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GOSSER - Geological Safeguards and Security R&D Project in Finland - How STUK prepares itself for the Final Disposal in Finland

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The licensed construction of the disposal facility in Finland begun in autumn 2016 as the foundation works for the encapsulation plant and the excavations of the access tunnels to the canister shaft and canister storages in the geological repository were initiated. The disposal of spent nuclear fuel is scheduled to start in Finland in mid 2020's after the operational licence is granted. To ascertain that necessary technical safeguards tools are available at that time, STUK, the Radiation and Nuclear Safety Authority of Finland has set up a national R&D project GOSSER (Geological Disposal Safeguards and Security R&D). GOSSER's main objective is the finalisation of the national Finnish concept for safeguarding the final disposal of the spent nuclear fuel. This concept and related R&D efforts are coordinated with the Finnish facilities, European Commission and the IAEA. Activities in GOSSER include so far: 1) Participation in R&D of robust, reliable, and accurate methods to verify spent nuclear fuel prior to final disposal. The work has been done in cooperation with Helsinki Institute of Physics, the IAEA and other international partners. 2) Participation in the Safeguards-by-Design process of the Finnish encapsulation plant and final repository and, when necessary, development of safeguards methodologies for attaining knowledge of the verified nuclear material and to maintain it for future generations.

Keywords: Spent Nuclear Fuel; Safeguards; IAEA; Geological Disposal; Final Disposal; Safeguards-by-Design

1. Introduction

In November 2015 the Finnish Government granted the licence to construct the disposal facility consisting of the encapsulation plant (EP) and the geological repository (GR). The operator (Posiva), Finnish State Regulatory Authority (STUK), IAEA and the European Commission are cooperating on developing safeguards measures and on designing the necessary safeguards infrastructure for these facilities. The spent fuel disposed of will not be accessible for verification using traditional safeguards measures. The international and national safeguards measures have to create confidence that no nuclear material is diverted before, during or after the disposal process and that no undeclared nuclear activities take place at the disposal facilities. Moreover, the operational phase of the facilities will last over a century, thus the safeguards-related technological infrastructure should be flexible and upgradable. Safeguards by design (SbD) e.g. planning the safeguards measures and designing the necessary safeguards infrastructure during the design phase of the facilities has many benefits. Cost-efficiency is assured by including safeguards equipment such as cameras, radiation detectors, cables and conduits, into the facility design.

A plan for the operator's safeguards activities during the construction and operation of the disposal facility was included by the operator in the application for the construction licence. This included the main steps in nuclear material accountancy and control during the facility development and preliminary plans for the control and accountancy during spent fuel transfers through the encapsulation and disposal process. The plan was approved by STUK during the licensing process and an assessment was included in the STUK Statement [1]. However, in order to ascertain that necessary technical safeguards tools are available at the time needed, STUK launched the national R&D project GOSSER (Geological Disposal Safeguards and Security R&D). The main objective of GOSSER is the finalisation of the national Finnish concept for safeguarding the final disposal of the spent nuclear fuel. This concept and related R&D efforts are coordinated with the Finnish operators, the European Commission and the IAEA.

The key task of GOSSER (named LOVE) is to develop a robust, reliable, and accurate method to verify spent nuclear fuel prior to final disposal. The IAEA requires that spent fuel is verified at a partial defect level before transfer to "difficult to access" locations; however, there is no current method available that can reliably detect a diversion of less than 50% of the pins in a fuel element. The Finnish Support Programme to the IAEA Safeguards has researched the applicability of Passive Gamma Emission Tomography (PGET), and it will be the main candidate for further investigation. Combined with other methods, like gamma spectrometry and neutron measurements, it can be used to verify the correctness and completeness of the declared fuel at pin level. Another task of GOSSER (named JOY) is to evaluate and, when necessary, develop safeguards methodologies for attaining knowledge of the verified nuclear material and to maintain it for future generations. This task may require different techniques from traditional C/S, including geophysics and novel technologies, as well as methods from societal

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verification and long term data management. GOSSER will recognise the interfaces between safeguards, security and safety [2]. Security and safeguards both share a common objective: spent nuclear fuel is secured from unlawful actions.

2. Verification of spent fuel prior to disposal

STUK has a regular NDA verification programme. The goal of this programme is to verify that information provided by the operator is correct and complete, maintain and develop NDA expertise, prepare for final disposal and support IAEA safeguards conclusions. STUK performs 1 – 2 measurement campaigns annually at each Finnish NPP site Olkiluoto and Loviisa. The traditionally used verification tools are SFAT, eFORK and GBUV [3]. Since early 2017 year also the PGET device is used for verification as well as testing [4].

The Finnish Support Programme to the IAEA Safeguards has studied the applicability of Passive Gamma Emission Tomography (PGET) [5]. Under the GOSSER project, a research group was established in 2015 to study and develop the PGET method further. The Finnish Funding Agency for Innovation (TEKES) provides funding for the Finland Distinguished Professor Programme (FiDiPro) at the Helsinki Institute of Physics (HIP) for the years 2015 – 2018. STUK has a guiding role in the work and also actively participates in method development. The aim is to develop a combination of robust, reliable, and accurate methods to verify spent nuclear fuel prior to final disposal, down to detecting diversion of single fuel pins. Because the IAEA and GOSSER project share the same main goal, to develop functional apparatus for partial defect level spent fuel verification, the LOVE project can provide in-kind support to the work conducted under IAEA MSSP tasks. This will include, for instance, arranging test campaigns with the NPPs.

The latest tests with the prototype have shown the applicability of the method. Combined with other methods, like gamma spectroscopy and neutron measurements, it can provide precise and accurate verification results. The first campaigns with the upgraded PGET in Finland took place in February 2017 in Loviisa and in April in Olkiluoto. The campaigns went very well. The deployment of the system was easy (see Fig. 1) and the PGET demonstrated its ability to reconstruct and analyse images of various fuel types with relatively short acquisition times (about 5 min). Missing pins were detected with good confidence. Examples from these measurements are presented in Figure 2. The progress is reported also in the MSSP task report [6]. It is also foreseen that the PGEG will be authorised for spent fuel verification measurements. Although the technology has been developed and demonstrated, some research is still needed to support system development.

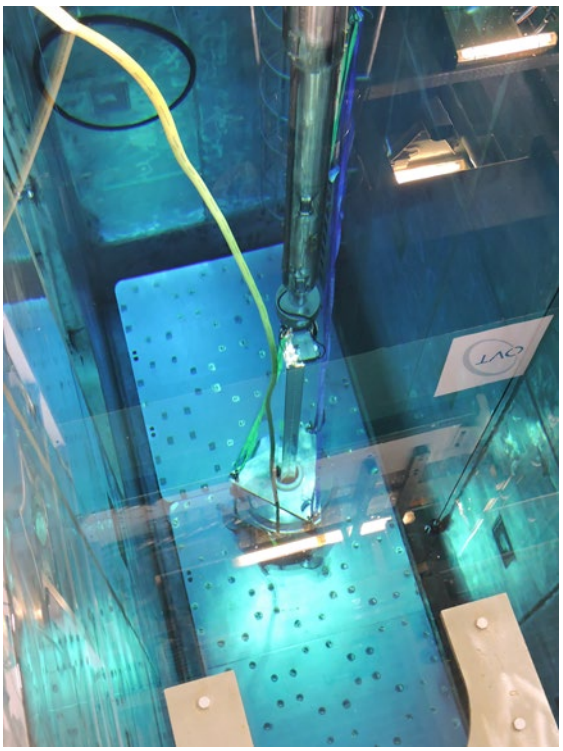

Figure 1. The PGET in spent fuel pool.

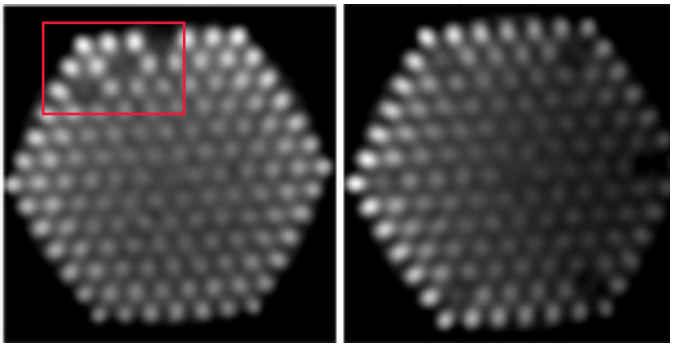

Figure 2. Examples from PGET measurements [5].

3. Safeguards-by-Design process

In addition to the NDA measurements several other safeguards practices and measures are to be developed and implemented with the facility design, construction and commissioning. The safeguards equipment infrastructure to be installed in the Olkiluoto encapsulation plant is already developed in cooperation between the stakeholders, IAEA, European Commission, STUK and the operator [7]. However, the design of the facility is still being optimised by the operator. Continuous communication between the stakeholders is essential to assure that the operator maintains safeguardability of the facility and that the inspectorates are able to modify their equipment infrastructure according to changes in plant design. A similar process is foreseen to be conducted for geological repository during the initial planning and construction phase. Geological investigations and construction of the geological repository will continue in parallel through its operational period. Due

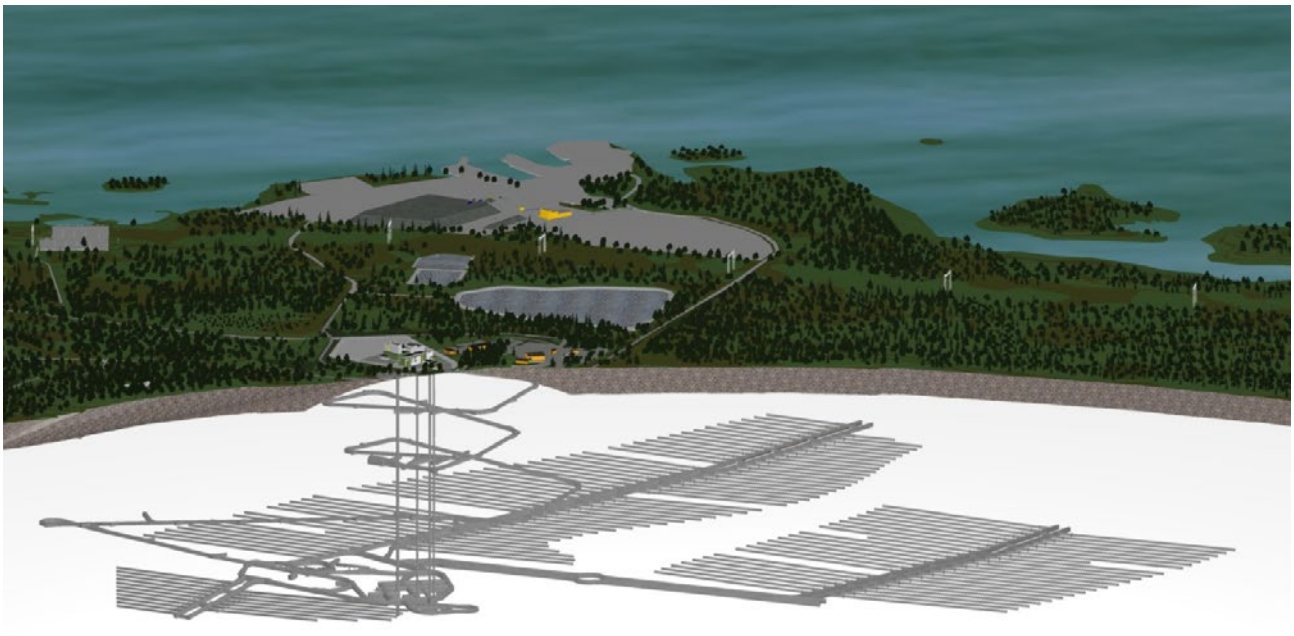

Figure 3. Layout of the disposal facility at Olkiluoto.

to unforeseen elements in the geology and rock mechanics, the repository layout at Olkiluoto cannot be rigidly planned in advance, so any safeguards measures in the repository needs to have enough flexibility to adapt to design changes. The current layout of the facility is shown in Figure 3. The basic technical characteristics (BTC) and the site declaration are to be updated when major changes are introduced in the design process.

The operator presented its plan to control the integrity of the fuel canisters and to demonstrate and to document their safe transfer to the emplacement hole with their construction licence application. This plan was approved by STUK in 2015 with the remark that the operator has to facilitate safeguards measures by STUK, the EC and the IAEA with the progress of the project. Currently, the material accountancy for fuel canisters is a part of the negotiations of the Facility Attachment to be agreed between the IAEA and the EC. Both STUK and the operator are consulted from the beginning of this iterative process. Also, the ultrasonic identification of the canisters is under method development [8]. In the disposal process, the Continuity-of-Knowledge and supporting Containment and Surveillance measures will be essential; whereas the annual physical inventory verification (PIV) of the underground repository cannot be carried out in a traditional manner. The Safeguards-by-Design process will cover also these aspects.

In order to detect undeclared activities, STUK has direct access to and, in cooperation with safety, also de facto full time institutional presence at the active final disposal facility site. In the national concept development this asset will be utilised. Currently the Olkiluoto monitoring programme was reassessed in [9]. and a few recommendations were suggested to have more safeguards use of the operators data and safety assessment. STUK follows the daily research and work plans, and the continuous monitoring of the site as safety assessment of a geological repository is of international research interest with also societal and safeguards aspects e.g. [10]. STUK has also contacts to other authorities in Finland that are e.g. licensing construction activities and therefore can report about any undeclared safeguards-relevant activities. In contrast to this, the international safeguards inspectorates lack these capabilities, therefore, they have to employ technological solutions, which STUK has less need for that. STUK however must be aware of the capabilities and properties of these techniques. As the GOSSER project is based on external cooperation, STUK does not need to perform its own research for this purpose. It is sufficient to follow what other institutions are developing in Finland and abroad for the safety assessment and security precautions and to demonstrate this to the inspectorates.

4. Summary

The GOSSER project was launched because safeguards for spent fuel disposal is a new challenge and new concepts need to be developed and implemented already during the early design and construction of the final disposal facility licensed in 2015. The time span of the overall disposal project is more than100 years so process optimisation has high pay off opportunities. As the disposal facility is of a new kind to be safeguarded, the methods developed and applied in Finland have to gain international acceptance.

The disposal of spent fuel requires that safety, information security and other security arrangements and the safeguards required to prevent the proliferation of nuclear weapons are properly implemented. This requires the reconciliation of all areas resulting in the implementation of 3S in an appropriate manner. This, in turn, requires action from the operators producing, encapsulating or disposing of spent nuclear fuel as well as the authorities (STUK). Although, the European Commission and the International Atomic Energy Agency (IAEA) have strong roles in the safeguarding of nuclear materials they are not directly in the focus of this project, however, they will benefit from its developments.

The novelty of the disposal concept calls for adequate research and provides the reasoning for establishment of GOSSER R&D project. If GOSSER is not successful, in the worst case there is a risk that the credibility of the disposal concept is questioned and; moreover, the future generations may not have adequate information to satisfy themselves that the spent fuel is fully and reliably disposed of in the repository. The main objective of GOSSER is the finalisation of the Finnish concept for safeguarding the disposal of the spent nuclear fuel by 2018.

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