Bundesanstalt für Materialforschung und -prüfung

Sicherheit in Technik und Chemie

25.10.2016

TECHNICAL REQUIREMENTS FOR HIGH LEVEL WASTE DISPOSAL CONTAINERS WITH REGARD TO THEIR RETRIEVABILITY DURING OPERATION AND RECOVERY AFTER REPOSITORY CLOSURE

Holger Völzke, Eva Kasparek, Dietmar Wolff, Teresa Orellana

7th IGD-TP Exchange Forum
October 25-26th, 2016
Córdoba, Spain

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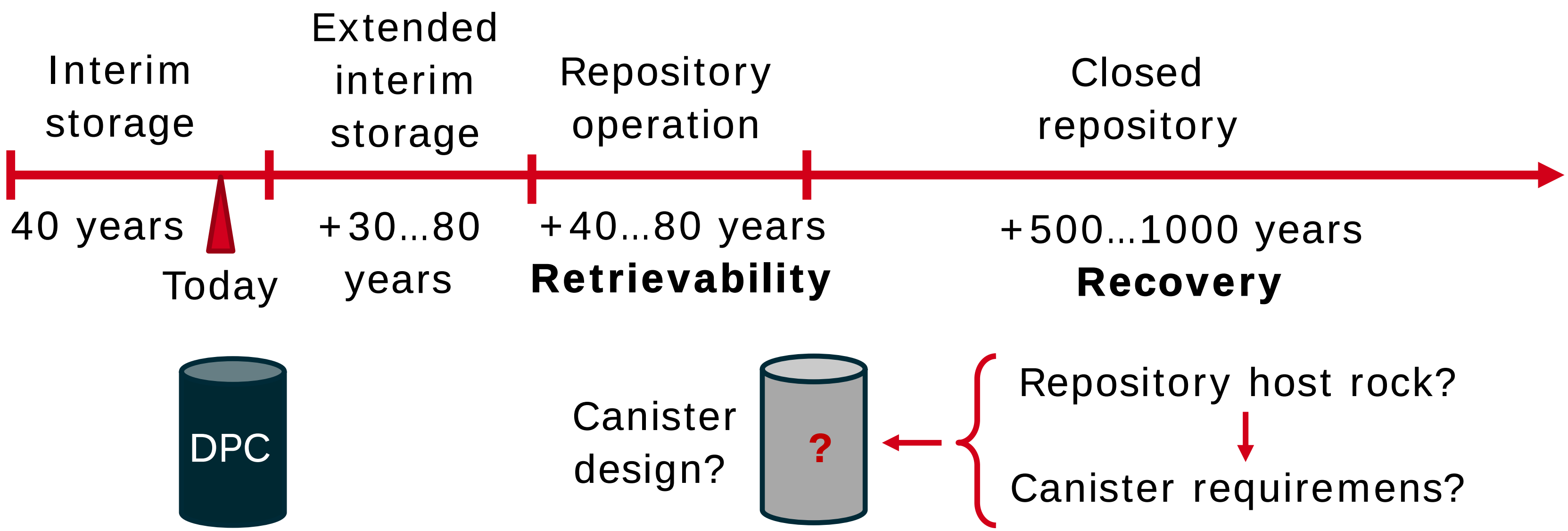
1. SAFETY CONTAINER REQUIREMENTS

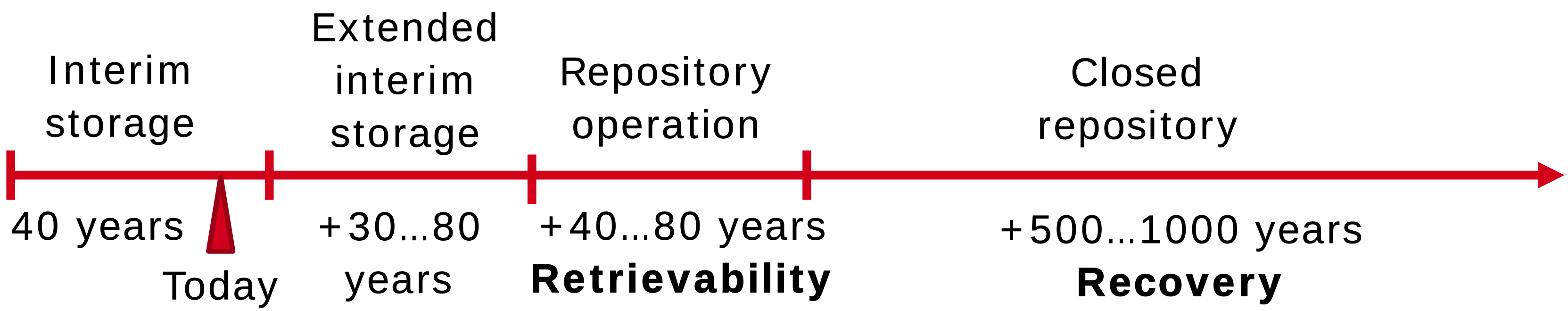
Basic considerations



Dual purpose cask for transportation and interim storage of SF and HLW. Safety evaluation for normal conditions and accidents

Safety evaluation for retrieval (≈100 years) and recovery (500...1000 years) must consider stress factors depending on the host rock formation during repository operation (handling, accidents, heat removal, external pressure, corrosive media, etc.) and after closure.

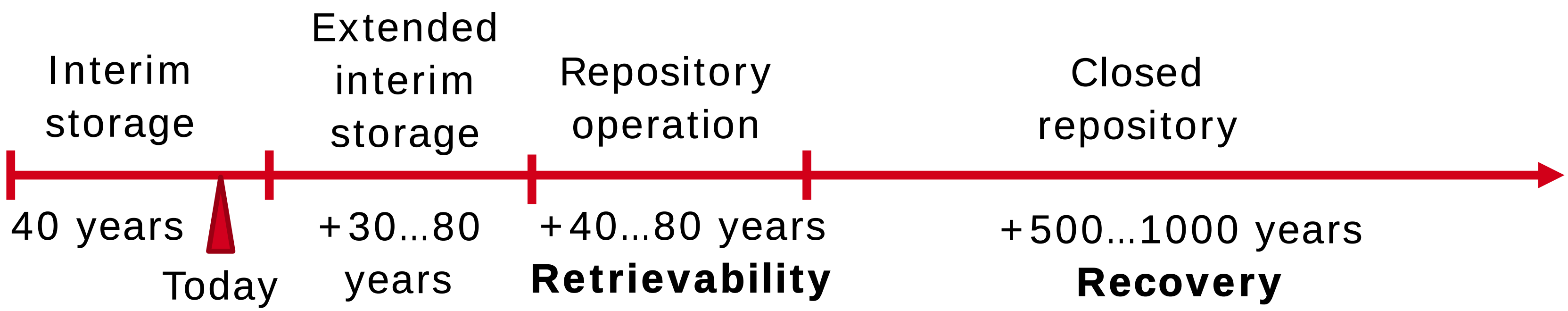
Basic container safety requirements



- **Safe confinement of the radioactive material**
- **Subcriticality**
- **Dose rate minimization**
- **Decay heat removal**

Basic container safety requirements result from the same nuclear protection goals as for transportation and interim storage and are aimed to ensure **safe container emplacement and potential retrieval during repository operation and recovery after repository closure**

Specific container safety requirements



- **Sufficient shielding of ionizing radiation**
- **Proper container design for operability and surveillance**
- **Safe package handling and transportation**
- **Accident safe container design**

According to the container design and to the repository conditions, specific container requirements must be laid down in order to assure **safe handling and container storage in the final repository as well as** to enable **safe retrieval and recovery operations**

Technical container safety aspects during repository operation

BAM

Stress factors from operational conditions at the repository

Maximum normal operational loads

- Mechanical stresses from handling operations
- Temperatures (maximum and minimum)
- Irradiation
- Media impacts (ageing, corrosion, etc.)
- Max. impact duration

Maximum stresses by accidental scenarios

- Fire, collision, container drop, other impacts

Container design and materials

- Material- and component properties (minimum and maximum)
- Geometry (incl. tolerances)
- Consideration of ageing effects

Technical container safety aspects for retrieval

- Container as a **technical barrier** → proof of reliability and robustness of container safety functions until final closure **(≈100 years)**
- Potential container retrieval technically organized and regulated from the beginning of storage operations:
  - **Access** to and **handling** of containers which are already stored in sealed areas and their **transport** to the surface
  - Reliable predictions about the condition of the **"oldest" container** and the **most unfavourable repository boundary conditions**
  - **Safety functions provided by additional components or procedures**, e.g. container over-packs, cut-out from salt regions surrounding the containers, ...
- General development of the state of science and technology
  → **CRITERIA FOR RETRIEVAL? Monitoring?**

Technical container safety aspects for recovery

- Recovery → potential **emergency operation** to be generally avoided by a **robust repository safety concept and container design**
- Approval and construction of a **new mine** for recovery
- Maintenance of the **essential safety functions** of containers emplaced in the repository **for 500 or even up to 1.000 years**

  → Primary: safe confinement; subcriticality ➡ **Mechanical stability**

  → Shielding, decay heat removal (decay over time)
- Behaviour and properties of the container **inventories** and **relevant repository boundary conditions**
- Significant dependence on **host rock and disposal concept**: loads exerted by the host rock, ground water and filling material over time
- Loads during recovery operation
- External **corrosive effects** by the respective host rock formation

POTENTIAL CONTAINER CONCEPTS

Option 1: Improvement of existing transport and storage containers

Disadvantages:

- Various container types designed primarily for transportation and interim storage
- Large and heavy containers (20 … >100 Mg)

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- Containers contain also organic materials like polymers
- Complex safety assessments concerning ageing effects during very long periods of time until container retrieval or recovery
- Supplementary measures for satisfying disposal requirements (e.g. container up-grading, backfilling of the container cavity with magnetite or welding of lids)
- High remaining decay heat of single containers

Option 1: Improvement of existing transport and storage containers

Advantages:

- No complex and expensive repackaging and reconditioning
- No secondary wastes
- Experience and studies gained on ageing and degradation effects during extended interim storage

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Can existing containers meet the requirements?

- ➢ **Assessment of host rock stress factors on the containers**
- ➢ **To which extent can the container barrier properties be up-graded?**

Option 2: Development of specific disposal containers

BAM

Selected international developments (host rock dependent):

- **Crystalline:** presence of water and anisotropic mechanical stresses
  - Container as durable technical barrier: corrosion resistant for 1 million years (e.g. KBS-3 / Sweden)
- **Clay:** with low water permeability and anisotropic mechanical stresses
  - Container as technical barrier for almost 1.000 years (e.g. steel container in Opalinus clay / Switzerland)
- **Salt:** without water access and isotropic mechanical stresses
  - Container concepts without barrier function so far (e.g. Pollux / Gorleben)
  - Fast closure of disposal drift

Technical container barrier functions

Ability for container retrievability and recovery

Option 2: Development of specific disposal containers

Disadvantages:

- Secondary wastes:
  - Elaborate repackaging and reconditioning of spent fuel assemblies
  - Used old containers

Advantages:

- Favourable handling operations due to smaller volume and container mass
- Container design for withstanding specific host rock stress factors

- **Robust disposal specific container design possible**
- **State of science and technology → continuous review of container design**

CONCLUSIONS

1. **Retrievability** and **Recovery** procure **additional container requirements.**
2. **Higher robustness** of container safety functions are required **for increasing storage time frames and enabling container retrievability and recovery.**
3. **Repository boundary conditions** need to be defined for demonstration of **container safety requirements** and proper **container design**. They are influenced by the **host rock.**
4. **Retrieval** seems to be generally **feasible** for all container concepts. Containers must keep compliance at least to certain extent with **all basic and container specific safety requirements.**

5. **Containers** must maintain their **essential safety functions** for enabling **recovery**, i. e. their **mechanical integrity**. The recovery option is minimized by a robust repository safety concept and container design.
6. **Existing transport and storage containers** could be **up-graded** and used **as final disposal containers**. The assessment of **host rock stress factors** should prove **whether** the existing containers could meet the **requirements for storage, retrieval and recovery.**
7. **Robust design of new containers** for withstanding specific host rock stress factors is proven to be **possible**. The ability for **retrieval and recovery** increases **with increasing container barrier properties.**