Radiation and Nuclear Safety Authority 48/0002/2016
February 13, 2018

Guide YVL D.7 Barriers of a disposal facility for spent nuclear fuel

1 Introduction

Guide YVL D.7 deals with the technical design, manufacture, installation and construction of barriers intended for the spent nuclear fuel disposal facility, as well as the control of these operations. The barriers may consist of, for example, the so-called engineered barriers, like the disposal canister, the buffer material surrounding the canister, backfill and plugs, and the natural barrier, i.e. the bedrock. In Finnish geological conditions, spent nuclear fuel shall be disposed of in crystalline bedrock. This Guide does not discuss other possibilities for geological disposal.

The control of the construction of a nuclear waste facility, including that of Posiva's underground research facility Onkalo, has been based on Guide YVL D.5 "Disposal of nuclear waste" and the application of Guide YVL E.6 "Buildings and structures of a nuclear facility". Engineered barriers have not been manufactured as production runs before this. The new Guide is required for the following reasons:

- Guide YVL D.5 deals with the design of the disposal concept, the long-term safety of disposal and the safety case, the operational safety to some extent and the related requirements, but not the practical implementation.
- Guide YVL D.5 will be updated during 2017, and the practical design and implementation requirements in it will be moved to this Guide.
- Guide YVL E.6 or other E-series YVL Guides have, as a rule, proven to be difficult to apply (or inapplicable) with respect to, for example, barriers based on clay materials, or rock construction.
- The licensees need to be able to anticipate regulatory control and plan their operations also from the point of view of regulatory control.
- Regulatory control needs to be clarified in order to reduce ambiguity and ensure that the level of requirement remains as consistent as possible regardless of the person conducting the inspection.
- The supervision of nuclear waste facilities needs to be made more consistent with the supervision of nuclear power plants.
- Document submittals and inspections at the construction site need to be made more systematic.
- For some sub-areas, there are not even national-level instructions, for example, instructions guiding design and implementation, or they cannot be applied to disposal facilities as such.

Guide YVL D.5 primarily aims to define the principles and preconditions and set out the framework conditions for safe disposal of nuclear waste and demonstration of the safety required at different periods, whereas Guide YVL D.7 sets out to answer questions related to the practical design and implementation of disposal and the type of quality assurance, documents and regulatory oversight that shall be used so that the requirements of YVL D.5 can be considered to be met.

With regard construction, the Guide is based on conventional rock and concrete construction methods and experience gained from the Posiva's Onkalo project and, in many respects, the practices prevalent there. The requirement and control models in the Guide are based on the E series YVL Guides in order to have regulatory practices between the various nuclear facilities as consistent as possible.

The objective was to come up with a comprehensive Guide including all the requirements for the implementation of the disposal and disposal facility in one document instead of references to instructions included in other Guides of different series, or having the licensees interpret instructions prepared, by definition, for nuclear power plants. In places, Guide YVL D.7 is quite detailed.

The facility build in Finland is the first spent nuclear fuel disposal facility in the world. This means that the only experience we have with corresponding facilities is that gained by Posiva in the course of its own disposal project. Due to the unique nature of the project to be implemented in Finland, barriers must be manufactured and constructed using, in addition to Guide YVL D.7, a wide range of high-level expertise and knowledge available and based on an ethically-sustainable operational practice. It must be understood that knowledge and competence increase all the time not only in Finland but also around the world, and this must also be utilised in the project. It is to be expected that needs for updates will arise as a result of the application of Guide YVL D.7 and experience gained later on.

2 Scope of application

Guide YVL D.7 addresses the technical design, manufacture, installation and construction of barriers intended for the spent nuclear fuel disposal facility, as well as the control of these operations. The type of nuclear waste within the scope of the Guide is spent nuclear fuel.

The Guide addresses the operations and regulatory control of operations related to the design, manufacture, installation and construction of barriers in the construction and operation stage of a disposal facility for spent nuclear fuel. The licensing, construction or operating stages as such have no influence on the application of the Guide. The Guide does not address separate licensing stages, such as the application for a construction or operating license; these are addressed in other YVL Guides. The Guide does not address the closure of the facility, but the closure of the facility must be taken into account already in the design stage of the facility.

The construction of the disposal facility of spent nuclear fuel (HLW) has moved from the research and development stage and underground research facility to the implementation stage of the disposal facility. There are currently two LILW repositories for disposal of power plant waste in Finland, and it will be several years before new ones will be constructed. For these reasons, the section regarding the disposal of spent fuel was prioritised, and the disposal facilities for power plant waste have been left out of Guide YVL D.7. The aim is to expand Guide YVL D.7 at a later point in time to also cover the VLJ-repositories.

3 Justifications of the requirements by topic

3.1 Chapters 3 and 4 General requirements for design, implementation, documentation and records for barriers

Chapters 3 and 4 concretise the contents of the detailed plans included in Section 108 of the Nuclear Energy Decree (161/1988) and how the safety-related factors and safety regulations should be taken into account and present. In drafting the Guide, the intention was to identify different barriers and common factors related to the various safety classes of these structures, in order to come up with systematic requirements of the same type for multiple barriers. The safety significance of the various structures and components was also taken into account. The requirements in Chapters 3 and 4 typically apply to two or more barriers or work stages. Chapters 5–8 provide detailed barrier-specific instructions specifying the requirements set in Chapters 3–4.

Chapter 3 presents general requirements for, for example, the setting of the requirements, design, verification of the design solutions and methods, manufacture of the barriers, installation, construction and inspections by the licensee. Manufacture and installation always refer to engineered barriers, whereas construction refers to rock and concrete construction, i.e. to natural barriers, concrete barriers or concrete barrier parts.

Guide YVL D.7 becomes applicable upon the completion and approval of the general facility and safety design completed with system descriptions in accordance with Guide YVL B.1 “Safety design of a nuclear facility” and the transition to detailed requirement specification, design and further on to the implementation of the systems.

Requirements pertaining to the requirement specification (Chapter 3.1) specify that the functional and technical requirements related to design and implementation must be connected to the operational and long-term safety and that this must be demonstrated. Chapter 3.1 links Guide YVL D.7 to Guide YVL D.5 and the safety case (Figure 1). Existing norms, standards and regulations shall be applied whenever possible. It is to be expected that this will not always be possible due to the unique nature of the disposal facility and the exceptionally long period of operation.

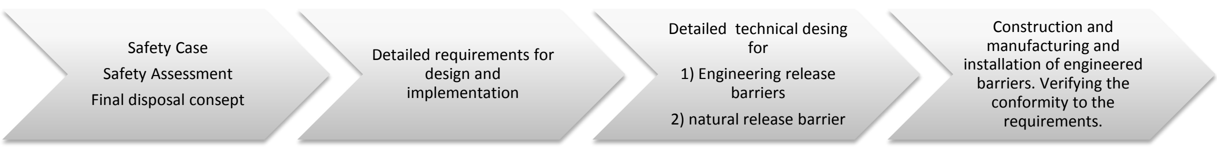

Figure 1: The connection between long-term safety and the design and construction of engineered barriers.

Depending on the size of the disposal facility, it will receive over time dozens or hundreds of cubic meters of different materials, some of which are natural (e.g. copper and clay) and some of which are foreign to the living environment or bedrock. Requirements concerning the materials (Chapter 3.2) ensure that the selection and behaviour of the materials are planned and controlled. The barrier-specific Chapters contain requirements concerning the safety of materials from the point of view of long-term safety.

The design shall provide (Chapter 3.3) solutions that are based on the requirements defined and justifiable. Technical design must be connected to the long-term safety case; this provides an interface to Guide YVL D.5. All input data, loads, stresses, conditions and service lives must be known and anticipated. Inspection and inspectability shall be taken into account already in the design stage.

For disposal facilities and barriers, due to the exceptional long-term safety requirements, it is to be expected that development of methods will also be required. Chapter 3.4 presents cases requiring procedure tests to ensure the acceptability of the design solution prior its implementation. Such unique or new methods include, for example, drilling of the deposition holes and compacting of the buffer blocks. Procedure tests are not required in case of known and commonly used methods provided that the requirements set for the end product are not exceptionally demanding.

Chapters 3.5–3.8 present general requirements related to manufacturing, installation and construction. For engineered barriers, Guide YVL D.7 presents quite detailed requirements. The requirements for rock construction mainly focus on factors that, at this point, are identified as having safety significance. Due to the long-term and unique nature of disposal, the views of the factors significant to safety may change over time. The bedrock must at all times form and maintain conditions that are favourable to engineered barriers (YVL D.5) in order to ensure their long-term performance. As for construction, standards of good building practice shall, as a rule, be deemed sufficient, and Guide YVL D.7 mainly contains requirements needed due to the special characteristics of the disposal facility. Standards of good building practice means that valid laws and decrees regarding construction, the regulations and guidelines of the Finnish Building Regulations and, for example, the general quality requirements and instructions observed in the construction industry and infrastructure engineering (RYL, InfraRYL, RT building information cards, RIL instructions, BY instructions, etc.) are observed.

Chapter 3.9 presents general requirements for the inspections carried out by the licensee, including the readiness inspections, receiving inspections, construction inspections and the related intermediate inspections and installation inspections. Most inspections may be repeated in the same type for different barriers and at different work stages. Depending on the item, the content of the inspection will vary as specified in the barrier-specific chapters. According to Chapter 3.10, the licensee shall request for a regulatory inspection at an appropriate stage allowing, as a rule, the inspection to be carried out in one go. Regulatory inspection assumes that the licensee has through its own activities ensured the conditions of the item to be inspected and the prerequisites for its acceptability in advance.

As for deviations, standard STUK practices for nuclear facilities shall be applied. Guide YVL D.7 emphasises that the long-term safety significance of the deviation shall also be evaluated and justified. As the requirement specification connects the technical requirements and design to the long-term safety requirements and, consequently, to Guide YVL D.5, the requirement concerning deviation connects the deviation process to Guide YVL D.5.

Chapter 4 presents general content and quality requirements concerning documentation, as the national guides and practices do not cover all the relevant aspects (e.g. clay structures). The purpose of these requirements is to streamline and improve the manageability of the documents through a sufficiently uniform mode of presentation.

Technical designs shall be unambiguous and form a logical entity (Chapter 4.1). Summary of justifications is required (Chapter 4.2) to ensure that the licensee shall first assess and inspect the conformity to requirements of the system or structure and/or the related document.

The design documents and the result and as-built documentation shall demonstrate a systematic mode of presentation and thoroughness (Chapters 4.3 and 4.5). It must be possible to demonstrate the acceptability and feasibility of the solutions and their implementation with this documentation. This is to ensure that the application already contains sufficient information for the processing and acceptance of the matter even if the mode of presentation as such may vary greatly. As the duty to archive documents cannot be defined and outlined in detail at early stages due to the globally unique nature and exceptionally long-running disposal facility pilot project, the duty to archive shall, as a rule, continue until the duty of care of the licensee ends (Sections 9 and 32 of the Nuclear Energy Act, Section 29 of Regulation STUK Y/4/2016). It is to be expected that the views of the significance of various factors to safety will change in the future, and the old information will have to be revisited. Requirement 433 does not require that the licensee shall preserve all information but at a minimum the information sufficient to demonstrate the fulfilment of the regulatory requirements and the licensee’s own requirements valid at any given time. Various research documents should be preserved for possible later analysis and studies. The duty to archive may be defined in more detail item- or component-specifically. As for temporary structures and structures that will be removed, there is no need to require duty to archive until the end of the duty of care. The information required for different barriers is specified in the barrier-specific chapters.

3.2 Chapter 5 Canister

The canister for the spent nuclear fuel is classified in higher safety class (2) than the other engineered barriers (3). It is, physically and functionally, the first nuclide barrier. For this reason, the design, manufacture and quality control of a canister shall be more detailed and specific than in the lower safety class. The other barriers are there to protect the canister and to ensure that the conditions and the operating environment remain favourable to the canister. The other barriers start to function as nuclide barriers if/when the performance of the canister is degraded.

Special processes are used in the manufacture of the canister. The manufacturer using the special process must have a separate approval from STUK. Requirements for the approval of the manufacturer and the special processes are presented in Guide YVL E.3 “Pressure vessels and piping of a nuclear facility”. Requirements in Chapters 4.21–4.26 of Guide YVL E.3 shall be applied to manufacturers that manufacture canister components using a special process. According to Guide YVL E.3, STUK may issue separate decisions to define the manufacturers and subcontractors of canister components for which no separate approval is required even if special processes are used in manufacture.

As the system in question belongs to the higher safety class, and there is no prior experience of industrial production of equivalent structures available, an independent third party shall control the manufacture of the materials and structures, as well as the qualification of the manufacturing procedures and methods, of the canister. The canister is not classified as pressure equipment, but the Guide applies the Pressure Equipment Directive (2014/68/EU) to the conformity assessment bodies (third party). This is justified since the conformity assessment bodies already have a broad range of experience in conformity assessment of metallic equipment and structures that can be utilised in controlling the manufacture of the canister structures.

Organisations participating in the testing and inspections and the inspection methods used shall be qualified for high safety class work in compliance with the requirements. Requirements for the acceptance of organisations are presented in Guides YVL E.1 “Authorised inspection organisation and the licensee’s in-house inspection organisation” and YVL E.12 “Testing organisations for mechanical components and structures of a nuclear facility”. Furthermore, as the system in question belongs to the higher safety class, and there is no prior experience of industrial production of equivalent structures available, actions by an independent third party shall be used for this sub-area as well.

The compliance of each canister shall be ensured, as each canister must be leak-proofed. To achieve this, the manufacture of each canister shall be conducted with care, detailed quality control and careful manufacture result documentation and construction inspection.

3.3 Chapter 6 Clay-based barriers

Clay-based engineered barriers (buffer, backfill) are made of natural clay. The characteristics of natural clay may vary greatly, so it is necessary to provide a detailed description of the clay to be used and to determine its relevant properties. The characteristics of the clay must be known and the allowed range of the characteristics determined by means of preliminary assessments and tests. The tests shall cover the data needs related to feasibility and long-term safety.

For the procurement of clay-based materials, the licensee shall provide the determined product specifications and the related testing methods as part of the construction plan. With the material batch, the producer or supplier of the material shall provide a material certificate based on which it is possible to trace and establish the mining site of the batch and to verify the compliance of the key characteristics of the material prior to the manufacture of the components.

In the KBS-3V reference concept, one deposition hole contains approximately ten buffer blocks or, alternatively, even about a hundred when using smaller blocks. The number of tunnel backfill blocks used in the reference concept is approximately 100 per each metre, i.e. approximately 1,100–1,400 according to the final deposition hole distance. Small pellets are used to backfill various voids with volumes of cubic metres per one final deposition hole distance.

Due to the large volumes of the blocks and pellets mentioned above, they will be manufactured as series production. Consequently, the respective manufacturing, quality control, storage and identification may be realised using methods applicable to series production. In the KBS-3V reference concept, the identification of a buffer block may be carried out block-specifically. Backfill is a massive structure, and as the clay expands, it fills up the voids. Identification of tunnel backfill blocks may be carried out pallet- or transport platform-specifically as variations in characteristics of a single component within the tolerances does not compromise the compliance of the operation of the structure or system. Identification of pellets may be carried out, for example, big bag-specifically.

3.4 Section 7: Concrete barriers

The requirements, inspections and control for concrete barriers are based on Guide YVL E.6 “Buildings and structures of a nuclear facility” that may largely be complied with as such. Guide YVL D.7 presents requirements that further specify Guide YVL E.6 or deviate from Guide YVL E.6. Concrete barriers may affect the performance of other barriers in the long-term, and this shall be taken into account in barrier design. Such identified factors may be related to the water-tightness, integrity and materials (for example, pH of the extract, concrete additives) of concrete barriers. Compliance with the requirements may require deviation from concrete standards in which case the possibility of concrete mass development shall not be ruled out.

3.5 Chapter 8 Rock construction

The underground facility systems of the disposal facility belong to safety class 3 or EYT/STUK depending on the safety functions of the rock surrounding the tunnels. If the purpose of the rock is to ensure favourable long-term disposal conditions and to slow down and limit the migration of released radionuclides, it belongs to safety class 3. If its purpose is to protect the disposal facilities from external disturbances (natural phenomena) and inadvertent human entry and to promote the preservation of favourable conditions of the rock surrounding the disposal facility, it belongs to class EYT/STUK.

Chapter 8.1 emphasises above all the consideration of long-term safety in the requirements set for the design. In this respect, disposal facility projects deviate significantly from conventional rock construction projects.

Chapter 8.2 presents requirements concerning the rock volumes selected for disposal. Due to the long-term and exceptional nature of disposal, the level of detail of the documentation required for the construction work is higher than that for conventional rock construction sites. The disposal facility documentation carried out in all rock tunnels also aims to gather input data for suitability assessments and long-term safety analysis, updated using the data gathered, for yet to be built disposal facilities.

The suitability assessment of the designed disposal rock volume shall be started upon the selection of the disposal site. As rock is a heterogeneous material and the conditions may change significantly even in small scale, the suitability of the designed facilities shall be assessed, and the suitability of the constructed disposal facilities shall be verified throughout the construction stage of the facility. Direct observations can be made by drilling and from the tunnel surfaces, but other than that, predictions are based on indirect observations (geophysics and hydrogeological methods) providing the basis for interpretations and prognoses by combining the observations. Bedrock groundwater properties consist of chemical composition and physical characteristics as well as, for example, dissolved gases and microbes. The assessment shall take into account at least the factors listed in para. 806, but as experience is gathered, the licensee shall also be prepared to develop its assessment procedures.

Requirements in Chapter 8.3 emphasise the consideration of long-term safety in the positioning of the underground spaces and detailed design. As experience is gathered, preparations shall be made for possible changes. The requirements related to the layout design, distances and prevention of collapses have been set from the point of view of operational safety. Based on current knowledge, the facility must remain operable for over 100 years, and the stresses subjected to, for example, reinforcements and sealing structures in deep rock tunnels are exceptional. These shall be taken into consideration already in the design stage.

Chapter 8.4 aims to guide the licensee carrying out the construction and operational activities to design, assess, approve, manage and use only such materials that alter as little as possible those natural bedrock characteristics that are favourable/beneficial with regard disposal or that have an adverse effect on the performance of the engineered barrier. There are data available on the long-term behaviour of various metallic materials (for example copper) and clays in different natural conditions, based on which the long-term behaviour of these materials can also be predicted. The substances and materials used in the construction operations are, however, new and foreign to the natural environment. The long-term behaviour and subsequent impact on the engineered barriers of these are not fully known and cannot be predicted reliably. Substances that are known to be harmful shall not be used in the disposal. As for other foreign substances, quantitative limitations aim to reduce any adverse effects in the future. Where possible, the materials shall also be removed upon the closure of the disposal facility.

As for the rock tunnel design documents and as-built documents (Chapters 8.5–8.6), the aim, in principle, is to follow the standard method and division used in conventional rock construction sites. The special features of the disposal are taken into account in the requirements concerning the contents of the documents.

The construction of a nuclear waste facility will cause changes and disturbances in the disposal site’s bedrock and bedrock groundwater. Chapter 8.7 deals with the monitoring and control of the changes and disturbances caused by the construction. In the Guide, the term “disturbance” refers to adverse effects to the natural condition of the bedrock and bedrock groundwater (chemical, physical and other properties of groundwater as well as, for example, the pressure levels) caused by human action. A disturbance has or may have an adverse and widespread effect on the long-term safety of the disposal concept. The term “change” refers to a situation that, based on current knowledge, does not necessarily harm the disposal system. Requirements 829–832 aim to guide the licensee to design and create an investigation and monitoring programme in accordance with Regulation STUK Y/4/2016 “Radiation and Nuclear Safety Authority Regulation on the Safety of Disposal of Nuclear Waste”**.** As part of this programme, the disturbances and changes caused by the construction shall be monitored in order to keep the conditions favourable enough during the construction up to the time the change or disturbance starts, after the closure, to develop toward the normal state. New research results may change the views regarding the disturbances and changes. This possibility shall be taken into account as the licensee determines criteria for acceptable materials.

The licensee shall define the properties of the disposal site bedrock and bedrock groundwater (surveying the normal status) before starting the construction of the nuclear waste facility. The licensee shall define for the investigation and monitoring programme variables a set of normal status limit values which, if exceeded or not met, start actions that aim to control the disturbance in order to limit any long-term adverse effects. The requirements guide the licensee to document and report measurement data, observations and the exceeding of action limits, related to the monitoring of disturbances and changes caused by the construction. The licensee shall, in particular, focus on the handling and control of long-term exceeding of action limits that have lasted at least over a year or exceeding of action limits that develop quickly, as long-term or non-recoverable changes are the most significant as regards the long-term safety of the disposal and uncertainties in the safety assessments.

Chapter 8.8 deals with inspections required from the licensee during the implementation stage of the construction of the rock tunnels, including the readiness to begin the construction, documentation of rock surfaces, rock engineering structure (excavation, reinforcement, sealing) documentation and construction and commissioning inspections of the tunnel entities. The licensee’s own inspections and control form the basis for ensuring the functionality of the procedures.

The verification of the readiness to begin the construction and the structural inspection of an entity may be performed for entities no larger than those in the implementation planning scope. Since the bedrock investigation and rock engineering design proceeds in stages, the readiness to begin the construction of the rock tunnels may only be verified in parts. Depending on the completion status of the licensee’s rock classification and design documentation, this could be performed, for example, for the part that will become the central tunnel and a couple of disposal tunnels at the same time. At least in the early stages of operation, it shall be necessary to perform a separate readiness inspection for each hole.

With the inspections of the documentation of rock surfaces, the licensee shall verify that the bedrock data required for different purposes (technical design and modelling related to the safety case) has been compiled and that the documentation reflects the observations appropriately. The aim of the inspection of the documentation of rock surfaces is to verify that the licensee has performed the geological surveys of the surfaces of excavated facilities (floor and walls), determined the rock quality, measured the as-built dimensions by laser scanning or similar method, surveyed and classified the fractures and geological zones and the related water-conducting areas on the surfaces, recorded the documentation and inspected and approved and prepared various visual realisations, prepared the suitability analysis of the rock at the site as well as opened or processed any deviations related to the inspection item.

With the inspections of the rock engineered structures, the licensee shall verify in a traceable manner that the structure, rock tunnel and as-built documentation comply with the design documents and the licensee's requirements. Although single components are not safety-classified, there are safety requirements related to the materials to be used and the structural-level design solutions.

3.6 Chapters 9 and 10 Documents to be submitted to STUK and STUK's regulatory control measures

In drafting Chapters 9 and 10, the intention was to identify different barriers and any common factors related to the various safety classes of these structures, in order to come up with systematic requirements of the same type for multiple barriers by simultaneously taking into account the safety classification of the various structures and components. These chapters concretise the application of Sections 109 and 110 of the Nuclear Energy Decree as regards disposal facilities for spent nuclear fuel.

The submission dates of the documentation to be submitted for approval and information shall be determined in a delivery plan to be drawn up separately. The licensee shall observe the processing times of the authority in its deliveries. Due to the special nature of the disposal facility, the monthly construction report shall contain a concise summary of the R&D work related to barriers, cases of exceeding of action limits for monitoring, and deviations. Cases of exceeding of action limits for monitoring significant to long-term safety and the plan to take the case in question under control shall be submitted for information.

The Guide takes into account the large production volumes of certain components and structures by applying different control model to series production and control of structures that are of special or unique nature. In this case, it has been considered that the type designs for the production of structures or facilities of the same type may be approved in one go. In addition, the prerequisites for starting serial production are ensured, for example, by means of readiness inspections and supplier assessments, and the serial production quality is controlled by means of, for example, witness points or random inspections.

Through its supervision at the places of manufacture and the construction sites, STUK aims to ensure that the licensee's own supervision and inspections shall result in a compliant end product. STUK shall not, in principle, repeat all the same inspections covered by the licensee's own supervision. The higher the safety class of the system or structure in question, the more detailed the control and inspections of the systems, structures and their components shall be. In addition to the safety significance, the design of the control models takes into account the size of the production run and the novelty or uniqueness of the product. STUK may also change the focus of the supervision between the various sub-areas if the need arises.

By derogation from the manufacture of the other engineered barriers, STUK shall not perform a separate readiness inspection for the disposal canister. Conditions for manufacture shall be assessed upon manufacturer assessments and manufacturer approvals. Unlike in the case of the other barriers, each disposal canister shall also be construction inspected by STUK, as it is a barrier belonging to the higher safety class.

The construction inspection of the manufacture of the disposal canister compiles the result documentation from the preceding tests and inspections. At this stage, the visual inspection of the canister shall also be performed. STUK will perform the construction inspection of the disposal canister also at the encapsulation facility following the sealing of the canister. This includes welding and NDT result documentation inspections as well as an indirect visual inspection. STUK will participate in the canister's receiving inspection at the encapsulation facility.

STUK shall perform a readiness inspection for the production of structures and components of clay-based barriers before the commencement of manufacture. The inspection ensures the prerequisites for starting the serial production according to the requirements are met. Once the conditions for manufacture have been ascertained to be adequate, supervising focuses on the construction inspections of the first batches and the subsequent control is designed to continue in the form of random inspections (announced or unannounced) for as long as the production meets the requirements. Recurrent errors or deviations, for example, discovered in random inspections may restart more frequent construction inspections.

STUK may also take material or structure samples for the purpose of making or having its own comparative tests made. Samples may be collected from different stages of the production before the components are installed in place. As the production volumes of the clay components are large, the samples taken do not harm the production significantly.

STUK's control will be focused on supervision of the installation of safety-classified engineered barriers, and STUK will conduct installation construction inspections and related intermediate inspections for engineered barriers. As for the disposal canisters and buffer, the verification of the compliance of the installation shall be conducted for each disposal hole separately. Separate verification may be conducted for the buffer bottom section, the canister and finally the buffer upper section. This procedure may be used to verify the compliance of the initial state of the canister and buffer, after which the canister and buffer will remain in passive state.

The conformity to requirements of the backfill shall at least be affirmed separately for each disposal tunnel and separately for each disposal hole distance at the most. The inspection interval shall be specified separately for each disposal tunnel based on the circumstances and disposal process needs. Circumstances may have a limiting effect on the length of the backfill section open at any given time, i.e. the starting of the backfill may have to be expedited due to, for example, water leakage in the tunnel. Water leakage causes the clay to expand, in which case the backfill and enclosure must be carried out quickly.

As for safety-classified concrete barriers, STUK will perform readiness inspection of the concreting, since the structures are massive and it is difficult to mend the concreting. The components of the concrete barriers, including the reinforcements, shall be inspected separately following their completion.

As for underground facility systems in safety class 3, STUK shall perform technical readiness inspection to ensure that the design of the entity to be implemented is up-to-date and that sufficient consideration is given to the operational and long-term safety of the underground space. STUK shall perform the readiness inspections of the rock spaces in safety class 3 for a tunnel entity no larger than that in the planning scope at a time. The scope may cover, for example, part of the central tunnel and a couple of disposal tunnels at a time. The entities to be inspected shall be specified separately. At least in the beginning, readiness inspection shall be performed for each disposal hole separately, but depending on the licensee's arrangements, several holes may be inspected during one readiness inspection. Based on experience gained, the scope and frequency of the readiness inspections may later need to be reviewed.

As for class EYT/STUK underground facility systems, STUK may, based on exceptional conditions or long-term safety, define items to be significant and therefore subject to STUK's readiness inspection as in safety class 3 rock tunnels. These may include, for example, construction of pressure-resistant concrete structures in demanding rock quality or water-conductivity conditions, or local geological conditions having a role in groundwater chemistry disturbance related to the disposal facilities.

The aim of the rock surface documentation inspection carried out by STUK is to verify that the licensee has carried out a comprehensive geological and hydrogeological surface characterisation and documentation and that, based on visual inspection, the documentation inspected by the licensee is consistent with the observations. The inspections shall be targeted to all safety class 3 tunnels. In addition to the spot check-type reviews of the documents related to the item in question, the inspection shall also include spot check-type visits at the item to verify what has been realised. As for rock tunnels and spaces in class EYT/STUK, STUK shall primarily supervise the licensee's inspection activities but will not make own systematic inspection at the site. The tunnel ceiling shall be shotcreted, normally for safety reasons, as soon as possible following the licensee's own geological surveys and as-built measurement. Case-specifically, it may also be necessary to shotcrete some sections of the tunnel wall immediately after the excavation for occupational safety reasons. Regulatory inspections of these special items shall be agreed upon separately with the licensee.

STUK shall perform the work- and technology-specific intermediate inspections of rock engineering structures in rock tunnels belonging to safety class 3. The inspections shall, for example, verify that an excavation, reinforcement or sealing structure as a whole conforms to the design and requirements. STUK will not target systematic inspections on rock engineering components, including, for example, reinforcing bolts, mesh, bolt grout and grouting recipe. Random component inspections may be performed. The structures and components are defined separately in Guide YVL D.7. As for rock tunnels in class EYT/STUK, STUK shall primarily supervise the licensee's inspection activities but will not make own systematic inspections at the site. In case of exceptional circumstances, such as rock fragmentation or significant water leakage points, STUK may perform a separate inspection at the site.

The licensee may invite STUK to inspect and approve the rock surface documentation and rock engineering structures in entities of its own choice, provided that the licensee ensures that the structures and rock surfaces to be covered will be inspected according to the requirements before proceeding to the covering work stage. With the exception of the covering work stage, it is, in principle, possible to have the rock surfaces and rock engineering structures inspected in one go. The surfaces are typically covered over a longer tunnel section a time. Naturally, the covering stage can only be inspected after the covering is completed.

The construction inspection of rock tunnels combines the intermediate inspections, i.e. rock surface documentation inspections and work- or technology-specific intermediate inspections of rock engineering structures, of an area chosen by the licensee. The licensee invites STUK to perform a structural inspection of rock tunnel at entities of its choice. The inspection invitation requires that the preceding intermediate inspections of the tunnel entity chosen have been performed and any inspection requirements thereof have been dealt with appropriately, that the licensee has defined the parts of the bedrock suitable for disposal, that any deviations and exceeding of action limits have been dealt with acceptably, and that quality control records have been reviewed and approved.

3.7 Hold points and witness points in the tables of Annexes A–C

As for the hold points and witness points, the terms defined in Guide YVL E.3 shall apply:

- Hold point shall refer to an inspection for which advance invitations have been sent to the parties defined in the inspection plan and whose supervision is a condition for proceeding with the work unless the parties have given written permission to proceed without their presence.
- Witness point shall refer to an inspection for which advance invitations have been sent to the parties defined in the inspection plan but whose supervision is not a condition for proceeding with the work. Having received the invitation, the invited parties may, however, separately require that they be present in order for the work to be continued.

3.8 Definitions

Underground facility systems and rock engineering structures and components are defined in Guide YVL D.7 to facilitate the adoption of commonly used nuclear plant terminology at nuclear waste facilities.

4 International provisions concerning the scope of the Guide

Key IAEA guides concerning disposal are the following:

- Disposal of Radioactive Waste. Specific Safety Requirements. IAEA Safety Standards Series No. SSR-5.
- Geological Disposal Facilities for Radioactive Waste. Specific Safety Guide. IAEA Safety Standards Series No. SSG-14.

5 Impacts of the Tepco Fukushima Dai-ichi accident

In practice, the Fukushima accident does not have any impact on the Guides concerning disposal facilities. At the time of the disposal of spent fuel, active cooling is no longer required, and the amount of fuel being processed is small.

In Finnish geological conditions, a major earthquake and tsunami like those that caused the Fukushima accident are not possible geologically. The Japanese archipelago is situated within the zone of collision of five tectonic plates. The area contains all three plate tectonic boundary types (divergent, convergent and transform plate boundaries), and Fukushima is situated by the Pacific. Finland, on the other hand, is situated in a stable area far from tectonic plate boundaries, the nearest being the Mid-Atlantic Ridge of the divergent tectonic plate type. Finland is not situated by an ocean.

Anticipated flooding and earthquakes possible in Finland shall be taken into account in the design.

6 References

Nuclear Energy Act (990/1987).
Nuclear Energy Decree (161/1988).
Radiation and Nuclear Safety Authority Regulation on the Safety of Disposal of Nuclear Waste (STUK Y/4/2016).
Disposal of Radioactive Waste. Specific Safety Requirements. IAEA Safety Standards Series No. SSR-5.
Geological Disposal Facilities for Radioactive Waste. Specific Safety Guide. IAEA Safety Standards Series No. SSG-14.