Long Term Storage of Spent Nuclear Fuel and HLW in Dual Purpose Casks towards Disposal
– Challenges and Perspectives –

Holger Völzke, Dietmar Wolff

Bundesanstalt für Materialforschung und –prüfung (BAM)

(Federal Institute for Materials Research and Testing)

Division 3.4 „Safety of Storage Containers“

Outline:

1. Spent Fuel Management in Germany
2. Technical Issues Concerning Spent Fuel Storage in Dual Purpose Casks beyond the Initial License Period
3. Strategic Aspects Concerning Extended Interim Storage Periods
4. Conclusions

Basically ruled by the Atomic Energy Act (Atomgesetz AtG)

NPP Grafenrheinfeld

Spent Fuel Pool

Dry storage in dual purpose casks with monitored double barrier lid closure systems

after 2005

Reprocessing (in F and UK)

Transport and storage casks in the Transport Cask Storage Facility Gorleben (Photo: GNS)

Vitrified HLW

> 1,000 loaded casks today

- 12 On-site LWR fuel interim storages
- 2 former central storages (Ahaus, Gorleben)
- VVER Interim Storage North
- AVR Interim Storage Jülich Research Center

Final Disposal

Initial concept:

- Centralized interim storage for up to 40 years (Ahaus, Gorleben)
- Conditioning plant and geological disposal located at one place (Gorleben)
- Repository available until 2035

Interim Storage Facility at Isar NPP

2002 → **Transport ban and change from centralised to on-site interim storage**

2011 Fukushima → **Phase out decision** shutting down 8 NPPs immediately and the remaining 9 until the end of 2022

2013 → **New „Repository Site Selection Act“**
→ Final site selection until 2031

Total spent fuel amount:
10,500 Mg spent fuel
6,700 Mg reprocessed

Consequences:

- Repository available after 2050
- Interim storage licenses expire between 2032 and 2047

→ ***At least 40 years of extended interim storage needed***

Current situation:

Storage Licenses issued by BfS (Federal Office for Radiation Protection) contain all relevant safety evaluations to satisfy the protection goals

∗ safe enclosure ∗ shielding ∗ subcriticality ∗ heat dissipation

under operational and accidental conditions of the specific storage facility and define conditions and requirements for safe and secure operation.

Interim dry cask storage concept:

"Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste"
Nuclear Waste Management Commission (ESK), Revised version of 10.06.2013,
http://www.entsorgungskommission.de/englisch/downloads/eskempfehlungesk30llberevfassung10062013en.pdf

"ESK-Guidelines for Periodic Safety Inspections and Technical Ageing Management for Interim Storage Facilities for Spent Nuclear Fuel and Heat-generating Radioactive Waste"
Nuclear Waste Management Commission (ESK), Version of 13.03.2014,
http://www.entsorgungskommission.de/downloads/empfehlungpsuzl13032014homepage.pdf

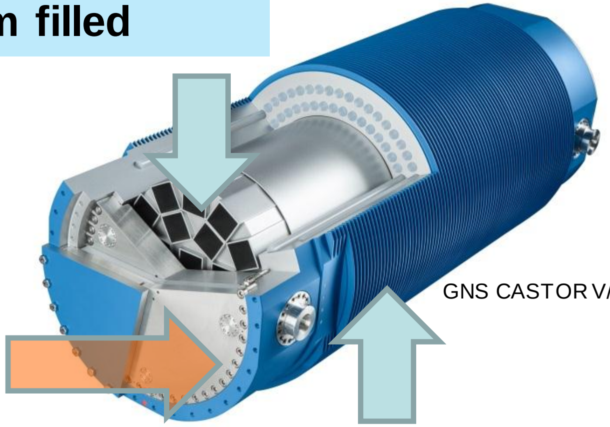
Site specific safety evaluation of casks and specific inventories performed for 40 years

Accident safe dual purpose casks for storage and transportation

Valid Type B(U) package design approval required before loading and during storage to guarantee permanent transportability !

Photos: GNS

Inert cask interior: vacuum dried and helium filled



Permanently monitored bolted double barrier lid system equipped with metal seals

Corrosion protection of outer surfaces

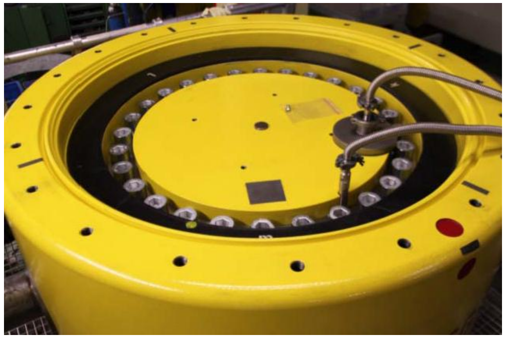
BAM

Current experiences (1):

- > 20 years of safe cask operation without any safety issue
- Optimization of cask loading and preparation procedures including the drying procedure
- No metal seal failure until today
- Few technical issues, e.g.
  - Water condensation and partially peeling paint in case of “cold” THTR casks
    - Optimization of the paint application process
    - Repair of all affected casks
    - Closure of selected ventilation hatches at the top of the storage building to reduce atmospheric humidity access
  - Self-indicated malfunction of some pressure monitoring devices
    - Replacement and investigation of all failed devices
    - Consideration of potential systematic failure mechanisms without significant outcomes
- Responsible authorities and technical experts nationwide share and discuss gathered information and experience organized by BAM semi-annually

Current experiences (2):

- Inspection of casks after storage prior to transportation (152 CASTOR® AVR casks at the interim storage Jülich):
  - Visual inspection of outer surfaces
  - Document check of all pressure monitoring systems from the previous storage period
  - Further inspection of 45 selected casks including
    - Removal of secondary lids, replacement of gaskets, leakage rate measurements after reinstallation, inspections of bolts and threaded holes
    - Leakage rate measurements of 30 primary lid systems
    - Examination of primary lid bolting torques
    - Check of block position measurements of all lids
  - Inspection, refurbishment and reassembling of trunnions including load tests to improve corrosion resistance in another storage building without climate control



Photos: FZJ

Outcomes:

- *Confirmation of sufficient technical condition of all casks including demonstration of primary lid leak-tightness*
- ***Confirmation of transportability after up to 20 years of storage***

Extended Interim Storage beyond 40 years

Ageing effects on DPCs (identification – evaluation)

Examples

Consideration of relevant stress factors of specific operation conditions and cask inventories

Metal Seals:

- Corrosion effects by remaining humidity
- Reduction of seal and bolt pressure force
- Reduction of useable seal resilience
- Resulting leakage rates (temp./time)
- Seal function under accident conditions

Polymer components for neutron shielding:

- Degradation by gamma-irradiation
- Thermal degradation
- Hydrogen release

Elastomer auxiliary seals:

- Degradation by gamma-irradiation
- Thermal degradation
- Loss of elasticity and seal function to provide test spaces for checking metal seal leak-tightness

Outer corrosion protection

- Paints
- Silicone sealings
- Trunnions

Internals:

- Baskets
- Cladding integrity
- Encapsulation of defect fuel assemblies
- Moisture absorbers

Pressure monitoring devices

- Reliability, failure rate

Main spent fuel strategy:

Current challenges:

- Transportation after long-term interim storage needs to be addressed by transport regulations (IAEA, national regulators)
- Significant delays of many national disposal and reprocessing programmes cause the need for extended interim storage periods
- Extended interim storage requires additional safety demonstrations for the long-term based on data from lessons learned and additional generic R&D programmes
  - International programmes have been started to gather and share information and data, e.g. IAEA CRP's, EPRI Extended Storage Collaboration Programme (ESCP)
  - Dry storage demo programmes are under way in the U.S., Korea, Japan
  - BAM has initiated R&D projects on metal and elastomer seals, and polymers for neutron shielding

Specific challenges in Germany:

Consequences of the nuclear phase-out decision:

- ❑ Soon after 2022 all spent fuel and HLW will be stored in dual purpose casks.
- ❑ After final shut-downs nuclear expertise and knowledge will diminish.
- ❑ Interim storage facilities will have to be operated independently from any other nuclear installation.
- ❑ Requirements for interim storage and subsequent transportation need to merged and managed by a consistent operational regime including inspections and ageing management.
  - ➢ Specific technical and regulatory guidance should be established.

Consequences concerning the present national disposal policy:

- ❑ Interim storage will need to be extended by several decades.
- ❑ Besides technical issues a broad public and political consensus will be needed to extend interim storage beyond 40 years up to 80 or even longer whether at established or new sites (centralised vs. decentralised).
- ❑ The existing spent fuel and HLW in a finally given number of dual purpose casks should be considered in the sense of a holistic approach including interim storage, transportation and final disposal and to provide appropriate disposal canister concepts.

Sometimes rapid changes in national nuclear policy do affect spent fuel management strategies significantly

Delays in providing a spent fuel repository lead to the need for extended interim spent fuel storage

Extended interim storage whether at established sites or at new locations does require broad socio-political consensus

The consistent German concept of dry interim storage in DPCs has proven to be a safe and secure spent fuel management strategy

Additional safety demonstrations and data for casks and inventories will be required for future extended interim storage periods beyond 40 years


Photo: GNS

For a most efficient and reliable strategy spent fuel management should include interim storage, transportation and disposal in a holistic approach