STUK

GUIDE **YVL D.3** / 15 NOVEMBER 2013

HANDLING AND STORAGE OF NUCLEAR FUEL

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 6.8 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 assemblies removed from a nuclear reactor are highly radioactive, and they generate heat and contain nuclear materials and fission products. The safe handling and storage of nuclear fuel assemblies requires in particular that the integrity of the assemblies and the leak-tightness of the nuclear fuel rods is ensured, that any leaking nuclear fuel assemblies are isolated, that effective radiation protection arrangements are applied, that the nuclear fuel is appropriately cooled, and that the formation of critical nuclear fuel configurations are prevented. The latter safety objective, in particular, also pertains to the storage of fresh nuclear fuel.

102. At nuclear power plants, spent nuclear fuel is initially kept in a water-filled storage pool inside the reactor building, from which it is moved inside a transfer cask into a separate interim storage facility for spent nuclear fuel.

103. Under the Nuclear Energy Act, final disposal into underground disposal facilities deep inside the bedrock is, for all practical purposes, the only viable method for the management of spent nuclear fuel. For the purpose of final disposal, spent nuclear fuel assemblies are transferred into a facility (*encapsulation plant*) where they are inserted into metallic final disposal canisters. Long-term safety requires that the final disposal canisters meet the specified quality requirements.

104. This Guide addresses the facilities and functions referred to in paragraphs 102 and 103. Sections 3 and 4 of the Guide provide requirements pertaining to the design of the handling and storage facilities for spent nuclear fuel, sections 5 and 6 provide requirements pertaining to the commissioning and operation of such facilities, and sections 7 and 8 outline the documents to be submitted to and the regulatory control exercised by STUK. The requirements are applicable to both fresh and spent nuclear fuel except where they explicitly apply to spent nuclear fuel.

105. 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).

106. According to Section 7 h of the Nuclear Energy Act, *the nuclear facility shall have the facilities, equipment, and other arrangements required to ensure the safe handling and storage of nuclear material required by the plant and any nuclear waste generated during operation.* According to Section 4 of the Nuclear Energy Decree, the provisions set out in nuclear energy legislation on both nuclear material and nuclear waste are applicable to spent nuclear fuel.

107. The Government Decree on the Safety of Nuclear Power Plants (717/2013) applies to the handling and storage of nuclear fuel in spent nuclear fuel storage facilities in connection with a nuclear power plant. The Government Decree on the Safety of Disposal of Nuclear Waste (736/2008) applies to the encapsulation of spent nuclear fuel for final disposal. The Government Decrees on the Security in the Use of Nuclear Energy (734/2008) and on Emergency Response Arrangements at Nuclear Power Plants (716/2013) also apply to the handling, storage, and encapsulation of nuclear fuel where applicable.

2 Scope of application

201. This Guide addresses the following operations taking place at nuclear facilities and nuclear power plants:

a. the dry storage of fresh nuclear fuel, the storage of fresh and spent nuclear fuel in storage pools adjacent to a reactor, and the storage of spent nuclear fuel in separate storage facilities;
b. the transfers of nuclear fuel at the plant site and in connection with storage and encapsulation, as well as the transfers of the transfer cask and the final disposal canister;
c. the encapsulation of spent nuclear fuel for final disposal; and
d. the planning, design, construction, and use of the aforementioned functions and the necessary facilities and systems.

202. This Guide is not applicable to the transport of nuclear fuel via public roads. The scope of this Guide is limited to encapsulation solutions in which nuclear fuel assemblies are, as such, inserted into final disposal canisters.

203. This Guide shall be complied with in the design, construction, and operation of a nuclear facility or a nuclear power plant.

204. The design requirements specified in Guide YVL B.1, Safety design of a nuclear power plant, shall apply to the design of safety systems for nuclear facilities referred to in this Guide. In Guide YVL D.3, safety function shall refer to functions important to safety the purpose of which is to manage transients, prevent the occurrence or escalation of accidents, or mitigate the consequences of accidents.

205. In designing a nuclear facility, provisions shall also be made for nuclear safeguards as required under Guide YVL D.1, Regulatory control of nuclear safeguards. Transport of nuclear fuel is governed by Guide YVL D.2, Transport of nuclear materials and nuclear waste. The decommissioning and waste management of the facilities discussed in this Guide is subject to Guide YVL D.4, Predisposal management of low and intermediate level nuclear waste and decommissioning of a nuclear facility. The disposal of nuclear waste is governed by Guide YVL D.5, Disposal of nuclear waste.

206. Several other YVL Guides issued by STUK are also applicable to the handling, storage, and encapsulation of nuclear fuel. This Guide contains references to the applicable Guides with the relevant paragraphs specified where practicable. The construction of nuclear facilities is addressed in Guide YVL A.5, Construction and commissioning of a nuclear facility. Nuclear security and the management of information security shall be taken into account in designing a nuclear facility. The requirements for the implementation of nuclear security are specified in Guide YVL A.11, Security of a nuclear facility, and the requirements for the management of information security are specified in Guide YVL A.12, Information security management of a nuclear facility. The requirements pertaining to the design and implementation of hoisting and transfer equipment at nuclear facilities are specified in greater detail in Guide YVL E.11, Hoisting and transfer equipment 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 nuclear facilities.

3 Nuclear and radiation safety

301. The handling and storage of nuclear fuel shall be designed so that the probability of damage to the nuclear fuel is very small.

3.1 Normal operation

302. In the handling and storage of nuclear fuel taking place at a nuclear power plant, the limit for the annual dose of an individual in the population, arising from the normal operation of the entire nuclear power plant, is 0.1 mSv (Government Decree 717/2013, Section 8). The encapsulation of spent nuclear fuel and the use of the encapsulation plant shall be designed so that the resulting release of radioactive substances into the environment remains insignificantly low (Government Decree 736/2008, Section 3).

303. Pursuant to the requirements set out in para 302 and the optimisation principle of Section 2 of the Radiation Act, the handling, storage, and encapsulation of spent nuclear fuel shall be designed so that normal operation of the facility does not cause any significant increase in the normal annual dose to the most exposed individuals of the population.

3.2 Operational occurrences and accidents

304. In the handling, storage, and encapsulation of nuclear fuel, the primary objective shall be the prevention of operational occurrences and accidents. In the handling, storage, and encapsulation of nuclear fuel, provisions shall be made for the management of operational occurrences and accidents and the mitigation of their consequences (Nuclear Energy Act, Section 7 d).

305. The annual dose to the most exposed individuals of the population arising as a result of an operational occurrence or an accident shall remain below the limit values indicated below (Government Decrees 717/2013 and 736/2008):

a. 0.1 mSv as a result of an anticipated operational occurrence;
b. 1 mSv in the event of a Class 1 postulated accident;
c. 5 mSv in the event of a Class 2 postulated accident; and
d. insofar as spent nuclear fuel storage facilities are concerned, 20 mSv as a result of a design extension condition.

306. 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 cladding failure of a nuclear fuel rod or significant mechanical deformation of a nuclear fuel assembly;
b. a handling error of a transfer cask, nuclear fuel assembly, or final disposal canister;
c. a leak of cooling water due to, for example, degraded leak-tightness of the liner of a nuclear fuel storage pool, a pool gate, or piping connected to the pool;
d. a leak in a gas-tight transfer cask, storage container, or handling cell;
e. a component failure or malfunction and the resulting non-operability of a non-redundant system;
f. loss of power in a nuclear fuel handling system or a related safety system; and
g. a contained fire in a safety-significant location.

307. 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 involving a nuclear fuel assembly or a transfer cask, storage container or final disposal canister containing fuel assemblies;
b. non-operability of a redundant system (e.g. the cooling system of a nuclear fuel storage pool or the underpressure and filtration system of a handling cell) due to component failures or malfunctions; and
c. a significant external event, such as a design basis earthquake or a crash of a light aircraft.

308. At least the following shall be considered as design extension conditions for a spent nuclear fuel storage facility:

a. anticipated operational occurrences and Class 1 postulated accidents that involve a common cause failure in the system designed for managing the event concerned;
b. combinations of failures selected on the basis of a probabilistic risk assessment; and
c. rare external events that are unlikely but nevertheless considered possible, such as extreme weather phenomena or a large-aircraft crash.

309. If the amount of nuclear fuel present in the encapsulation plant exceeds 100 tonnes of uranium, para 308 shall also be taken into account in connection with the encapsulation plant.

310. The dispersion analyses of radioactive releases and the analyses of the radiation doses arising from the releases shall be conducted in compliance with Guide YVL C.4, Radiological monitoring of the environment of a nuclear facility. This applies to normal operational states, operational occurrences, postulated accidents, and design extension conditions. Severe damage to spent nuclear fuel shall be practically eliminated in compliance with requirement 411.

4 Safety design of the facility and functions

401. The designing of the measures for handling and storage of nuclear fuel shall follow the requirements specified in section 3 of Guide YVL B.1 and, with regard to technical requirements, sections 4 and 5 of the Guide.

4.1 Management of design

402. The design of a nuclear facility shall be controlled and duly justified, and the design process shall proceed systematically as planned. Controlled design involves the verification of different design stages. The design outcomes shall be verifiable as being consistent with the design bases.

403. Requirements for the management of design are set out in section 3 of Guide YVL B.1. These requirements pertain to the licensee, the design process, documentation, verification, validation, qualification, and the justification for the choice of design solutions, among other things.

4.2 Radiation safety

404. The radiation protection planning of a spent nuclear fuel storage, encapsulation plant, and the operations conducted therein shall take into account the following considerations:

a. The facility shall have in place a classification of radiation protection areas and zones as provided for 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.
c. The facility shall have radiation monitoring systems in place as specified in Guide YVL C.6.
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.

405. The transfers of spent nuclear fuel assemblies and casks or canisters containing them shall be conducted in a radiation-shielded manner and by remote control so as to ensure that the exposure of workers remains as low as is practically achievable. The design of the radiation protection measures shall be based on the assumption that the maximum allowed amount of spent nuclear fuel is present in the area to be shielded. The spent nuclear fuel shall be assumed to have the highest possible burnup and the shortest possible cooling time. The design of radiation shields shall provide for scattered radiation and the possibility for local radiation beams through penetrations and openings.

406. The storage pool in which spent nuclear fuel is handled or stored shall be equipped with a pool water radioactivity monitoring system and a purification system. The purification system shall recover any radioactive substances released into the cooling water. Such materials are to be treated as radioactive waste. The surface materials of the pools shall be readily decontaminable.

4.3 Design of structures and systems

4.3.1 General design principles

407. The systems performing safety functions at nuclear facilities shall operate reliably. Section 4.1 of Guide YVL B.1 discusses the general design principles and requirements. The systems, structures and components of a nuclear facility shall be designed so as to ensure that they perform reliably under design-basis environmental conditions. Any auxiliary system of a system performing a safety function shall fulfil the same requirements as the system performing the safety function.

408. Provisions shall be made for the testing and accessibility for inspections of safety systems already at the design stage. Provisions shall be made for the renewal and replaceability of technologies in the design solutions. Provisions shall be made at the design stage for the future waste management and decommissioning of the facility. The amount of radioactive waste generated due to them shall be kept to a minimum to the extent practicable. A nuclear facility shall have sufficient arrangements in place for the handling and, where necessary, storage of radioactive waste.

4.3.2 Defence in depth safety principle

409. *The safety of a nuclear facility shall be ensured by means of successive levels of protection independent of each other (safety principle of defence-in-depth). This principle shall extend to the operational and structural safety of the plant* (Section 7 b of the Nuclear Energy Act 990/1987).

410. The defence in depth safety principle is discussed in section 4.3 of Guide YVL B.1. According to the principle, the defence of the safety functions of a nuclear facility is divided into successive levels. The safety functions of the first two levels prevent accidents from occurring. The safety functions of the next levels protect the facility, its operators, and the environment from the adverse effects of an accident. As regards a spent nuclear fuel storage facility and encapsulation plant, the first three levels of the defence in depth safety principle outlined in section 4.3 of Guide YVL B.1 are applied.

411. Events to be practically eliminated are specified in requirements 423–424 of Guide YVL B.1. The event to be practically eliminated with regard to a spent nuclear fuel storage facility is, as referred to in item 4) of para 424, *a loss of cooling resulting in severe damage to spent nuclear fuel.*

412. The events to be practically eliminated shall be identified using methods based on deterministic analyses, probabilistic reliability analyses, and expert assessments. Practical elimination cannot be solely based on compliance with a probabilistic limit value. Even if the probability of an event is very low, any additional reasonably practicable design features shall be implemented for reducing the risk.

4.3.3 Independence and strength of the defence in depth levels

413. According to Section 12 of Government Decree 717/2013 *the levels of defence required under the defence-in-depth principle shall be as independent of one another as is reasonably achievable.* The loss of any single level of defence may not impair the performance of the other levels of defence. The independence of the defence in depth levels is discussed in section 4.3.1 of Guide YVL B.1. The outlined principles shall be complied with in the design of a spent nuclear fuel storage facility and encapsulation plant.

414. The requirements pertaining to the strength of individual defence in depth levels are set out in section 4.3.2 of Guide YVL B.1 as follows: *No single anticipated failure or spurious action of an active component taking place during normal plant operation shall lead to a situation requiring intervention by systems designed to manage postulated accidents.*

415. To make the defence in depth levels sufficiently strong, provisions shall be made for failures so that systems performing a safety function consist of two or more redundant parallel systems or system components in order to enable the performance of the safety function even in case of inoperability of any of these.

416. The redundancy principle shall be applied to the complete train of systems consisting of the safety system and all auxiliary systems or functions necessary for performing the safety function.

417. The strength of the applicable redundancy principle depends on the importance of the safety function concerned. In the handling and storage of nuclear fuel, (N+1) is a sufficient strength for the redundancy principle (= failure criterion). This means that it must be possible to perform the safety function even in the event of a failure of any single component or system.

418. Below are some examples of safety functions in respect of which the (N+1) failure criterion must be applied.

Integrity of nuclear fuel rods

419. The integrity of nuclear fuel rods shall be secured in the handling, storage, and encapsulation of nuclear fuel. To this end, the mechanical and thermal stress imposed on nuclear fuel shall be kept to a minimum. Mechanical stress here refers to denting or dropping the nuclear fuel assembly. Thermal stress refers to the overheating of nuclear fuel.

420. Mechanical stress shall be kept to a minimum by keeping the transfer routes short and hoisting heights low. The transfer equipment shall have limitations in place for preventing the nuclear fuel assembly from departing from the allowed transfer route. The grabs of the hoisting device units involved in the transfer of nuclear fuel shall be designed so that any loosening or disengagement of the attached load is prevented

by two independent ways and that the grabs remain in a safe position in the event of a loss of power supply (electricity, vacuum, etc.). The detection of the position of a nuclear fuel assembly shall be secured by means of instrumentation and visually. It must be possible to transfer the nuclear fuel assembly into a safe position by means of manual control where necessary.

421. If the equipment transferring a transfer cask or final disposal canister cannot prevent dropping, the transfer cask or final disposal canister shall be able to retain its leak-tightness in the postulated drop.

422. The thermal load shall be kept to a minimum by ensuring the cooling of nuclear fuel. Nuclear fuel storage pools shall have sufficient water volume. The water volume and the fuel pool cooling system shall be designed so as to ensure that:

a. they are sufficient to cool the maximum amount of nuclear fuel generating the maximum decay heat;
b. the temperature of the pool water in normal operational conditions and anticipated operational occurrences does not impose a thermal load on the pool structures; and
c. the environmental conditions inside a storage pool room remain within the defined limits.

423. To prevent the loss of pool water in a nuclear fuel storage pool, the storage pools shall be designed so that:

a. the storage pools do not contain any pipe fittings that, if broken, would lower the water level to a point that would compromise cooling or the radiation shield of the nuclear fuel;
b. the gates of the pools are so designed that they retain their leak-tightness even if any one of the pools in the storage system concerned is drained of water;
c. any loss of coolant water in a storage pool due to an operational occurrence is compensated for by a make-up water system;
d. water can be fed into the storage pools from external sources;
e. measurement data on the water level and temperature of the storage pool is constantly available; and
f. the storage pools are equipped with leak detection.

Functions used for securing safety functions

Below are some examples of functions that are used for securing safety functions to which the redundancy principle is applied.

424. The atmosphere of a handling cell in which spent nuclear fuel is handled shall have underpressure compared to the surrounding rooms whenever it is used for handling spent nuclear fuel that is not enclosed in a hermetic container.

425. The handling rooms for nuclear fuel assemblies shall have radiation measurements in place for the monitoring and control of operational occurrences and accidents.

A rare external event and the loss of off-site power supply

426. Requirements regarding rare external events and the loss of off-site power supply are set out in para 452 of Guide YVL B.1. The spent nuclear fuel storage facilities shall have the necessary arrangements in place for ensuring sufficient cooling of the spent nuclear fuel in fuel storage facilities in the event of rare external events. These arrangements shall enable the monitoring of the water level in nuclear fuel storage pools containing spent nuclear fuel for at least eight hours without recharging the DC batteries. Additionally, reliable capability shall exist to keep the spent nuclear fuel underwater in the event of the loss of the facility's AC power distribution systems and their permanently installed on-site and off-site power sources.

427. Furthermore, a sufficient inventory of water and fuel and capability to recharge the DC batteries shall exist at the plant site in order to enable these arrangements for a period of 72 hours.

4.4 Safety classification

428. The systems, structures, and components of a nuclear fuel storage facility and encapsulation plant shall be classified according to their functional and structural importance to safety. The

classification shall be based not only on the safety of the facility but also on the long-term safety of final disposal. The safety class shall be considered when setting requirements for the design, fabrication, installation, testing, and inspection of the item being classified. The classifications related to the operation of a nuclear fuel storage facility and encapsulation plant shall comply with Guide YVL B.2, Classification of systems, structures and components of a nuclear facility.

429. Any structures, systems, and components with a major bearing on the prevention of a criticality accident, cooling of nuclear fuel, isolation of radioactive substances, radiation shielding, preventing mechanical damage to or corrosion of nuclear fuel assemblies, or fire safety shall be classified in terms of the safety of the nuclear fuel storage facility and encapsulation plant.

430. The relevant structures and functions to be considered in the classification in terms of long-term safety include the final disposal canister and its fabrication, sealing, and inspection.

431. The structures and components of a nuclear fuel storage facility and encapsulation plant shall be classified according to their earthquake resistance as specified in Guide YVL B.2.

4.5 Ensuring the subcriticality of nuclear fuel

432. The subcriticality of nuclear fuel shall be ensured by means of structural design solutions.

433. The transfer casks, storage racks, handling equipment, and final disposal canisters for nuclear fuel assemblies shall be designed so as to ensure criticality safety (the exclusion of a chain reaction sustained by neutrons) in planned operational conditions and in the event of an anticipated operational occurrence or postulated accident. The requirements pertaining to criticality safety are set out in Guide YVL B.4, Nuclear fuel and reactor.

434. The criticality analyses related to the storage of spent nuclear fuel shall be based on the placement of nuclear fuel assemblies in accordance with the Operational Limits and Conditions. Furthermore, the chances for placing the nuclear fuel assemblies in incorrect storage locations due to identification errors, for example, shall be taken into account in the considerations.

4.6 Operational safety

435. The handling operations at a nuclear fuel storage facility and encapsulation plant shall be designed so that the transfers of heavy or otherwise dangerous objects are avoided in areas where a dropped load or a malfunction would damage the nuclear fuel or a component or structure important to safety.

436. The spent nuclear fuel storage facility and encapsulation plant shall have sufficient arrangements in place for ensuring the proper handling of nuclear fuel assemblies that are impaired, damaged, or stuck in their storage locations. It shall be possible to seal any nuclear fuel assemblies or rods from which radioactive substances are leaking in the spent nuclear fuel storage facility into a gas-tight canister or container for storage.

437. The spent nuclear fuel storage facility shall have the rooms and equipment necessary for the condition monitoring of nuclear fuel assemblies.

438. The storage facilities for nuclear fuel and their use shall be planned so that any storage pool or the reactor core can be emptied of nuclear fuel for the purpose of repair work.

439. The spent nuclear fuel storage facility and encapsulation plant shall have the rooms and equipment necessary for decontaminating the shipping or transfer casks used at the facility and other contaminated objects.

440. The encapsulation plant for spent nuclear fuel shall be designed so that any handling room can be decontaminated for the purpose of maintenance and repair work.

441. The encapsulation plant for spent nuclear fuel shall have arrangements in place for the repair of a sealed final disposal canister or the re-encapsulation of nuclear fuel.

4.7 Acceptance of nuclear fuel for encapsulation

442. Acceptance criteria shall be defined for any properties of nuclear fuel for final disposal that have a bearing on operational safety and the long-term safety of final disposal. When defining the criteria, at least the information specified in para 705 shall be considered. A plan shall be prepared for the encapsulation of nuclear fuel assemblies which deviate from the design bases of the final disposal canister, such as mechanically deformed assemblies.

4.8 Encapsulation

443. Acceptance criteria shall be defined for the properties of the final disposal canister that have a bearing on the long-term safety of final disposal. Only final disposal canisters that satisfy the acceptance criteria may be transferred to the final disposal facility. In order to ascertain that the acceptance criteria are duly satisfied, the licensee shall:

a. prepare construction plans pertaining to each final disposal canister type in accordance with section 7 of Guide YVL E.3, Pressure vessels and piping of a nuclear facility, where applicable;
b. qualify the instructions and methods used in the fabrication of the final disposal canister in accordance with section 8.4.3 of Guide YVL E.3;
c. oversee the fabrication of the final disposal canister structures to a sufficient extent;
d. conduct a receiving inspection for the final disposal canister structures delivered to the encapsulation plant during which the quality inspection records are reviewed and control tests are carried out; and
e. conduct a final inspection following the sealing of the final disposal canister in order to ascertain the acceptability of the welding and ensure that the final disposal canister has not sustained any damage during the encapsulation process.

4.9 Other design considerations

444. The storage conditions of spent nuclear fuel shall be designed so that the condition of nuclear fuel assemblies, fuel racks, or storage pools will not significantly deteriorate during the storage period. By controlling the choice of materials and the chemical properties of the cooling water, corrosion of nuclear fuel assemblies, storage racks, and storage pool liners shall be kept as low as reasonably achievable.

445. When the handling, storage, and encapsulation processes for nuclear fuel are designed, priority shall be given to simple and inherently safe concepts.

446. A nuclear fuel storage facility and encapsulation plant shall have appropriate rooms and equipment for conducting inspections of nuclear fuel. The control pursuant to Guide YVL D.1 shall be provided for in the design of the encapsulation plant.

447. The requirements specified in section 5.3 of Guide YVL B.1 shall be complied with, where applicable, in the control rooms for the spent nuclear fuel storage facility and encapsulation plant.

448. Any rooms where a fire could cause substantial radioactive releases shall be equipped with fire alarm and extinguishing systems. Detailed requirements pertaining to fire alarm and extinguishing systems are specified in Guide YVL B.8, Fire protection at a nuclear facility.

449. The transfer cask for spent nuclear fuel shall meet the strength and leak-tightness requirements for a BF-type packaging set out in the transport regulations for dangerous goods (Decree of the Ministry of Transport and Communications on the Transport of Dangerous Goods by Road (369/2011)).

5 Transporting nuclear fuel into the facility and commencing its operation

501. Before any spent nuclear fuel is transported into the nuclear facility, the licensee shall ascertain that the systems and components related to the safe handling, storage, and monitoring of nuclear fuel are operable and that the radiation protection, nuclear security, and emergency preparedness arrangements necessary for the use of nuclear material are in place. This requirement applies to the transport of spent nuclear fuel into the spent nuclear fuel storage facility and encapsulation plant.

502. The commissioning of a spent nuclear fuel storage facility and encapsulation plant is defined in para 339 of Guide YVL A.1, Regulatory oversight of safety in the use of nuclear energy.

503. Prior to commissioning, pre-operational testing of a spent nuclear fuel storage facility or encapsulation plant shall be carried out in compliance with Guide YVL A.5.

6 Operation of the facility

601. The holder of an operating licence for a spent nuclear fuel storage facility or encapsulation plant shall have the documents approved by STUK as required under Section 36 of the Nuclear Energy Decree and the relevant Government Decree (Sections 23–26 of Government Decree 717/2013 or Section 18 of Government Decree 736/2008). These documents shall be kept up-to-date at all times so as to reflect the current structure and state of the facility.

602. The requirements pertaining to operational documents are set out in section 7 of Guide YVL A.6. Examples of operational documents include operating instructions of systems, operating procedures for operational occurrences and accidents, and the Operational Limits and Conditions. With regard to spent nuclear fuel storage facilities and encapsulation plants, the requirements of Guide YVL A.6 shall be complied with as decreed in the applicability decision referred to in para 206.

603. The operating procedures shall define the functions performed on nuclear fuel, the preconditions for performing such functions, the respective measures, responsibilities, and records.

604. The holder of an operating licence for a spent nuclear fuel storage facility shall have a STUK-approved monitoring programme in place for tracking the changes in the properties and storage conditions of nuclear fuel assemblies. The programme shall define the extent and frequency of the periodic inspections of nuclear fuel and its storage conditions, as well as the inspection methods and equipment to be used. The monitoring programme shall be submitted to STUK for approval in connection with the application for an operating licence.

605. The results of the inspections under the monitoring programme referred to in para 604 shall be submitted to STUK for information within six months of the date of the inspection. Any abnormal observations of s shall be reported to STUK without delay.

606. The spent nuclear fuel storage and handling systems and the related equipment shall have a periodic testing programme in place for ensuring the reliable operation and condition of structures, systems, and components related to safety. The requirements pertaining to the periodic testing programme of nuclear power plants are specified in section 5.3 of Guide YVL A.6, Conduct of operations at a nuclear power plant.

607. The holder of an operating licence for a spent nuclear fuel storage facility or encapsulation plant shall have an operating experience feedback programme in place for systematic collection, analysis, and reporting of operating experiences and events at the facility and other equivalent facilities and for following safety research. Based on the monitoring of feedback, the opportunities for enhancing safety shall be considered and any improvement measures deemed justified

shall be implemented. The monitoring of the feedback from operating experience shall comply with the requirements of Guide YVL A.10.

608. Each nuclear fuel assembly in the spent nuclear fuel storage facility shall be identified on the basis of the markings made on it prior to its transfer into the encapsulation plant and at the encapsulation plant before it is sealed in a final disposal canister. Correspondingly, the final disposal canisters shall be identified on the basis of the markings made on them prior to their transfer into the final disposal facility. The radioactivity and nuclear material information pertaining to nuclear fuel assemblies shall be verified using the methods set forth in Guide YVL D.1 and complemented, where necessary, by representative measurements.

609. If the licensee, following the commissioning of the facility concerned, wishes to modify any system, structure, component, or mode of operation of the facility that STUK has previously approved, the licensee shall seek STUK's approval for the modification plan as provided for in Section 112 of the Nuclear Energy Decree prior to its implementation. Plant modifications shall comply with the requirements laid down in Guide YVL A.5.

610. A spent nuclear fuel storage facility and encapsulation plant shall have emergency preparedness arrangements in place the extent of which shall be commensurate with accidents considered possible and the planning of which shall, where applicable, be based on the Government Decree on Emergency Response Arrangements at Nuclear Power Plants (716/2013) and Guide YVL C.5, Emergency preparedness arrangements of a nuclear power plant.

611. 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 nuclear fuel storage facility or encapsulation plant shall also specify the other positions important for safety and define the required qualifications according to section A27 of Guide YVL A.1.

612. The licensee shall verify the qualifications of the individuals working in the positions referred to in para 611 prior to the commissioning of the facility as provided for in Section 20 of the Nuclear Energy Act and prepare training programmes for developing and maintaining the competence of the personnel. Detailed requirements on the verification of qualifications for positions important to safety are presented in section 3.4 of Guide YVL A.4, Organisation and personnel of a nuclear facility.

7 Documentation to be submitted to STUK

701. The due fulfilment of the safety requirements pertaining to the nuclear facility concerned shall be demonstrated by means of documents submitted to STUK at different stages of the nuclear facility licensing process (Nuclear Energy Decree 161/1988). Guide YVL A.1 sets out the general licensing procedures for a nuclear facility. More detailed requirements pertaining to the documents to be submitted at different stages are set out in section 6 of Guide YVL B.1. The reporting obligations related to spent nuclear fuel are also specified in Guide YVL A.9, Regular reporting on the operation of a nuclear facility. Below are additional requirements supplementing those set out in section 6 of Guide YVL B.1 that are to be considered in the storage and encapsulation of nuclear fuel.

702. The licensee shall submit to STUK a preliminary safety assessment report in connection with the construction licence application for a nuclear facility. Para 612 of Guide YVL B.1 stipulates *that the ability of the plant and its systems to perform the assigned safety functions shall be demonstrated by means of deterministic analyses of anticipated operational occurrences and accidents, which shall be presented in the preliminary safety analysis report.* Guide YVL B.3, Deterministic safety analyses for a nuclear power plant, sets out more detailed requirements for the safety analyses. STUK will issue a decision on the applicability of Guide YVL B.3 to other nuclear facilities.

703. Paras 606–612 and 617–623 of Guide YVL B.1 set out the requirements pertaining to the content of the preliminary and final safety assessment report. In addition to said requirements, the safety assessment reports concerning the encapsulation plant shall describe the fabrication method, properties, and acceptance criteria for the final disposal canister.

704. The safety assessment reports concerning the nuclear fuel handling facility shall describe the properties of the types of nuclear fuel assemblies being handled. Acceptance criteria shall be prepared for the types of nuclear fuel being handled, and plans shall be drawn up for the handling, storage, and final disposal of nuclear fuel assemblies that deviate from the acceptance criteria.

705. Records shall be prepared of the spent nuclear fuel transferred to the encapsulation plant and of each final disposal canister, based on which the following data can be determined to an accuracy of an individual assembly and canister:

a. the initial enrichment level, burnup, and heat generation of the nuclear fuel;
b. the activities of dominant radionuclides, including the activation products of structural parts;
c. the structural and material properties that have a bearing on the long-term safety of encapsulation or final disposal; and
d. the potential leak of nuclear fuel or damage to a nuclear fuel assembly.

706. The safety assessment reports shall be kept up-to-date as specified in Guide YVL A.1. In addition to any plant modifications, the updates to the safety assessment reports shall address any changes in the properties or handling and storage conditions of nuclear fuel assemblies that may have a bearing on safety.

707. The safety assessment reports shall be supplemented with topical reports the purpose of which is to clarify on what kind of experimental studies and theoretical analyses the design and planning of the facility are based. The topical reports shall, in particular, address any events and functions important to safety.

708. The licensee shall submit to STUK the probabilistic risk assessment of the design stage in connection with the construction licence application for a nuclear facility and the probabilistic risk assessment in connection with the application for an operating licence. The requirements concerning the probabilistic risk assessment of a nuclear fuel storage facility are specified in Guide YVL A.7, Probabilistic risk assessment and risk management of a nuclear power plant. The methods used in the risk analysis of a spent nuclear fuel encapsulation plant shall be selected and applied commensurate with the risks associated with the different stages of the encapsulation process. Qualitative methods can be applied in the probabilistic risk assessment of the encapsulation plant, supplemented by quantitative analyses where necessary.

709. STUK shall be provided with an opportunity to access the records prepared on nuclear fuel and final disposal canisters, which STUK shall record in a permanent manner as stipulated in Section 9 of Government Decree 736/2008.

710. The operating procedures specified in para 602 shall be submitted to STUK for information prior to the commissioning inspection as stipulated in section 4.6 of Guide YVL A.1.

711. The monitoring programme referred to in requirement 604 shall be submitted to STUK for approval in connection with the application for an operating licence. Any updates to the monitoring programme shall be submitted to STUK for approval.

8 Regulatory oversight by the Radiation and Nuclear Safety Authority

801. A separate storage facility for spent nuclear fuel or encapsulation plant is a nuclear facility of considerable general significance (Nuclear Energy Act, Section 11; Nuclear Energy Decree, Section 7), the construction of which is subject to a Government decision-in-principle. Section 24

of the Nuclear Energy Decree specifies the documents concerning a planned nuclear facility that shall be submitted as enclosures to the application for a decision-in-principle.

802. STUK will process the applications related to the licensing of a spent nuclear fuel storage facility or encapsulation plant as provided for in section 7 of Guide YVL B.1.

803. STUK oversees the construction, commissioning, and operation of the nuclear fuel storage facility and encapsulation plant in accordance with Guides YVL A.1, YVL A.5, and YVL A.6.

804. STUK oversees the implementation of encapsulation to the extent it considers necessary. The implementation of encapsulation comprises the verification of the fulfilment of the acceptance criteria set for the canister and nuclear fuel and the follow-up of the records kept of the canisters and nuclear fuel.

805. As part of their international nuclear safeguards activities, the IAEA and the European Commission conduct on-site inspections in order to verify the accuracy of the information provided by the operators as provided in Guide YVL D.1.

Definitions

System

System shall refer to a combination of components and structures that performs a specific function.

Encapsulation

Encapsulation shall refer to the operations related to spent nuclear fuel to be enclosed in a final disposal canister at an encapsulation plant.

Encapsulation plant

Encapsulation plant shall refer to a nuclear facility that is used to encapsulate spent nuclear fuel for final disposal.

Qualification (systems and components)

Qualification shall refer to a process to demonstrate the ability to fulfil specified requirements (corresponds to the qualification process of the ISO 9000 standard).

Validation

Validation shall refer to confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled. (ISO 9000)

Corrosion

Corrosion shall refer to a physical and chemical reaction between metal and its environment that introduces changes to the metal's properties and may lead to a significant reduction in the functionality of the metal, its environment, or the technical system of which they are part.

Criticality

Criticality shall refer to a state where the output and loss of neutrons, created in nuclear fission and maintaining a chain reaction, are in equilibrium so that a steady chain reaction continues. (Government Decree 717/2013)

Spent nuclear fuel

Spent nuclear fuel shall refer to nuclear material that has been used as nuclear fuel for the production of nuclear energy and that contains significant amounts of nuclear waste. (Nuclear Energy Decree 161/1988)

Operational event

Operational event shall refer to a failure, flaw or non-conformity in safety functions, systems, components, structures or an organisation's activities that has a bearing on radiation safety or nuclear safety. Operational events also include emergencies and disturbances as well as events compromising radiation safety. Operational events also include events taking place during the construction phase.

Final disposal canister

Final disposal canister shall refer to a hermetic, corrosion resistant and mechanically

strong container where spent nuclear fuel is enclosed.

Licensee

Licensee shall refer to the holder of a licence entitling to the use of nuclear energy. The use of nuclear energy refers to the operations laid down in Sections 2(1) and 2(2) of the Nuclear Energy Act.

Redundancy

Redundancy shall refer to the use of alternative (identical or diverse) structures, systems or system components, so that any one of them can perform the required function regardless of the state of operation or failure of any other.

Normal operation (DBC 1)

Normal operation (DBC 1) shall refer to the planned operation of a nuclear power plant according to the Operational Limits and Conditions and operational procedures in place. These also include testing, plant start-up and shutdown, maintenance and refuelling. As far as other nuclear facilities are concerned, normal operation shall refer to similar plant operation.

Anticipated operational occurrence (DBC 2)

Anticipated operational occurrence (DBC 2) shall refer to such a deviation from normal operation that can be expected to occur once or several times during any period of a hundred operating years. (Government Decree 717/2013)

Postulated accident

Postulated accident shall refer to a deviation from normal operation which is assumed to occur less frequently than once over a span of one hundred operating years, excluding design extension conditions; and which the nuclear power plant is required to withstand without sustaining severe fuel failure, even if individual components of systems important to safety are rendered out of operation due to servicing or faults. Postulated accidents are grouped into two classes on the basis of the frequency of their initiating events: a) Class 1 postulated accidents (DBC 3), which can be assumed to occur less frequently than once over a span of one hundred operating years, but at least once over a span of one thousand operating years; b) Class 2 postulated accidents (DBC 4), which can be assumed to occur less frequently than once during any one thousand operating years.

Design extension condition (DEC)

Design extension condition (DEC) shall refer to:

a. an accident where an anticipated operational occurrence or class 1 postulated accident involves a common cause failure in a system required to execute a safety function (DEC A);
b. an accident caused by a combination of failures identified as significant on the basis of a probabilistic risk assessment (DEC B); or
c. an accident caused by a rare external event and which the facility is required to withstand without severe fuel failure (DEC C).

Accident

Accident shall refer to postulated accidents, design extension conditions and severe accidents (Government Decree 717/2013).

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).

Construction plan

Construction plan shall refer to the design documentation compiled for the purpose of pre-inspection conducted by STUK or an authorised inspection body.

Transfer cask

Transfer cask shall refer to a container in which spent nuclear fuel is transported within the plant site.

Design basis

Design bases shall refer to all requirements, definitions and bases for normal operational conditions and accidents that pertain to the design and operation of a plant, system and component.

Probabilistic risk assessment (PRA)

Probabilistic risk assessment (PRA) shall refer to a quantitative assessment of hazards, probabilities of event sequences and adverse effects influencing the safety of a nuclear power plant. (Government Decree 717/2013)

Verification

Verification shall refer to confirmation, through the provision of objective evidence, that set requirements have been fulfilled.

Auxiliary system

Auxiliary system shall refer to a system required to actuate, control, cool or operate a system executing a safety function, or otherwise maintain the conditions required by the operational prerequisites of the safety function.

Safety system

Safety system shall refer to a system that has been designed to execute safety functions.

Operational Limits and Conditions (OLC)

The Operational Limits and Conditions (OLC) set out the technical and administrative requirements for ensuring the plant's operation in compliance with the design bases and safety analyses; the requirements for ensuring the operability of systems, structures and components important to safety; and the limitations that must be observed in the event of component failure.

External events

External events shall refer to exceptional situations or incidents occurring in the vicinity of a nuclear power plant that could have a detrimental effect on the safety or operation of the plant.

Emergency arrangements

Emergency arrangements shall refer to advance preparation for accidents or events impairing safety at the nuclear facility or in its site area or other places or vehicles where nuclear energy is used. (Nuclear Energy Act 990/1987)

Storage container

Storage container shall refer to a container used in the dry storage of spent nuclear fuel.

Failure criterion (N+1)

(N+1) failure criterion shall mean that it must be possible to perform a safety function even if any single component designed for the function fails.

Annual dose

Annual dose shall refer to the sum of the effective dose arising from external radiation within the period of one year, and of the committed effective dose from the intake of radioactive substances within the same period of time. (Government Decree 717/2013)

Nuclear material

Nuclear material shall refer to special fissionable materials or source materials, such as uranium, thorium and plutonium, suited for obtaining nuclear energy. (Nuclear Energy Act 990/1987)

Nuclear safeguards

Nuclear safeguards shall refer to regulatory control preventing the proliferation of nuclear weapons to ensure that the nuclear materials and nuclear energy are used peacefully as defined in international treaties, and to ensure that they or any technology related to them is not used to promote the proliferation of nuclear weapons.

Common cause failure

Common cause failure shall refer to a failure of two or more structures, systems and components due to the same single event or cause.

References

1. Nuclear Energy Act (990/1987).
2. Radiation Act (592/1991)
3. Nuclear Energy Decree (161/1988).
4. Government Decree on the Safety of Nuclear Power Plants (717/2013).
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. WENRA Working Group on Waste And Decommissioning (WGWD), Waste and Spent Fuel Storage Safety Reference Levels Report, version 2.1.
9. IAEA SSR-2/1, Safety of Nuclear Power Plants: Design, 2012.
10. IAEA SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation, 2011.