REGULATORY CONTROL IN THE CONSTRUCTION OF SPENT FUEL DISPOSAL FACILITY IN FINLAND

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Abstract

Finland was the first country to license a spent nuclear fuel encapsulation plant and a disposal facility. Posiva Ltd (Posiva) submitted the construction license application (CLA) in the end of 2012. Radiation and Nuclear Safety Authority (STUK) made the review of the CLA and in February 2015 the statement and safety evaluation report were submitted to the Ministry of Economic Affairs and Employment (MEAE). The construction license for Posiva was granted by the Government in November 2015.

STUK started planning the regulatory control of the construction activities after finishing the CLA review. The regulatory control of the encapsulation plant construction follows mainly the principles of a nuclear facility control taking into account the graded approach. The control of the construction of the underground disposal facility requires a novel approach since excavating safety classified rooms in the bedrock keeping in mind the long term safety aspects differs from the other types of nuclear facility construction.

Posiva constructed the underground rock characterization facility, Onkalo, at the facility site during 2004 - 2016. STUK controlled the construction of Onkalo similarly as it would have been a nuclear facility because from the very beginning Onkalo was planned to be a part of the future disposal facility. The experience gained from the control of the Onkalo construction was applied in the development of the regulatory control concept of the disposal facility construction.

The article will give an overview on the regulatory control concept of the spent nuclear fuel encapsulation plant and the underground disposal facility during the construction phase. The construction phase covers the detailed design of systems, structures and components, as well as the feasibility demonstrations, the construction activities, monitoring the construction effects to the underground disposal facility and the commissioning.

The review phase of the operating license application is expected to begin in the early 2020s. The planning for the review of the operating license application is on going at STUK. This aspect is also discussed in the article.

1. INTRODUCTION

1.1. Background

Finland is one of the foremost countries in the world in developing the disposal of spent nuclear fuel (SNF). The Construction License Application (CLA) for the Olkiluoto encapsulation plant and spent nuclear fuel disposal facility was submitted to the government in the end of 2012 and the construction license was granted to Posiva in November 2015. The facilities are expected to start the operation before 2025. The Finnish spent nuclear fuel disposal program has been a long-term project with over 30 years of parallel development of the repository project and the regulatory approach to spent fuel management.

In 1983 the government made a strategy decision on the objectives and target time schedule for the research, development and technical planning of nuclear waste management. While the export and the international disposal solution were still the preferred options, the strategy decision required the licensees without the possibility to export SNF abroad for reprocessing to prepare also the disposal option in Finland. The strategy decision also gave the timeline for the milestones on the way to an operating disposal facility by around 2020.

1.2. Licensing procedure of a nuclear facility

The licensing procedure for an encapsulation plant and a disposal facility has several steps that are similar to all nuclear facilities in Finland. These steps are defined in Nuclear Energy Act [1] and Decree [2]. These licensing steps are:

— The Decision in Principle (dip): is required for a nuclear facility having considerable general significance. This is essentially a political decision: the government decides if the construction project

is in line with the overall good of the society. The decision can be applied for one or more sites, the host municipality has a veto right and the parliament has the choice of ratifying or not ratifying the decision;

— The Construction License (CL): is granted by the government and authorizes the construction of the nuclear facility. The actual construction is regulated by STUK and includes several review and approval steps;
— The Operating License (OL): is granted by the government and authorizes the operation of the nuclear facility for a certain period. For the disposal facility the operating license is needed before nuclear waste can be disposed.
— The Decommissioning Licence: is granted by the government and authorizes the decommissioning of the nuclear facility. The decommissioning license has to be applied and granted before the last operating license expires.

The first step in the licensing process was reached in the end of 1999 when Posiva, the implementer of the disposal program, submitted the application for a Decision-in-Principle [4] for a spent fuel disposal facility in Olkiluoto. The DiP was granted by the government in late 2000, approved by the host municipality and ratified by the parliament in early 2001. A specific feature in the DiP was that it gave Posiva the authorization to start constructing an underground rock characterization facility and acquire characterization data from the actual planned disposal depth, as required by regulation.

Posiva constructed the underground rock characterization facility, Onkalo, at the facility site during 2004 - 2016. STUK supervised the construction of Onkalo similarly as it would have been a nuclear facility. The reason for this was that from the very beginning it was planned that Onkalo will be a part of the future disposal facility. The experience gained from controlling the construction of Onkalo was used in the development of the regulatory control concept.

1.3. Construction license review

The Nuclear Energy Decree [2] section 35 defines the documentation to be submitted to STUK when applying for a construction license. The documentation should give a detailed description about the facility, the principles of the operational safety and the post-closure safety. In addition to the Nuclear Energy Decree section 35, the STUK regulation on Safety of Disposal of Nuclear Waste [4] requires that the licensee has to provide the post closure safety case for the disposal facility.

Posiva submitted the construction license application (CLA) and supporting documentation to the authorities at the end of 2012 and supplemented the documentation during the following years. During the CLA review phase STUK accepted the required documents. In the decisions concerning these documents STUK set approximately 90 requirements for Posiva to be fulfilled in the future phases of the encapsulation plant and disposal facility project.

STUK performed a thorough review and assessment of the CLA documentation to ensure the compliance with the safety requirements. The CLA and STUK's review covered aspects of safety, security and nuclear safeguards. The scope of application was the operational safety of the facilities and post closure safety of the disposal. The regulatory assessment of the adequacy and acceptability of Posiva's CLA was submitted to the Finnish government in February 2015 [6]. The conclusion of the assessment was that the encapsulation plant and the disposal facility for the spent nuclear fuel proposed by Posiva can be constructed to be safe. The Finnish government granted the construction license to Posiva in November 2015.

2. PLANNING OF THE REGULATORY SUPERVISION

STUK started planning the regulatory supervision of the construction activities after finishing the CLA review. The regulatory control of the encapsulation plant construction will follow mainly standard principles of a nuclear facility supervision taking into account the graded approach. The regulatory control of the construction of an underground disposal facility requires a novel approach since excavating safety classified rooms in the bedrock keeping in mind the long term safety aspects differs from the traditional nuclear facility construction.

When planning the regulatory control, the experiences gained during the regulatory control of Onkalo were applied.

During the Onkalo construction, the regulatory control was mainly based on the two regulatory guides: The Guide YVL D.5 “Disposal of nuclear waste” and the Guide YVL E.6 “Buildings and structures of a nuclear facility”. Based on the experiences gained of the regulatory control of the Onkalo construction, it was obvious that these guides were not detailed enough for the regulatory control of the disposal facility construction due to its special features such as excavating the underground rooms and all the special features related to that. Even though there were some applicable requirements for manufacturing large metallic objects like a copper canister, the YVL guides were not detailed enough for this purpose. Also, the YVL guides lacked the requirements concerning the manufacturing the clay based engineered barriers. Thus, based on these facts a new regulatory guide was established to specify requirements concerning the construction and manufacturing the release barriers of the spent fuel disposal facility. The new Guide YVL D.7 “Release barriers of spent nuclear fuel disposal facility” [7] was published in 2018.

3. THE REGULATORY CONTORL CONCEPT OF THE DISPOSAL FACILITY DURING THE CONSTRUCTION

The purpose of STUK’s regulatory control of Posiva disposal facility is primarily to ensure that the design, location, orientation and construction are carried out in such a manner that the geo-environment retains its favorable characteristics and conditions needed for the safety functions. In particular, this implies the minimization of:

- Host rock responses to excavation, excavation disturbed areas and zones;
- Groundwater leakages to the tunnels and shafts;
- Introduction of foreign, potentially harmful substances to disposal facility during the construction (cement and other grouting materials, reinforcement materials, explosives etc.); and
- Pathways from surface to disposal rooms.

The graded approach is applied in STUK’s regulatory activities (approvals, reviews and assessments, inspections). All the systems, structures, and components, including underground rooms, of the facility are classified based on their significance to safety. In addition to the technical documentation, also the management system and safety culture of Posiva are subjected to STUK’s regulatory control.

According to the Nuclear Energy Decree [2] section 109, after the construction licence has been granted, STUK is controlling the implementation of the facility project in detail. The purpose of the control is to ensure that the conditions of the construction licence and the approved plans referred to in section 35 are complied with and that the nuclear facility is also in other respects constructed in accordance with regulations issued on the basis of the Nuclear Energy Act [1].

Following chapters will give an overall view on the implementation of regulatory control on Posiva’s disposal facility.

3.1. The Construction Inspection Programme

Based on the Nuclear Energy Act [1] and the Guide YVL A.5 [8] STUK launched a construction inspection program (CIP) immediately after the construction license was granted for the license applicant. With the CIP STUK supervises the overall functionality of the licensee’s management system, organization, processes, procedures and adequacy of resources. STUK conducts inspections focused on different fields of activity including also the licensee’s control of subcontractors whose work can be deemed to have major implications on safety.

The CIP is one of the key instruments for the regulatory control of construction and commissioning activities. Topics of the inspections are planned biannually and the goal is to have 8-10 inspections per year. Target for planning of CIP is to cover regularly all the main processes and major parts of sub-processes defined in the license applicant’s management system.

The CIP for Posiva project is covering the management system such as, the organization, human resources and training, safety culture, quality assurance, project management, design procedures, and also procedures in technical areas such as monitoring of the underground construction effects, rock classification, rock excavation procedures, safeguards and post closure safety case. In addition to the inspection of the management system within the CIP STUK verifies also that the operations of the organization comply with the management system.

No critical deviations or non-conformances have been revealed in the inspections. However, STUK has presented several requirements for Posiva to further develop and to improve the processes and procedures as well as different project programs and plans.

STUK considers that Posiva has developed and implemented the management system to cover all the activities specified for this stage of the construction project. Posiva is also continuously improving the management system.

3.2. Verification of the readiness to start the construction

According to the section 108 of Nuclear Energy Decree [2] various phases in the construction of a nuclear facility cannot be commenced until STUK has ascertained for each phase that all safety-related factors and safety regulations have been given sufficient consideration.

Posiva requested STUK in the fall 2016 to verify Posiva's readiness to start the construction of the underground disposal facility. STUK and Posiva agreed that this will be done with three inspections focusing on open issues from CIP inspections, Posiva's internal guidance and organizational readiness related to construction of an underground disposal facility. STUK made the inspections during October and November 2016 and after the last inspection of these three STUK concluded that Posiva is ready to proceed to the construction phase. Posiva started the construction outside the scope of Onkalo on the 1st of December 2016.

The construction license that was given to Posiva by the government included conditions and one of them was that the licensee had to start the construction work within the next two years. Otherwise the construction license would cease to exist. STUK verified the start of the construction and gave a statement to the MEAE on the verification. Based on the STUK statement, MEAE confirmed that Posiva had started the construction work within the timeframe set in the construction license application.

The construction license granted for Posiva covers both the encapsulation plant and the underground disposal facility. Second phase of the project will be the encapsulation plant construction and as stated in the section 108 of Nuclear Energy Decree [2], STUK will ascertain Posiva's readiness also for that part. Based on the time schedule by Posiva this is expected to be in summer 2019.

3.3. Regulatory control of the construction of the encapsulation plant

The regulatory control of the encapsulation plant will follow the same procedures as for the other nuclear facilities taking into account the graded approach which focuses the regulatory control based on the safety relevance. The basic design of the encapsulation plant was accepted within the construction license application review. STUK set requirements to Posiva concerning the design to be fulfilled later in the phase of detailed design. After the construction license was granted Posiva continued designing the systems, structures and components in detailed level. The detailed level design of some facility components are soon to be approved at STUK and after that the licensee may proceed to manufacture of the components.

The Guide YVL A.5, Construction and Commissioning of a Nuclear Facility [8] gives detailed guidance for the licensee and describes also STUK's procedures for the regulatory control concerning the construction of the disposal facility. The guide covers the requirements for the design, manufacturing, construction, installation, commissioning and reporting during the construction.

3.5. The regulatory control of the construction of the disposal facility

For the construction of the underground disposal facility the same regulatory control procedures as for the other nuclear facilities are not applicable straightforward. Excavating and drilling safety classified underground tunnels with post closure safety functions are specific to this facility and regulatory control procedures have to be adjusted for the purpose.

To outline the regulatory requirements for the control of underground excavation and construction STUK has published a new regulatory guide YVL D.7 mentioned earlier in the article. When planning the regulatory control concept and setting the requirements STUK has taken into account the experiences from the control of the underground rock characterization facility (Onkalo) [9].

According the Guide YVL D.7 the design documentation (e.g. main drawings, detailed design plans of excavation, reinforcement and injection and requirement specifications) has to be delivered to STUK for approval or for information depending on the document type and safety classification of the rooms to be excavated

After approval of the design documentation, STUK will perform an inspection on the readiness to start the excavations. During the construction STUK performs inspections on the rock surface mapping documentation before the surfaces are covered by shot creating and on the as built technical documentation of the excavated rooms.

3.6. The commissioning inspections

The commissioning inspection will be the final regulatory control procedure during the construction for the excavated rooms. It will conclude all the findings from earlier reviews, inspections, handling of non-conformances during the construction and in the quality control documentation.

Based on the graded approach the design documentation approvals and on-site inspections described above are performed for the safety classified rooms of the disposal facility. STUK may also perform, based on consideration, documentation reviews and on-site inspection for rooms that are classified to non-nuclear safety class if it considers that the rooms might have some effect on the post closure safety.

3.7. The monitoring

One of the key issues for to the post closure safety of the disposal concept is maintaining the favourable properties of the site hydrology, hydrogeology and rock mechanics during both construction and operation of the disposal facility. Posiva is carrying out a comprehensive monitoring program to follow the effects of the construction on the site properties and STUK is following closely planning and developing of the monitoring program as well as the results of the monitoring.

3.8. The supervision of feasibility of the disposal concept

Based on the construction license review Posiva had not yet fully demonstrated the feasibility of the disposal concept and a few of the requirements in the decision on Preliminary Safety Assessment Report (PSAR) concerned this issue. These include demonstrating among other things:

— The capability to excavate underground disposal rooms that fulfil the specifications
— The manufacture of engineered barrier components
— The installation of engineered barrier components

The Engineered Barrier Systems (EBS) are the copper canister, the bentonite buffer, the back filling of the tunnels and the structures of isolation and closure. For these EBS components the STUK control covers design, manufacture and installation. During the early construction period the regulatory control of EBS focuses on the R&D projects of Posiva that aim to demonstrate the manufacturing of EBS components fulfilling the requirement specifications set for them in the design documentation.

To demonstrate the feasibility of the concept, Posiva has developed a three stage approach. The first stage is the Full Scale In Situ System Test (FISST) in which Posiva aims to demonstrate the system level feasibility in the real environment. The second stage focuses on demonstrating the feasibility of the whole disposal system starting from receiving the transfer cask in the encapsulation plant and ending to tunnel back filling and installing the tunnel plug. These disposal system feasibility tests are performed with the dummy fuel elements. The third stage of the feasibility demonstration is a part of the commissioning after the operating licence and will be done with the spent nuclear fuel. STUK is following the FISST and supervising the planning, execution and reporting of the feasibility tests.

3.9. The regulatory control of the post closure safety case development during the construction of the disposal facility

The post closure safety case is linked to the construction of the disposal facility and feasibility of the disposal concept: the changes in post closure safety case might have influence on the construction of the disposal facility and feasibility of the disposal concept and vice versa.

STUK set several requirements in the decision [5] concerning the post closure safety case to be fulfilled before or in the operation license application. To follow the development work of Posiva to fulfil these requirements STUK and Posiva have agreed to communicate regularly of the development work. The first step of the development work was to have a common understanding on the targets for the development work for each requirement. To reach this point, several meetings were organized during 2015-2016 between STUK and Posiva. In the second step Posiva developed project plans to address the requirements and delivered those to STUK for information. To have a clear overall view on Posiva's development work, STUK required Posiva to include all the project plans into the existing disposal concept development plan or in some other similar plans.

STUK has followed the development work in the meetings with Posiva. Posiva has also provided post closure safety case reports for information to STUK and STUK has given Posiva comments to further develop the reports.

4. PREPARATION TO THE OPERATING LICENSE APPLICATION REVIEW

Posiva is has started planning the upcoming operation license application phase by planning the schedule and preparing the documentation. Posiva plans to submit the operation license application (OLA) in 2020.

STUK has agreed with Posiva that a part of the OLA documentation will be provided to STUK for the pre-review before the license application is submitted. Based on the experiences from other nuclear facility supervision projects, the pre-review facilitates the actual review of the OLA documentation by giving an overall view of the documentation. The pre-review is also a risk management tool for both sides to identify the possible nonconformance well in advance before the application is officially submitted for the review. The role of the pre-review is strictly limited to commenting the documentation; no official approvals are done based on the pre review.

5. LESSONS LEARNED

The Posiva disposal facility is a first of a kind nuclear facility. There are some similarities with the existing nuclear facilities but also plenty of features unique to the underground facility. Thus, some of the nuclear facility regulatory control concepts can be used in the regulatory control of a disposal facility but there are features for which the regulatory control concept has to be reformulated.

The level of nuclear safety significance of a disposal facility is different compared to the existing nuclear facilities in Finland. The regulatory control of a disposal facility has to be adjusted according to the safety significance which means that the graded approach has to be applied. The regulatory control of the underground rock characterization facility Onkalo was a learning process for STUK and Posiva and based on the experiences and knowledge acquired during the time, STUK has adjusted the regulatory control plans for the disposal facility construction.

The Finnish licensing system allows that the facility level nuclear safety design has to be fixed in the early phase of the licensing and the design in the detailed level can be provided in the later licensing phase. In Posiva's case the facility level safety design was approved during the Construction License Application review and it was known that the detailed design of the system, structures and components will be provided later on during the construction phase. During the detailed design there are always aspects revealed that urge to change also the facility level design and safety approach in some level. The challenge is to manage the safety concept and the overall facility level safety principles when a several minor changes are simultaneously implemented in the design. It might be useful to have fixed check points for analysing the facility level design often enough to confirm that the defined facility safety design features are still valid despite of changes made during the detailed design.

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