RESEARCH TOWARDS PROLONGED INTERIM STORAGE FROM THE REGULATORY BODY PERSPECTIVE

M. SCHWERDTFEGER
Federal Office for the Safety of Nuclear Waste Management
Salzgitter, Germany
Email: michael.schwerdtfeger@bfe.bund.de

C. DROBNIEWSKI
Federal Office for the Safety of Nuclear Waste Management
Salzgitter, Germany

C. BORKEL
Federal Office for the Safety of Nuclear Waste Management
Berlin, Germany

C. GASTL
Federal Office for the Safety of Nuclear Waste Management
Salzgitter, Germany

C. BUNZMANN
Federal Office for the Safety of Nuclear Waste Management
Salzgitter Germany

Abstract

The Federal Office for the Safety of Nuclear Waste Management (BfE) is the competent licensing authority for interim storage of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) in Germany. The concept of dry interim storage comprises dual purpose casks (DPC) equipped with a double barrier lid system with permanent monitoring of its leak-tightness. Existing storage licences in Germany are limited to 40 years. Due to the time needed for site selection, licensing procedure, construction and commissioning of a deep geological repository (DGR), a prolongation of the interim storage period will be necessary to bridge the gap until final disposal. To demonstrate if safety requirements could be fulfilled by the transport and storage cask beyond the initially licensed 40 years additional research is required. Research towards material degradation e.g. ageing of cask materials or internals, fuel assembly behaviour and behaviour of storage facility buildings and operational equipment is the basis for the safety of prolonged SNF storage. To identify potential fields of further interest it is also necessary to acquire additional data for the above mentioned research. As interim storage facilities are a key step towards the final disposal, it is also necessary to conduct research towards the impact of prolonged interim storage on the final disposal, especially due to the increasing relevance of ageing effects like material degradation. This includes foremost data acquisition and storage as a prerequisite to enable a safety based choice of actions. Furthermore, as Germany is phasing out of nuclear energy, the knowledge management in the nuclear field gains enormous importance especially with regard to human resources. The BfE as licensing authority has initiated several research projects to cover the foresaid topics to be presented in this article.

1. INTRODUCTION

With the restart of the site-selection process for the DGR for HLW in Germany in 2017 (Site Selection Act, 05. May 2017), the timeframe for dry interim storage of SNF and HLW has changed from the initially envisaged 40 years to a longer – not clearly definable – timeframe. Even though the site-selection process is envisaged to define the final disposal site by 2031, it is clear that including the subsequent licensing phase, time for construction of the facility and the time needed for disposal operations will make a longer interim storage period necessary.

Even though the basic regulatory framework for dry interim storage as laid down in [1] is based on the timeframe of 40 years, it includes already requirements for ageing management and periodic safety reviews to ensure the safety over the lifetime of the facility. More detailed guidelines exist for periodic safety review and ageing management [2]. The necessary prolongation of the licensing period requires more focus on those

aspects as pointed out in a discussion paper [3] of the German Nuclear Waste Management Commission, for instance. Needs of the BfE for research and development evolving from extended interim storage were identified and included in the Research Agenda of BfE [4] which has a focus on the next four years and is renewed biennially. General goals and principles of BfE research are defined in the Research Strategy [5]. Research projects to be initiated are agreed upon in yearly Research Plan. This structure ensures that the long term goals of research are reached, but also new evolvements can be included as well.

The identification of aspects requiring further research reflects results of international discussions and research relevant to the prolonged storage. This includes publications of organisations such as the IAEA [6], or OECD/NEA [7,8] and international research programs like [9,10]. Identifying and collecting this relevant data and research will be a further field of activity for the BfE. Since it is out of scope of this article to give a comprehensive list of such documents and activities the mentioned documents are to be considered as illustrative examples. Research Strategy [5] and Research Agenda [4] were discussed in the frame of an expert-workshop and put in a public consultation process. Based on the numerous comments the documents are actually being revised.

Even though the licenses of the existing interim storage facilities in Germany are still valid for more than a decade, it is necessary to initiate foresaid research and data acquisition now, to address the present and future issues related to the prolonged interim storage. All aspects concerning safety functions relevant to dry interim storage have to be regarded for identifying research needs and will be described in the following.

2. RESEARCH REGARDING CASK AND CASK INVENTORY

In the concept of dry interim storage of SNF, the main safety component which primarily provides the containment and confinement of the radioactive material is the dual purpose cask (DPC). Therefore, the behaviour of the DPC is of utmost importance for a possibility to license the interim storage. Up to now, the licensed storage period is limited to 40 years and hence the safety assessment investigations were performed for this duration. To prolong the storage period, it is therefore necessary to conduct research to enable a thorough safety assessment in the licensing procedure for the storage.

For the casks the most important features needing special attention are:

- The fuel assemblies (inventory);
- The inner structure holding the fuel assemblies;
- The lid system and;
- The systems allowing safe handling of the casks, e.g. Lifting trunnions.

Fuel assemblies are prone to several ageing effects which are mostly driven by temperature dependent mechanisms. For instance, hydride-reorientation can be of relevance to the mechanical behaviour of the cladding material. Additional effects arise from the possible pressure build-up inside the claddings by gas accumulation due to radioactive decay. Depending on the detailed loading procedure and the individual assemblies potential corrosion effects must be considered in the long term behaviour. It must be noted here that for typical SNF and the specific loading procedure only a minimal amount of potentially corrosive content is present.

Closely connected to the mechanical and chemical stability of the spent fuel assemblies itself is also the inner structure of the casks that keeps the inventory in place. The resulting geometry of the inventory is one basis to ensure for instance the criticality safety. It is also necessary to cope with mechanical loads during handling and possible accidents. In analogy to the fuel assemblies, the structural integrity of the inner structure therefore has to provide the safety functions over the whole storage period and it has to be proven that ageing and/or corrosion have no detrimental effect on the safety.

Substantial knowledge on the behaviour of the storage fuel and the inner cask structure is especially important since these cannot, or at least not easily, be exchanged or repaired after cask loading. As potential necessary procedures for inspection and repair can depend on the availability of an appropriate facility for handling the open casks. As most of the available facilities will be shut down in the phase out process for nuclear energy in Germany, this has to be addressed.

The double lid barrier system which is used in the dry storage concept in Germany is the primary system to prevent radioactive releases during storage. It has to be proven that the lid system guarantees the necessary leak-tightness over the whole storage period including the exclusion of systematic failures. To extend the lifetime of such a barrier system, or more specifically to prove the foreseen possible lifetime – especially for the seals – additional research is necessary. It is important to point out that the potential degradation effects discussed here are long term effects and that there are only a few options to speed up research on these effects, e.g. accelerated ageing. Therefore, a stringent planning of the necessary investigations is essential.

While it is technically possible to exchange the lid seals in the case of failure, the necessity of hot cells (for exchanging the primary lid) and the associated risk of potential exposure of personnel to radiation makes those actions a scenario to be avoided. In the existing storage facilities only the exchange of the secondary lid seals is possible. If the primary lid seal is not function properly the only possible measure in the storage facility itself is the addition of a third lid system which is welded upon the DPC to ensure the double barrier system.

Although storage of spent fuel in DPC is mostly static – meaning the casks are stored and monitored, but for instance not moved without sound reason – it is necessary to be able to handle the casks. For regular inspections or maintenance – such as the foresaid repairs of lids – and the transport after storage towards the DGR, the systems for safe handling must be in operational state. The cask trunnions have to meet the safety requirements until the end of the lifetime of the cask. If it is deemed necessary to have them exchanged, requirements on the fitting systems connecting the trunnions onto the casks have to be fulfilled. The focus of research is therefore more towards the secure possibility of providing save trunnions at the time necessary, instead of providing secure functionality over the whole storage time like for fuel assemblies. Since trunnions are an external component, effects like corrosion can be of higher concern than for inner structures, depending on the environment. As the cask storage facilities for dry storage in Germany are concrete buildings, the amount of corrosive environmental impact e.g. moisture is minimized.

3. RESEARCH REGARDING STORAGE FACILITY BUILDINGS

The storage facility buildings for the dry storage of dual purpose casks in Germany provide additional safety elements in combination with the storage casks. Buildings provide additional shielding of radiation, enable a safe heat exchange and reduce the environmental impact onto the storage casks. They also have to enable the safe function of storage equipment, such as the cask monitoring systems and cranes. Additionally, the layout is such that all the work inside the building can be conducted safely and in accordance to radiation protection requirements.

As facility buildings are massive structures that are built to last decades the necessary research is to be focussed on maintenance and inspection. Compared to the casks, repairs and maintenance of storage facilities enable a much broader range of measures to cope with ageing effects.

Ultimately, if the prolonged storage would range over such a long period that the existing storage facility would not provide the necessary safety for the whole time – while the safety functions of the casks are demonstrated – it is obvious that building a new facility is technically feasible.

4. RESEARCH REGARDING STORAGE FACILITY EQUIPMENT

The storage facility equipment has to provide its function for the storage period. However, depending on the specific equipment, repair- and exchangeability of the equipment can lower the requirements on longevity of the equipment. The pressure monitoring system for the double barrier lid system for instance is designed in such a way that all components can be safely exchanged during storage. For crane systems – even though in principle also exchangeable – maintenance and inspection are the primary measures to ensure functioning and therewith safety.

Longer storage periods impose the requirement to ensure the resources enabling repairs and / or exchange. Research and Development in this field should therefore focus – besides ageing and wear – on questions comparable to knowledge management, such as record keeping to provide information to produce certain equipment. For prolonged storage also the question arises how newer technologies and equipment can be included or applied to the existing facility.

5. RESEARCH REGARDING HUMAN RESOURCES

Prolonged storage periods are a challenge for the involved stakeholders – one of them is the licensing authority. This challenge is increased due to the fact that Germany is phasing out of the commercial use of nuclear energy since keeping and increasing knowledge and qualified personnel in such an environment is a key to provide safety for the prolonged storage period.

Research in the field of knowledge keeping and human resources is therefore focussed on questions like necessary structures to keep qualified staff and acquiring new well trained staff. Among other aspects, this research must support a strategic decision if the knowledge should be concentrated in a few organisations, or if one aims at keeping a more distributed structure of knowledge and competences.

Depending on this development, additional issues like keeping a plurality driven safety culture in the field of interim storage arise.

Resource management and financing will also be an important issue as possible reduction in public appearance of this topic might lead to misconceptions. Research towards public information and involvement will therefore be also an important field.

6. INTERFACE WITH FINAL DISPOSAL

Finally, only a proper knowledge management and record keeping can enable a safe and appropriate final disposal option in the DGR. Knowledge transfer cannot be unidirectional. Both, dry interim storage of SNF and HLW and its disposal in a DGR are linked.

For planning prolonged dry interim storage facilities a reliable schedule for interim storage is needed and would be beneficial to facilitate decision making. This is also true for knowledge of technical aspects regarding waste and waste packages that are relevant for the specific requirements of the future DGR. On the other hand, for detailed planning of a DGR, i.e. developing disposal canisters, barriers, etc., any changes to the inventory, its behaviour or limitations to conditioning measures which might come up with prolonged storage, are important.

7. CONCLUSION

The restart of the site-selection process for a DGR in Germany poses several necessities for research in a variety of fields. This also includes the interim storage as bridging solution prior to final disposal. The dry interim storage concept as realized in Germany needs to be investigated with regard to the requirements resulting from the longer storage periods.

While storage components like the dual purpose casks cannot easily be replaced, other parts of the interim storage concept can in principle be exchanged during the lifetime of the facility. From this distinction the main branching point in the research – the goal – arises. For the former, the research goal is to determine the timescale beyond the initially planned 40-years of storage during which the present concept can be considered safe from a licensing perspective. This is mainly research into ageing and degradation mechanisms, which might give indications regarding the maximum period of time for which the safety of the interim storage can be proven. The latter needs research focussed on repair, maintenance and exchange of components and ensuring the possibility to do so over the necessary timeframe.

Technical issues are intertwined with the aspects of knowledge management and resource management which gain increasing importance with longer timeframes. The possibility to inspect, repair, maintain and / or exchange components or equipment requires the availability of qualified staff and facilities as well as the availability of the components. Research towards the question how this can be ensured is therefore important for long term safety of interim storage – independent of the realized concept.

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