Perspective of Dry Interim Storage of spent nuclear fuel (SNF) in Germany

Christoph Gastl and Julia Palmes
Federal Office of Radiation Protection

ABSTRACT

According to article 6 of the German Atomic Energy Act, storage of nuclear fuel requires a license granted by the competent authority in this field, which is the Federal Office of Radiation Protection (BfS). In 1995 a license to store spent nuclear fuel (SNF) and vitrified high level waste (HAW) for the interim storage facility in Gorleben was granted. Dry Interim storage at the NPP sites in its current form started in 2002 in the interim storage facility next to the NPP Lingen. Since this time each NPP erected its own storage facility and three central storage facilities have been built. All of these facilities use dry storage in metallic dual purpose casks (DPCs). The actual storage licenses for SNF and the HAW (which is stored in Gorleben and Rubenow) are limited to 40 years after closing the transport and storage cask. The first license to expire will be the storage license for the interim storage facility in Gorleben in the year 2035.

During the last two years in Germany preparatory consultations to restart the process towards finding a repository took place, organised by a commission. This commission consists out of members of the scientific community, religious parties, social communities and environmental organizations as well as members of federal states governments and members of the German parliament (Bundestag). Recently the commission decided to extend its working period until summer 2016. Taking this background into account the BfS plans to intensify its research into extended interim storage with respect to potential material degradation leading to interference with safety functions (e.g. neutron shielding material).

This includes topics like ageing of gasket materials which are already studied in ongoing experiments (e.g. at the Federal Institute for Materials Research and Testing) as well as studies of long term relaxation processes. Because of the need for transportation towards a repository another important field is the behaviour of the inventory under mechanical loads. For SNF, first calculations showed that because of the lower decay heat load after 60 years due to hydride reorientation the cladding might become much less ductile.

INTRODUCTION

The concept of dry interim storage of irradiated fuel in casks for transport and storage was developed in the late 1970s [2]. The first storage license in Germany according to this concept was granted in 1983 for storage of SNF in the storage facility in Gorleben. In june 1992, the first cask destined for dry interim storage was loaded (with spent fuel of the THTR-reactor for storage in Ahaus).

The actual storage licenses for SNF and HAW from reprocessing plants (which is stored in Gorleben and Rubenow) are limited to 40 years starting with the first cask emplacement. The first of these actually valid storage licenses is dated from 1995 (Gorleben). Additionally, the lifetime of each loaded cask is limited to 40 years on from closure after loading, as for this period safety of enclosure could be proven. Interim storage of SNF in its actual form in storage facilities on the sites of the NPPs started in 2002 in the interim storage facility next to the NPP Lingen. Since 2005 delivering SNF for reprocessing is forbidden and direct disposal is the only allowed way of waste treatment in Germany. Because of this in the following years each NPP had to erect its own storage facility in addition to the three existing storage facilities

In all of these facilities dry storage in metallic casks inside concrete buildings is used. A remarkable requirement for the storage license is the need for a valid package design approval during the whole storage period of 40 years. This enables the possibility to transport the cask at any time to a nuclear facility away from the storage facility. As usually the package design approval is only valid for three years, it has to be renewed quite often. For casks already in storage there is the possibility of granting the package design approval for ten years. In combination with a newly introduced monitoring program even longer periods should be possible.

As the last NPP in Germany is going to be out of commission in 2022, the number of casks to store can be calculated. In the year 2013, 332 different casks were in the storage sites at the NPPs. It is expected to have about 1046 different casks with SNF in the different storage sites after all SNF from the NPPs has been loaded into casks. Totally, at the end of 2013 **1000** loaded casks were stored in all storage facilities in Germany. The HAW from reprocessing in France is stored in Gorleben in 108 casks, and five casks with HAW from the experimental reprocessing facility in Karlsruhe are stored in Rubenow. Research reactor fuel e.g. from the pebble bed reactors is stored in Jülich, Ahaus and Rubenow.

All safety functions like subcriticality, safe enclosure, radiation shielding and decay heat dissipation are guaranteed by the cask. The storage building serves mainly as weather protection and additional radiation shielding. In Germany two cask concepts are licensed and in use: the CASTOR® design of the manufacturer GNS and TN design of the manufacturer TNI.

The CASTOR® design is based on a spheroidal graphite cast iron body with neutron moderator rods within. TNI uses a forged steal body surrounded by moderator compartments at the outside. Both designs use as required in ”Guidelines for dry cask storage of spent fuel and heat-generating waste” a double lid system with metallic gaskets which is constantly monitored.

Description

The actual storage licenses for spent nuclear fuel (SNF) and the vitrified high level waste (HAW) are limited to 40 years. As no opening of the cask is intended during the storage period the condition of the inventory and the cask before loading has to be known in detail. This requires for instance detailed knowledge of the history of the SNF loaded as well as supervision of the manufacturing process of all the cask components. Furthermore, the loading and drying procedure of the cask is strictly regulated. This is necessary to ensure that no temperatures occur which might affect the behaviour of cask components or fuel rods during storage time. With this strategy dry interim storage is successfully performed in Germany since 1993.

According to § 9a cap. 3 the Federal Government is responsible for the availability of a repository. For the future the National Disposal Program for Germany was published in August 2015. According to this the repository for high level waste should start operation around 2050. Also a receiving storage is planed once the location for the repository is fixed which is expected to happen in 2031. As the first license for an interim storage facility expires in 2035 preparations have to be started to be able to elongate the time span for interim storage in case of a delay of this timescale. The actual licensed 40 year period to cover the expected gap between unloading spent fuel from the reactor, cooling down in the reactor pool, loading in casks and final disposal was defined in the 1980ties and a repository was expected in 2012. According to the German Atomic Energy Act latest version an elongation of interim storage is only possible if the German Bundestag is consulted.

In order to identify possible need for research the current interim storage concept has to main parts: storage facility, cask and inventory. First the storage facility itself, the building and infrastructure which is today part of the larger NPP complex might then be the last remaining part and has to be independent. If we talk about another 40 years of storage the building itself is close to the 100 year lifetime considered for concrete building. The technical equipment of the facility has been kept functional and up to date. This includes the radiation measurement installations as well as the heavy-duty crane for cask lifting.

Second the cask itself is fulfilling all our safety goals so its condition has to be closely monitored. The cask material is considered to be radiation tolerant even for much longer storage times and resulting longer irradiation. The decay of inventory can be taken into account as well. The closure system consisting of two lids with independent gaskets and a pressurized interspace is bolted and the pressure is monitored. The preload of the bolts has to remain high enough to guarantee

swaging of the gaskets even after long term relaxation. Same applies for the trunnions bolted to the cask body. In this special case the latest development is the use of ultrasonic checkable bolts which allows preload measurement at any time.

Third the inventory of the casks and the basket. Vitrified HAW is considered to be less problematic as the nuclear material is enclosed in the glass matrix which is stable under the storage conditions. Spent fuel elements and especially the fuel rod cladding is considerably more problematic as dry storage was not expected when these materials were developed. So in order to allow handling of fuel elements or transport of a loaded cask after dry storage for longer periods more knowledge about the material parameters is necessary. In the different cask types different basket designs with different materials are realized.

So what is currently done to identify and cover possible knowledge gaps.

The Federal Ministry for the Environment Nature Conservation Building and Nuclear Safety has started a research project named: Safety issues of the long-term interim storage of SNF and HAW in 2007 conducted by the GRS (Gesellschaft für Anlagen und Reaktorsicherheit), Öko-Institut Darmstadt and BAM (Federal Institute for material Testing and Research). This report presents the current state of the art in science and technology in the field of dry storage and deals with the issue of compliance with safety parameters on which the licence is based with a view to an extended storage period. It also contains an overview about the national and international situation of storage.

BfS has several research topics in the field of transport and storage of SNF. In 2016 experiments with irradiated fuel rods under accidental conditions for transport are planed with analysis of fracture. Another field of ongoing research are the code systems used for criticality analysis. Here the accuracy of criticality calculations should be tested and quantified.

BAM is independently conducting research in the field ageing of gaskets as well metallic and elastomeric.

CONCLUSION

After the storage period of 40 years' provision is made for transporting the casks to a repository. The German committee defining the criteria for the repository search process has started its work in May 2014. The site for the repository is expected to be found 2031. This timescale is close to the expiring date for the interim storage facilities in Gorleben (31.12.2034) an in Ahaus (31.12.2036), so an extension has to be considered. Prior to the licensing procedure for an extension, the German Parliament has to decide about this option. Once the storage license has expired, an extension or a new license will only be granted if the at this time relevant requirements are met. This will require detailed knowledge about the happenings and accidents during the previous storage period as well as possible ageing

mechanisms have to be respected. All experience of the periodic safety assessment (PSÜ) and accompanying experiments conducted till now and during the licensed storage time will be needed. In Germany the storage sites Gorleben and Lingen took part in a test run of the PSÜ and delivered reports. The outcome of these reports was used for improvement of the PSÜ procedure, which will be used on all other sites during 2014 and then every five years.

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