the Nuclear Energy Decree prior to its implementation. The modification plan shall comply with the requirements set out in Guide YVL A.1, Regulatory oversight of safety in the use of nuclear energy.

605. The licensee shall oversee the fabrication of the disposal system components. If the safety class of the component is 3 or higher, the licensee shall qualify the instructions and methods used in its fabrication.

606. The holder of an operating licence for a disposal facility for spent nuclear fuel shall review the quality control documentation to ensure that the emplacement of the canister, the installation of the surrounding buffer material and the backfilling of the emplacement rooms have been performed in an acceptable manner.

607. The disposal canister shall be uniquely identified before insertion inside the buffer material so as to confirm its radioactivity and nuclear material inventory.

608. Prior to the commissioning of a disposal facility, a baseline survey of the radiological status of the facility's environment shall be carried out as provided in Guide YVL C.4, Assessment of radiation doses to the public in the vicinity of a nuclear facility.

609. The amount of radioactive materials released to the environment from a disposal facility shall be monitored by means of representative measurements performed at the potential release pathways of radioactive materials. Release measurements are covered, where applicable, by Guide YVL C.3, Limitation and monitoring of radioactive releases from a nuclear facility.

610. A radiation monitoring programme shall be implemented in the vicinity of a disposal facility, the extent of which shall be determined based on the foreseen releases of radioactive materials. Environmental radiation monitoring is covered, where applicable, by Guide YVL C.4, Assessment of radiation doses to the public in the vicinity of a nuclear facility.

611. The radiation protection and exposure monitoring of the operating personnel of a disposal facility shall be carried out in compliance with YVL C.2, Radiation protection and exposure monitoring of nuclear facility workers.

612. A disposal facility shall have emergency response arrangements in place, the extent of which shall be commensurate with the foreseen accidents, and the design of which shall, where applicable, be based on Guide YVL C.5, Emergency arrangements of a nuclear power plant.

613. Under Section 7 k of the Nuclear Energy Act, the licensee shall appoint a responsible manager and his or her deputy for the nuclear facility. The holder of an operating licence for a disposal facility shall also specify the positions and functions important to safety and define the required qualifications. The licensee shall verify the competences of the individuals in these positions prior to the commissioning of the facility and prepare training programmes for developing and maintaining the competence of the personnel. The organisation of a nuclear facility is addressed in Guide YVL A.4, Organisation and personnel of a nuclear facility.

7 Demonstration of compliance with safety requirements

7.1 Principles for the demonstration of safety

Operational safety

701. Compliance with the safety requirements pertaining to the planned operation of the disposal facility for nuclear waste shall be verified in connection with the pre-operational testing of the facility at the latest. The performance of safety systems designed in view of operational occurrences and accidents shall be verified in connection with the pre-operational testing as far as practicable.

702. In the event that the probability or consequences of an anticipated operational occurrence or a postulated accident cannot be shown to remain insignificant by reference to the design basis or safety systems, compliance with safety requirements shall be demonstrated by means of computational analyses. The representativeness of the analyses shall be ensured by considering various kinds of occurrences and accidents with the greatest safety impact that may occur in connection with the disposal of the type of nuclear waste concerned.

703. The fulfilment of the requirements concerning radiation protection of the facility's workers and the public in its vicinity shall be primarily demonstrated by means of a deterministic safety analysis. Additionally, if an accident may have severe consequences based on deterministic analyses, it shall be assessed by means of a probabilistic risk assessment where the probability of accidents and the potential radioactive releases resulting from them are assessed.

Long-term safety

704. Compliance with the requirements concerning long-term radiation safety, and the suitability of the disposal method and disposal site, shall be proven through a safety case that shall at least include:

a. a description of the disposal system and the definition of barriers and safety functions;
b. the specification of performance targets for the safety functions;
c. a definition of the scenarios (scenario analysis);
d. a functional description of the disposal system and a description of the conditions prevailing at the disposal site by means of conceptual and mathematical modelling, and the determination of necessary model parameters;
e. an analysis of the quantities of radioactive materials that are released from the disposed

waste, penetrate the barriers and enter the biosphere, and an analysis of the resulting radiation doses;
f. whenever possible, an estimation of the probabilities for activity releases and radiation doses arising from unlikely events impairing long-term safety;
g. uncertainty and sensitivity analyses and complementary qualitative considerations; and
h. a comparison of the outcome of the analyses against the safety requirements.

Detailed requirements for the content of the safety case are provided in Annex A.

Acceptance of waste for emplacement in the disposal facility

705. Criteria shall be defined for the nuclear waste and waste packages being disposed of, based on the operational safety of the disposal facility and the long-term safety of disposal which any waste brought into the disposal facility shall satisfy. Requirements pertaining to the criteria to be imposed on spent nuclear fuel are set out in Guide YVL D.3, Handling and storage of nuclear fuel.

7.2 Safety analysis reports and their annexes

706. When the preliminary and final safety analysis reports pertaining to a disposal facility are prepared, the requirements set out in section 6 of Guide YVL B.1, Safety design of a nuclear power plant, shall be complied with where applicable. Additionally, the safety analysis reports shall at least provide:

a. a description of the safety principles, design bases and other criteria adopted in the design of the disposal facility;
b. a detailed description of the disposal site and description of its bedrock based on the investigations conducted to date;
c. a description of the wastes to be disposed of, their processing and packaging methods, the characteristics of the disposed waste packages, and any materials to be installed around them;
d. a clarification of the criteria referred to in para. 705 and the grounds thereof;
e. a description of the disposal facility (excavations, engineered structures and systems) and its implementation (construction, operation and closure); a detailed description of the part of the facility already implemented and a plan for the parts that will be constructed later;
f. a description of the disposal activities; an outline in the preliminary safety analysis report and a detailed description in the final safety analysis report;
g. a description of the disposal facility's personnel and of the procedures used for verifying the competences of the persons in positions important to safety; an outline in the preliminary safety analysis report and a detailed description in the final safety analysis report;
h. a description of the research, monitoring and control programmes to be implemented at the disposal facility (programmes referred to in para. 506, ageing monitoring programme, operating experience feedback programme); an outline in the preliminary safety analysis report and a detailed description in the final safety analysis report;
i. a summary of the analyses concerning the operational safety of the disposal facility addressing the radiation exposure of workers and potential radioactive releases, and the resulting radiation doses arising from normal operation, operational occurrences and accidents; and
j. a summary of the safety case pertaining to long-term safety.

707. The safety analysis reports shall be supplemented with topical reports, the purpose of which is to clarify on what kind of experimental studies and analyses the design and planning of the disposal facility and its operations are based.

7.3 Periodic safety review

708. The licensee shall carry out a periodic safety review for the disposal of nuclear waste at least once every 15 years, unless otherwise provided in the conditions of the operating licence. The periodic safety review shall include assessments of the disposal facility's safety status and the long-term safety of disposal as well as potential

development targets in view of maintaining and enhancing safety, taking due account of the considerations of para. 602, among other things. The safety analysis report and safety case shall be updated to reflect the results of the safety review. The periodic safety review shall be conducted in compliance with the requirements of Guide YVL A.1, Regulatory oversight of safety in the use of nuclear energy, where applicable.

8 Regulatory oversight by the Radiation and Nuclear Safety Authority

8.1 Decision-in-principle and licensing processes

801. A disposal facility for nuclear waste is a nuclear facility of considerable general significance (Nuclear Energy Act, Section 11, Nuclear Energy Decree, Section 6), the construction of which is subject to a Government decision-in-principle unless otherwise provided in the transitional provisions of the Nuclear Energy Act (Section 84). Under Section 24 of the Nuclear Energy Decree, at least the following safety-relevant documents concerning the foreseen facility shall be annexed to the application for a decision-in-principle:

a. an outline of the technical principles of the planned nuclear facility;
b. a description of the safety principles adopted and the design criteria observed to avoid or limit environmental impact; and
c. an evaluation of the suitability of the foreseen site for its intended purpose.

The documents and their annexes shall be detailed enough to allow STUK to carry out a preliminary safety assessment based on them as provided in Section 12 of the Nuclear Energy Act.

802. When a construction licence for a disposal facility for nuclear waste is applied for, the documents specified in YVL A.1, Regulatory oversight of safety in the use of nuclear energy, shall be submitted to STUK for approval where applicable.

STUK will review and approve the additions to the respective documents insofar as the intention is to enlarge the disposal facility under the terms and conditions of an existing operating licence. Additionally, a report discussing the potential impact of the foreseen enlargement work on the safety of existing nuclear facilities shall be submitted to STUK for approval.

803. When an operating licence for a disposal facility for nuclear waste is applied for, the documents specified in YVL A.1, Regulatory oversight of safety in the use of nuclear energy, shall be submitted to STUK for approval where applicable.

STUK will review and approve the additions to the respective documents insofar as the intention is to commission an enlargement of the disposal facility under the terms and conditions of an existing operating licence. The commissioning of such facilities is subjected to the Radiation and Nuclear Safety Authority's approval as provided in Section 20 of the Nuclear Energy Act.

8.2 Oversight of the construction, operation and closure of a disposal facility

804. STUK oversees the construction and commissioning of a disposal facility for nuclear waste in accordance with Guides YVL A.1, Regulatory oversight of safety in the use of nuclear energy, and YVL A.5, Construction and commissioning of a nuclear facility. STUK will issue a separate decision as to the applicability of Guide YVL A.6, Conduct of operations at a nuclear power plant, to the conduct of operations at a disposal facility.

805. In the event that an underground research facility, intended to constitute a part of the foreseen disposal facility, is constructed at the disposal site prior to the issuance of the construction licence, STUK oversees the design and construction of the research facility to the extent it sees fit following the same procedure as that pertaining to the construction of the disposal facility. A precondition for the commencement of the construction of a research facility is that STUK has approved the following documents:

a. a detailed description of the research facility and its construction timetable and the methods to be used in construction;
b. a description of the potential effects of the construction of the research facility on the characteristics of the disposal site's bedrock, in particular in view of long-term safety;
c. a proposal for a safety classification document;
d. a report on quality management during construction;
e. a plan for arranging the necessary safeguards to prevent the proliferation of nuclear weapons insofar as nuclear materials are intended to be emplaced in the repository; and
f. a description of the arrangements for facilitating STUK's regulatory control.

The documents shall be kept up-to-date during the construction of the research facility.

806. The construction of the various parts of the disposal facility shall be implemented stepwise such that the investigations concerning the suitability of the rock volume to be excavated and the classification pursuant to para. 507 have been brought to completion prior to the commencement of each construction stage. A precondition for the commencement of an individual construction stage is that STUK has approved the modified or detailed construction plan following the procedure described in para. 604.

807. STUK will conduct a commissioning inspection on all safety-classified rock caverns and structures, as well as on those that are important to long-term safety.

808. The licensee shall inspect and approve the rock caverns and structures subject to a commissioning inspection prior to STUK's inspection.

809. In the commissioning inspection of rock caverns and structures, STUK will inspect that:
a. the caverns and structures conform to the design documents (document review and visual inspection);
b. any non-conformances have been handled in an acceptable manner;
c. the quality control records have been inspected and approved; and
d. the licensee has conducted the commissioning inspections.

810. The commissioning of a disposal facility has been defined in Guide YVL A.1, Regulatory oversight of safety in the use of nuclear energy.

811. STUK oversees the fabrication of the disposal system components that are important to long-term safety. Depending on the type of component and its safety class, the oversight may include approval of the construction plan and the manufacturer, control of the manufacturing process, and construction inspections. STUK will witness receiving inspections at its discretion.

812. A spent fuel disposal canister may be transferred to its emplacement location after STUK has ascertained that the characteristics of the host rock surrounding the canister's emplacement location are acceptable to a sufficient extent. As a minimum, STUK will inspect the quality control documentation referred to in para. 606 and the records made on the disposal to ascertain that the emplacement of each disposal canister and the installation of the buffer materials and the backfilling of the emplacement rooms have been performed in an acceptable manner.

813. In the event that a part of a disposal facility is backfilled and closed during the operation of the facility, the approval procedure described in para. 604 shall be complied with.

814. A licensee with a waste management obligation shall apply for an order on the expiry of his waste management obligation when all the measures necessary for closing the disposal facility have been completed (Nuclear Energy Decree, Section 84). A prerequisite for the expiry of the waste management obligation is that STUK has confirmed that the nuclear waste has been permanently disposed of in a manner it has approved (Nuclear Energy Act, Section 33) and that the measures specified in Section 32 of the Nuclear Energy Act have been duly completed.

815. A precondition for the permanent closure of a disposal facility is that STUK has approved the closure plan, which shall include:

a. a description of the technical implementation of the closure of the repository;
b. an update of the safety case with due consideration given to the outcomes of the research, testing and monitoring programmes referred to in para. 506; and
c. a plan for the potential post-closure monitoring measures and a proposal for the restriction zone with prohibition on measures referred to in Section 85 of the Nuclear Energy Decree.

Definitions

Intermediate level waste

Intermediate level waste shall refer to waste that, because of its high level of activity, requires effective radiation protection arrangements when processed. The activity concentration of such waste is usually 1 MBq/kg–10 GBq/kg.

High level waste

High level waste shall refer to waste that, because of its high level of activity, requires highly effective radiation protection arrangements when processed and usually also cooling. The activity concentration of such waste is usually more than 10 GBq/kg.

Disposal facility

Disposal facility shall refer to an entirety comprising the rooms for the disposal of the waste packages (emplacement rooms) and the adjoining underground and above-ground auxiliary facilities.

Disposal site

Disposal site shall refer to the location of the disposal facility and, after disposal has been completed, the area entered in the real estate register in accordance with Section 85 of the Nuclear Energy Decree, and the ground and bedrock under it.

Short-lived waste

Short-lived waste shall refer to nuclear waste, the activity concentration of which after 500 years is below the level of 100 MBq/kg in each disposed waste package, and below an average value of 10 MBq/kg in waste in one emplacement room.

Low level waste

Low level waste shall refer to waste that, because of its low level of activity, can be processed without any special radiation protection arrangements. The activity concentration of such waste is usually not more than 1 MBq/kg.

Anticipated operational occurrence

Anticipated operational occurrence shall refer to such incident influencing the safety of a nuclear waste facility that can be expected to occur at least once during any period of a hundred operating years. (Government Decree 736/2008)

Postulated accident

Postulated accident shall refer to such incident influencing the safety of a nuclear waste facility that can be assumed to occur more rarely than once during any period of a hundred operating years; postulated accidents are grouped further into two classes on the basis of their frequency: a) class 1 postulated accidents, which can be assumed to occur at least once during any period of a thousand operating years; b) class 2 postulated accidents, which can be assumed to occur less frequently than once during any period of a thousand operating years. (Government Decree 736/2008)

Long-term safety

Long-term safety shall refer to the safety of disposal after the operational period of a disposal facility, taking account of radiological impacts on man and the environment. (Government Decree 736/2008)

Unlikely event impairing long-term safety

Unlikely event impairing long-term safety shall refer to potential events significantly affecting the performance of barriers that have a low probability of causing radiation exposure during the assessment period, and which can be caused by geological phenomena or human action.

Long-lived waste

Long-lived waste shall refer to nuclear waste the activity concentration of which after 500 years is above the level of 100 MBq/kg in a disposed waste package, or above an average value of 10 MBq/kg in waste in one emplacement room.

Scenario

Scenario shall refer to an evolution scheme describing the potential future behaviour of the disposal system.

Expected evolution

Expected evolution shall refer to such change affecting the performance of barriers that has a high probability of causing radiation exposure during the assessment period and which can be caused by interactions occurring in the disposal facility, by geological or climatic phenomena, or by human action.

Performance target

Performance target shall refer to a measurable or assessable characteristic of a barrier. The performance target shall include a criterion describing the characteristic which, when met, ensures the performance of a safety function.

Safety case

Safety case shall refer to documentation for demonstrating compliance with the long-term safety requirements.

Safety function

Safety functions shall refer to factors preventing and limiting the releases and migration of disposed of radioactive materials. (Government Decree 736/2008)

Barrier

Barrier shall refer to an engineered or natural structure or material used for achieving safety functions. A barrier may also be an aggregate formed by different structures and materials.

Annual dose

Annual dose shall refer to the sum of the effective dose arising from external radiation within the period of one year and the committed effective dose from the intake of radioactive substances within the same period of time. (Government Decree 736/2008)

Nuclear waste facility

Nuclear waste facility shall refer to a nuclear facility utilised for the encapsulation of spent nuclear fuel or the conditioning of other nuclear waste for disposal, and to a disposal facility for spent nuclear fuel or other nuclear waste. (Government Decree 736/2008)

References

1. Nuclear Energy Act (990/1987).
2. Nuclear Energy Decree (161/1988).
3. Radiation Act (592/1991).
4. Radiation Decree (1512/1991).
5. Government Decree on the Security in the Use of Nuclear Energy (734/2008).
6. Government Decree on Emergency Arrangements at Nuclear Power Plants (716/2013).
7. Government Decree on the Safety of Disposal of Nuclear Waste (736/2008).
8. Disposal of Radioactive Waste. Specific Safety Requirements. IAEA Safety Standards Series No. SSR-5.
9. Geological Disposal Facilities for Radioactive Waste. Specific Safety Guide. IAEA Safety Standards Series No. SSG-14.
10. The Safety Case and Safety Assessment for the Disposal of Radioactive Waste. Specific Safety Guide. IAEA Safety Standards Series No. SSG-23.
11. ICRP, 1998. Radiation protection recommendations as applied to the disposal of long-lived solid radioactive waste. ICRP Publication 81. Ann. ICRP 28 (4).

Annex A Safety case

A01. According to Section 14(1) of Government Degree 736/2008, *compliance with the requirements concerning long-term radiation safety, and the suitability of the disposal method and disposal site, shall be proven through a safety case that must analyse both expected evolution scenarios and unlikely events impairing long-term safety. The safety case comprises a numerical analysis based on experimental studies and complementary considerations insofar as quantitative analyses are not feasible or involve considerable uncertainties.*

A02. The safety case shall include a description of the disposal system: quantities of radioactive materials, waste packages, buffer materials, backfill materials, structures for isolation and closure, excavated rooms, the geological, hydrogeological, hydrochemical, thermal and rock mechanical characteristics of the host rock, and the natural environment at the disposal site.

A03. The safety case shall define the safety concept, barriers and safety functions with their performance targets.

A04. The scenarios shall be systematically composed to cover any events and factors that may be of relevance to long-term safety and that may arise from:

a. external factors, such as climate changes, geological processes and events or human actions;
b. radiological, mechanical, thermal, hydrological, chemical, biological and radiation-related factors internal to the disposal system;
c. quality non-conformances in the barriers; and

the combined effects of all the aforementioned factors.

A05. The base scenario shall assume that the performance targets defined for each safety function are met. The influence of declined performance of one or several safety functions shall be analysed by means of variant scenarios. Disturbance scenarios shall be constructed for the analysis of unlikely events impairing long-term safety referred to in para. 316. The argumentation for the assumed extent of the declined performance of a safety function shall be presented.

A06. In order to analyse the release and migration of disposed radioactive materials, conceptual models shall be constructed to describe the underlying events and processes. In addition to the models constructed to describe such release and migration processes, conceptual models shall also be constructed to describe the safety functions and the factors affecting them. The respective mathematical models are derived from the conceptual models, normally by way of simplification. Simplification of the models and the determination of the required input data shall be based on the principle that the performance of a safety function will neither be overestimated nor overly underestimated.

A07. The modelling and the determination of input data shall be based on high-quality scientific knowledge and expert judgement obtained through empirical studies, such as laboratory analyses, site investigations and evidence from natural analogues. The models and the input data shall be consistent with the scenario, assessment period and disposal system. Whenever the input data used in modelling involve random variations due to, for example, the heterogeneity of the bedrock, models that accommodate random variation shall be employed.

A08. The selection of computational methods, performance targets and input data shall be based on the principle that the actual radiation exposure and the actual quantities of released radioactive materials shall, with a high degree of certainty, be lower than those obtained through safety analyses.

A09. The significance of the uncertainties involved with the safety case shall be assessed by means of appropriate methods. The safety case shall include an assessment of the confidence level with regard to compliance with the safety requirements and of the uncertainties with the greatest impact on the confidence level.

A10. In the event that a scenario cannot be comprehensively and reasonably assessed by means of quantitative safety analyses, its significance shall be examined by means of complementary considerations, such as calculations by simplified methods, comparisons with natural analogues, or observations of the geological history of the disposal site. The significance of such considerations grows as the assessment period increases, and safety evaluations extending beyond the time horizon of one million years can mainly be based on complementary considerations. Complementary considerations shall also be made parallel to the actual safety assessment to enhance the confidence in the results of the analysis or certain part of it.

A11. The safety case shall be carefully documented. The basic assumptions that underlie each part of the safety case along with the methods employed, the results obtained and the relation of the part to the case as a whole shall be easy to ascertain (clarity), and the rationale for the assumptions, input data and models adopted shall be easy to find in the documentation (transparency and traceability).

A12. The quality of the safety case shall be ascertained through the management system related to the design, construction and operation of the disposal facility. The party implementing the project shall have an appropriate organisation, adequate competence and an appropriate information management system in place. The various stages of the preparation of the safety case shall be systematically planned, and the reliability of the results of crucial studies and analyses shall be ascertained by means of independent expert reviews or analyses, for example.