INTRODUCING SYSTEMATIC AGING MANAGEMENT FOR INTERIM STORAGE FACILITIES IN GERMANY

Angelika Spieth-Achtnich
Öko-Institut e.V., Germany

Gerhard Schmidt
Öko-Institut e.V., Germany

Abstract

In Germany twelve at-reactor and three central (away from reactor) dry storage facilities are in operation, where the fuel is stored in combined transport-and-storage casks. The safety of the storage casks and facilities has been approved and is licensed for up to 40 years operating time. If the availability of a final disposal facility for the stored wastes (spent fuel and high-level wastes from reprocessing) will be further delayed the renewal of the licenses can become necessary in future. Since 2001 Germany had a regulatory guideline for at-reactor dry interim storage of spent fuel. In this guideline some elements of ageing were implemented, but no systematic approach was made for a state-of-the-art ageing management.

Currently the guideline is updated to include all kind of storage facilities (central storages as well) and all kinds of high level waste (also waste from reprocessing). Draft versions of the update are under discussion. In these drafts a systematic ageing management is seen as an instrument to upgrade the available technical knowledge base for possible later regulatory decisions, should it be necessary to prolong storage periods to beyond the currently approved limits. It is further recognized as an instrument to prevent from possible and currently unrecognized ageing mechanisms. The generation of information on ageing can be an important basis for the necessary safety-relevant verifications for long term storage.

For the first time, the demands for a systematic monitoring of ageing processes for all safety-related components of the storage system are described. In addition, for inaccessible container components such as the seal system, the neutron shielding, the baskets and the waste inventory, the development of a monitoring program is recommended. The working draft to the revised guideline also contains recommendations on non-technical ageing issues such as the long-term preservation of knowledge, long term personnel planning and long term documentation as well as further aspects concerning the organization of the operator.

The application of the draft guideline is currently under test in selected storage facilities. The application process is closely monitored to evaluate its feasibility and to identify possible improvements for a later upgrade.

1. Technical and legal background

Up to 2002 two central storage facilities for spent fuel and high-active waste were in operation (see Table 1, storage capacity and emplaced wastes in metric tHM).

Table 1. **Central storage facilities, their capacity and emplaced wastes as of 31.12.201075**

Site	Storage capacity		Status		Emplaced
Gorleben	420 cask positions	3 800		X	37
Ahaus	420 cask positions	3 960		X	55

The facilities were licensed and built in the Eighties, waste emplacement started later on. Licensed in both facilities is the storage of spent fuel. Currently the facility in Gorleben is the only storage with a license to store high-active waste from reprocessing.

In 2002, additional at-reactor storage facilities were licensed, built and are operated since then (see Table 2).

Table 2. **At-reactor storage facilities, their capacity and emplaced wastes as of 31.12.201075**

Site	Storage capacity		Status		Emplaced
Biblis	135 cask positions	1 400		X	468
Brokdorf	100 cask positions	1 000		X	134
Brunsbüttel	80 cask positions	450		X	51
Grafenrheinfeld	88 cask positions	800		X	133
Grohnde	100 cask positions	1 000		X	135
Gundremmingen	192 cask positions	1 850		X	280
Isar	152 cask positions	1 500		X	214
Krümmel	80 cask positions	775		X	175
Lingen/Emsland	130 cask positions	1 250		X	327
Neckarwestheim	151 cask positions	1 600		X	333
Obrigheim	980 positions	286		X	100
	15 cask positions		X		
Philippsburg	152 cask positions	1 600		X	357
Unterweser	80 cask positions	800		X	72

Storage capacities of the facilities were designed for and limited by the permit to accommodate the needs for the then-applying legal operating limit of the reactors. The licenses for these facilities were granted for a storage period of 40 years, following the first cask emplacement.

2. Regulatory background

In the Eighties and Nineties the two central facilities were not very specifically regulated. Most of the applied rules were taken from analogous application. Specific and detailed regulation was first issued when the additional at-reactor-storages were applying for licenses. In a guideline[76] explicit safety requirements for the design and operation of spent fuel storages were set and applied within the permitting process for

[75] Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management Report of the Federal Republic of Germany for the Fourth Review Meeting in May 2012. – Bonn, August 2011

http://www.bmu.de/fileadmin/bmu-import/files/english/pdf/application/pdf/jc_4_bericht_deutschland_en.pdf

[76] Reactor Safety Commission (RSK): Safety Guidelines for Dry Interim Storage of Irradiated Fuel Assemblies in Storage Casks. – Bonn, April 5, 2001

http://www.entsorgungskommission.de/englisch/downloads/rskonlineempfdryinterime1.pdf

those facilities. The guideline's scope was explicitly limited to the storage of spent fuel in the decentralized at-reactor facilities.

After roughly ten years the guideline required an update mainly to

accommodate and include the central storage facilities as well to end the diverted path for central and at-storage storages and to achieve an overall applying regulation for all similar facilities,

fit the regulation to high-active waste as well, because of the relevant amount of those wastes stored nowadays and the similar requirements for the storage of those wastes,

upgrade the regulation to achieve full and more explicit compatibility with WENRA's Safety Reference Levels[77],

include more recent developments in other areas of nuclear regulation (such as newly formulated requirements for Safety Management Systems), and to

approach a more systematic ageing management.

One of the main differences between the German regulatory framework and WENRA's SRLs concerned periodic safety reviews (PSRs, see ref.[77]). While PSRs were to be conducted for nuclear reactors, and a detailed set of requirements for those reviews was in effect, those were at that time not required for storage facilities. The discussion process within the Nuclear Waste Management Commission (ESK) therefore lead to two new guidelines: one for PSRs[78] and another one as a general safety guideline[79]. Both guidelines now apply to all storage facilities uniformly.

3. Regulating ageing

In its previous guideline RSK[76] addressed ageing aspects very specifically for certain design and operational specialties (e.g. for the technical layout of certain structural components like the building materials against wear from thermal loads). In its section 2.15 "Long-term and ageing effects, long-term monitoring" ageing was explicitly addressed. The following requirements were set as minimum:

At intervals of 10 years, the facility operator regularly has to prepare a report about the condition of the storage building and the components necessary for interim storage.

The condition of the storage building and of the components necessary for interim storage has to be inspected by walk-down and suitable measures.

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[77] See the evaluation results in: WENRA Working Group on Waste and Decommissioning (WGWD): Waste and Spent Fuel Storage Safety Reference Levels Report, Version 1.2, February 2011, page 40 ff

http://www.wenra.org/media/filer_public/2012/08/30/wgwd_v1-2waste-and-spent-fuel-storage-safety-reference-levels.pdf

[78] Nuclear Waste Management Commission (ESK): ESK recommendations for guides to the performance of periodic safety reviews for interim storage facilities for irradiated fuel elements and heat-generating radioactive waste (PSÜ-ZL). – Bonn, 04.11.2010,

http://www.entsorgungskommission.de/englisch/downloads/eskepanlage1esk14homepageen.pdf

[79] Nuclear Waste Management Commission (ESK): Guidelines for dry cask storage of spent fuel and heat-generating waste. – Revised version as of 29.11.2012 (originally issued 21.06.2012), Bonn 2012, http://www.entsorgungskommission.de/englisch/downloads/eskempfehlungesk30llberevfassung29112012e.pdf

Recurrent settlement measurements have to be performed for the storage building.

Random inspections of the storage casks have to be carried out.

The results of recurrent inspections have to be evaluated.

As the period of 10 years of operation just exhausted last year for the very first constructed decentralized storage facilities, no 10-year-report (first requirement) has come to light so far, that we are aware of.

As can be seen, ageing phenomena were fully addressed, but a systematic ageing management was not formulated as part of those requirements.

Both new guidelines of 2010 on PSRs and 2012 on Safety address ageing. The 2012 guideline on Safety states:

"For the management of the long-term and ageing effects during the applied-for duration of use of the interim storage facility, an ageing management concept is to be submitted and measures to be carried out in accordance with the recommendations on ageing management."[79]

In its section 5.5 the PSR guideline states:

"With regard to technical ageing, reviews are to be performed and evaluated and the results are to be presented. As part of the PSR, the measures existing for the interim storage facility with regard to technical ageing (ageing management) are to be reviewed." [78]

The PSR guideline will be put into effect in a two-stage process, and so will be ageing management:

1. In Phase I of the process the guideline will be applied for two interim storage facilities (one central, one decentral). The process will be monitored and lessons learned will be drawn.

2. In Phase II of the process the guideline will be updated to reflect the lessons learned from the first stage. In this phase the guideline is planned to be finalized and then applies for all storage facilities.

To provide initial guidance for setting up ageing management programs ESK has issued a draft working paper on ageing management, to be tested together with the PSR guideline. The working paper's requirements for a monitoring concept for ageing addresses the following issues:

General: Sampling specificly to be derived from ageing and damaging mechanisms as well as from safety relevance of components, frequency for checks max. every 10 years,

Cask component: Depending from accessibility, accessible components require regular, representative checks at each storage facility; non-accessible components require a systematic national monitoring program.

Building: Design requirements, specifically handling components have to remain functional over the whole operating time, walk-downs and regular checks and inspections required, reporting requirements.

Components with indirect safety functions: for all those components a systematic analysis of stress and ageing mechanisms has to be performed, based on this the regular inspection scheme has to be evaluated and, if necessary, to be improved and specific ageing detection added.

For the last category, components or parts, the attachment to the working paper offers a template that demonstrates in more detail what is expected. The template is given in Table 1.

Table 1. **Proposed template for registering components for ageing inspections**

Component/Part			
Material(s)			
Function(s)			
Safety Objective		Direct	Indirect
	Enclosure		
	Shielding		
	Subcriticality		
	Heat transfer		
Stress/Wear under normal operation	Intensity	**Damage mechanism(s) Ageing effects**	
Mechanical			
Thermal			
Radiation (γ, n)			
Envir. condit. Moisture Other media Corrosion			
Inspection methods			

With applying that template to all components and parts that are directly or indirectly contributing to safety, a more systematic approach has been chosen.

Additionally, the working paper includes aspects of non-technical ageing, such as

long term availability of personal and qualification/knowledge/experience,

knowledge preservation and its updating and improving,

documentation in respect to safety and later disposal of the wastes,

safety management,

digital data storage and preservation.

The working paper has been issued by BMU in a limited form and is recommended for testing.

4. Conclusions

Ageing management is currently introduced in Germany in storage facilities for spent fuel and high-active waste. The necessary provisions, in general, are set in the newly introduced guidelines for Periodic Safety Reviews, while a working paper provides guidance in more detail.

Ageing management is here understood as a necessity to improve compatibility with international (EU, WENRA, IAEA) regulatory framework.

Ageing management is necessary to maintain safety over long (40 years) and perhaps even longer periods of storage and to detect and identify ageing mechanisms for all components that are directly or indirectly prone to such slow changes.

According to the influencing factor of non-technical aspects for long-term safety, such as knowledge management or long-term aspects of management systems a wider scope was chosen.

The first steps in ageing management are performed, now the proposed regulation has to be tested in practice and later improved.

References

ESK 2010a: Nuclear Waste Management Commission (ESK): ESK recommendations for guides to the performance of periodic safety reviews for interim storage facilities for irradiated fuel elements and heat-generating radioactive waste (PSÜ-ZL). – Bonn, 04.11.2010,
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WGWD 2011: See the evaluation results in: WENRA Working Group on Waste and Decommissioning (WGWD): Waste and Spent Fuel Storage Safety Reference Levels Report, Version 1.2, February 2011, page 40 ff, http://www.wenra.org/media/filer_public/2012/08/30/wgwd_v1-2waste-and-spent-fuel-storage-safety-reference-levels.pdf

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Institut für angewandte Ökologie
Institute for Applied Ecology

Introducing systematic aging management for interim storage facilities in Germany

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Angelika Spieth-Achtnich, Gerhard Schmidt

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Content

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- Technical background

- Regulatory background

- Regulating ageing

- Conclusions

2

Technical Background

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History: Central storages

- Initial interim storage capacity very limited
- Two storages in operation since the Nineties

Site	Storage capacity		Status		Emplaced
	(Number of storage positions)	[Mg HM]	Applied for	Licenced	[Mg HM]
Centralised interim storage facilities					
Gorleben	420 cask positions	3 800		X	37
Ahaus	420 cask positions	3 960		X	55

- Limited masses stored
- Facilities were not used as routine storage

Taken from: Joint Convention Report for Germany
Data on emplaced masses as of 31.12.2010

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Technical Background

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After 2001: Decentralized storages added

Site	Storage capacity		Status		Emplaced
	(Number of storage positions)	[Mg HM]	Applied for	Licenced	[Mg HM]
Onsite interim storage buildings					
Biblis	135 cask positions	1 400		X	468
Brokdorf	100 cask positions	1 000		X	134
Brunsbüttel	80 cask positions	450		X	51
Grafenrheinfeld	88 cask positions	800		X	133
Grohnde	100 cask positions	1 000		X	135
Gundremmingen	192 cask positions	1 850		X	280
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	15 cask positions		X		
Philippsburg	152 cask positions	1 600		X	357
Unterweser	80 cask positions	800		X	72

Taken from: Joint Convention Report for Germany; Data on emplaced masses as of 31.12.2010
Green: reactor operating, Red: reactor shut down

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Technical Background

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- On-site storage capacities accomodated to the 2001 consensus (plus limited extra space), capacities sufficient for current nuclear policy
- Storage periods limited to 40 years (credibility of federal declaration to finally dispose the wastes within this period), time frame currently at risk (draft law on site selection provides no time constraints/requirements)

Summary of technical background:

- **Increased storage masses**
- **Increased number of storage facilities**
- **Increasing storage time frames**

➔ **Need for regulation**

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Regulatory Background

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- Historically: 80s/90s: Gorleben and Ahaus were more seen under single-case modalities; no systematical regulation seemed necessary; more or less analogous adaption to existing nuclear reactor regulation
- First RSK* recommendation 2001 on interim dry storage developed accompanying the permit process for the 12 decentral storage facilities
- Shortcomings:
  - Only valid for decentral facilities
  - Only addresses spent fuel
  - Only very general provisions for addressing ageing aspects

* Reactor Safety Commission (Reaktorsicherheitskommission)

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Regulatory Background

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- Other shortcomings of the regulation, as identified in the WENRA process:
  - no Periodic Safety Review mandatory, maintenance and inspection requirements focus mainly on short-term aspects
  - no update to the safety documentation required after the permitting process, so Safety Case requirements are only met in conjunction with a permit update
  - Only very general provisions for addressing ageing aspects

➔ Changes/modifications/additions to the regulation deemed necessary

➔ ESK* was commissioned to prepare updates, compatible with current requirements

➔ Difference in regulating Decentral & Central storages ended

* Nuclear Waste Management Commission (Entsorgungskommission)

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Regulatory Background

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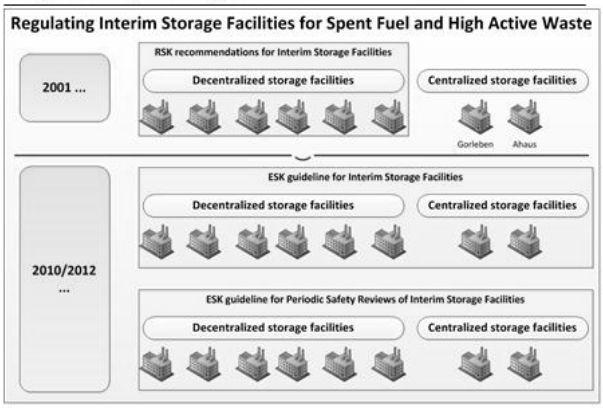

Regulating ageing

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- The PSR guideline
  - is to be tested in two selected storage facilities,
  - monitoring of the test phase shall be used to draw Lessons Learned,
  - is planned to be updated in the light of those experiences,
  - will finally be applicable for all storage facilities.
- Both, the general guideline and the PSR guideline, call for a systematic ageing management program, but do not specify details
- ESK prepared a working paper on ageing management with more detailed provisions, to also be applied within the test phase

➔ Ageing regulation is currently in the test phase

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Regulating Ageing

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Content of the ESK working paper on Ageing:

- **General:** Sampling specificly to be derived from ageing and damaging mechanisms as well as from the safety relevance of the components, frequency for checks max. every 10 years,
- Cask component:
  - accessible components require regular, representative checks at each storage facility,
  - non-accessible components require a systematic national monitoring program (beyond the scope of single operators).
- **Building:** Design requirements, specifically handling components have to remain functional over the whole operating time, walk-downs and regular checks and inspections required, reporting requirements.
- **Components with direct or indirect safety functions:** for all those components a systematic analysis of stress and ageing mechanisms has to be performed, based on this the regular inspection scheme has to be evaluated and, if necessary, to be improved and specific ageing detection added.

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Regulating Ageing

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Template for ageing checks for components & parts

Component/Part			
Material(s)			
Function(s)			
Safety Objective		Direct	Indirect
	Enclosure		
	Shielding		
	Subcriticality		
	Heat transfer		
Stress/Wear under normal operation conditions	Intensity	Damage mechanism(s) Ageing effects	
Mechanical			
Thermal			
Radiation (γ, n)			
Environmental conditions Moisture Other media Corrosion			
Inspection methods			

Taken from: ESK Working paper on ageing management (attachment)

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- Scope of the national program for inaccessible components:
  - Cask interior,
  - Built-in structures inside the cask,
  - Fuel/Waste inventory (VHLW packages, fuel cladding etc.),
  - Cask body,
  - Neutron moderator components,
  - Seals and seal systems,
  - Cask bottom seals.
- Not necessary for routine checks, but required as a technical basis to decide on prolonged storage periods
- Due to high expenditures: Coordination with other partners desirable

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- Addressed: Non-technical aspects of ageing
  - Long term personnel planning: measures to ensure professional experience over the longer term, including safety culture
  - Long term documentation and knowledge preservation: ensure that documents and knowledge are available and accessible over the long term
  - Operation management: long term aspects of safety management and electronic management systems
- Currently not addressed:
  - Obsolescence of components, parts, producers/suppliers/vendors, technical rules, quality and assurance

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Still to be done:

- Finalization of the PSR (currently draft phase of the first facility, start of work at the second facility)
- Set-up of the ageing management program for the first facility
- Drawing Lessons Learned from the process
- Update of the ESK working paper and finalization upgrade, publication as a guideline

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Conclusions

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- Ageing management is currently introduced in Germany in storage facilities for spent fuel and high-active waste. The necessary provisions, in general, are set in the newly introduced guidelines for Periodic Safety Reviews, while a working paper provides guidance in more detail.
- Ageing management is here understood as a necessity to improve compatibility with international (EU, WENRA, IAEA) regulatory framework.
- Ageing management is necessary to maintain safety over long (40 years) and perhaps even longer periods of storage and to detect and identify ageing mechanisms for all components that are directly or indirectly prone to such slow changes.
- According to the influencing factor of non-technical aspects for long-term safety, such as knowledge management or long-term aspects of management systems a wider scope was chosen.

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