

Introduction of An Ageing Management Approach for Packages for the Transport of Radioactive Materials

Sven Schubert, Adrian Reichardt, Steffen Komann, Frank Wille, Martin Neumann

*Division Safety of Transport Containers, Bundesanstalt für Materialforschung und -prüfung (BAM), Germany.
E-mail: sven.schubert@bam.de*

With integration of the new para 613A into SSR-6 [1] the consideration of ageing mechanisms is now obligatory for the design of packages and their approval. In addition, para 809(f) of SSR-6 [1] requires consideration of the effects of storage on ageing mechanisms, safety analyses and operation and maintenance instructions.

German competent authorities Bundesanstalt für Materialforschung und -prüfung (BAM) and Bundesamt für die Sicherheit der nuklearen Entsorgung (BASE) are considering the aspect of ageing in approval procedures. Ageing assessment is mainly focused on dual purpose casks (DPC) package designs which are long-term stored in interim storage facilities. For these package designs, the evaluation of ageing management is now mandatory for the maintenance of the package design approvals with a validity period of 5 years and beyond. The ageing management includes amongst others a gap analysis, the assessment of ageing effects and operational experiences during operation and interim storage.

BAM works on the compilation of a guideline for implementation of paras 613A, 809(f) and 809(k) for packages requiring competent authority approval at the application procedure in Germany. The paper describes essential items of ageing mechanisms and will give a foresight to the ageing management evaluation by BAM. The guideline will contain in the first part definitions, essential aspects of evidence concept and requirements regarding amount and quality of evidence about ageing mechanisms. A graded system, based on accessibility and exchangeability, will be launched for the requirements regarding amount and quality of evidence. In the second part, the ageing management of packages will be described.

1. Consideration of ageing mechanisms during design

Packages for the transport of radioactive materials shall fulfill the requirements of the IAEA regulations /1/.

The current version of the SSR-6 regulations /1/ contains new paragraphs that explicitly require the consideration of ageing mechanisms in the design of packages for radioactive materials. In para 613A, it is stated that for each design of a transport package the ageing mechanisms shall be considered. Para 809 (f) reiterates this requirement for packages subjected to interim storage, including the resulting effects to operating and maintenance instructions. According to para 809 (k), the establishment of a gap analysis program (GAP) for packages is required. This program shall provide the periodic assessment of changes of the state-of-the-art technology, and construction during interim storage.

The first step dealing with ageing is to identify the relevant ageing mechanisms, considering the known or estimated operating conditions. These operating conditions shall be transferred to the individual components of the package design. The specific ageing effects on each single component of the package shall be analyzed and evaluated. From BAM point of view, all expected relevant operating phases such as loading and drying, transport, unloading, interim storage and transport after interim storage, including the time duration of each phase shall be taken into account. Wet storage of fuel assemblies shall be also considered if applicable.

BAM recommends the following procedure for the preparation of the safety case parts with relevance to ageing mechanisms:

- Determination of the factors involved resulting from operation like from the environment, handling, construction and the inventory.
- Description of the factors involved that have a relevant effect on the ageing of the design and are to be considered as ageing mechanism.
- Analysis and evaluation of the safety-relevant ageing mechanisms with regard to their effects on the materials, components, coatings, connections, inventories or operating conditions of the package design.
- Prognosis and Evaluation of the ageing effects on materials, components, coatings, connections, inventories, or operating conditions against the defined specification of the package design.
- Establishment of a monitoring and surveillance program to control the present ageing effects to maintain the condition of a transport package design in accordance with the defined specifications.

For the implementation of the described procedure, the concept of the PDSR can be used as starting point. The PDSR shall demonstrate compliance of a package design with the regulatory requirements /2/. Therefore, the relevant nominal values for a package such as structural or thermal nominal values like screw tightening torques, tensile strengths, fracture toughness, microstructural states, pressure states, temperatures or leakage rates shall be described in the PDSR guide. Based on these nominal values, possible evaluation criterions like permissible stress and strains can be derived. These values are essential for the assessment of relevant ageing effects in terms of compliance of the package with the specification. An analysis of the safety-relevant ageing mechanisms with respect to these nominal values show the potential influence of ageing regarding the original defined specification.

The extent and quality of the evidence concerning the ageing assessment of the package components is focused on the accessibility or replaceability of the components as well as on the classification according to BAM-GGR 011 /3/. The procedure is clearly summarized in Table 1. The classification according to BAM-GGR 011 /3/ is carried out in relation to the effectiveness of the components regarding

- a) Containment of the radioactive contents,
- b) Control of external radiation levels,
- c) Prevention of criticality,
- d) Prevention of damage caused by heat

for achieving the protection goals defined by the dangerous good legislation /1/. In this context, higher requirements are placed on the evidence for components classified in grade 1 according to BAM-GGR 011 /3/ and which directly ensures the defined protection measurements. In general, a detailed and direct proof is required for these components regardless of their accessibility and replaceability. For non-accessible components of grade 1, theoretical considerations must be confirmed by experimental investigations, if necessary. The direct proof must be carried out with specific results from investigations on the component to be considered, the specific corresponding material or the operating condition. A transfer of results from investigations with similar components or materials is generally not permissible. For components that are ‘replaceable’ or ‘accessible but not replaceable’ and classified to grade 2 /3/, the evidence can also be provided indirectly. That means an adequate transfer of results from investigations on similar components or materials is generally accepted by BAM.

Component/ Component group	Requirements for the extent and quality of evidence
inaccessible	The verification of the materials, components, coatings, joints and operating conditions must be analyzed and evaluated in detail and directly. For components classified in grade 1, theoretical considerations shall be verified by experimental investigations, if necessary.
accessible/ not replaceable	The verification shall analyze and evaluate in detail and directly or indirectly the ageing behavior of the materials, components, coatings, joints and operating conditions. The evidence may include measures of continuous monitoring, periodic inspections, maintenance or repair that are part of the ageing management program.
replaceable	The verification shall analyze and evaluate in detail and directly or indirectly the ageing behavior of the materials, components, coatings, joints, and operating conditions. The evidence may include measures of continuous monitoring, periodic inspections, maintenance, repair or defined replacement of the component that are part of the ageing management program.

Table 1 : Requirements for the extent and quality of the evidence on ageing for components classified in grade 1 and 2 according to BAM-GGR 011 /3/

In addition, for a transport after interim storage, all safety-relevant changes that may occur to the inventory shall be taken into account in the safety case.

The results of the evidence for ageing set up the basis for the monitoring program and controlling the ageing effects (ageing monitoring program), which aims to maintain the defined meeting specifications of the package design in transport law.

2. Organization of ageing management

Maintaining the condition of the package design in accordance with the specification for a possible transport is a long-term task. In case of packages for interim storage with long storage periods this task becomes intergenerational. The condition of the transport packages in use must be monitored and maintained by appropriate measures. Therefore, an adequate management system for these packages shall be provided. From BAM point of view, the ageing management comprises of two types of measures. The ageing management comprises the organizational measures for the development-related adaptation of documents and evidence on the one hand and the technical measures which ensure the condition packages in accordance with the defined specification on the other hand. The ageing management shall ensure that all operating phases, from commissioning to decommissioning are covered.

The BAM guideline shall provide a wholistic guidance on how the applicant should define competencies and responsibilities for ageing management within his organization. In addition, responsibilities are defined regarding the provision of documents on ageing management to the competent authorities and operators. This also includes the provision of spare parts and the feedback of experience to the applicant.

The ageing management shall comply with the known current state of the art. This means that new recognized approaches and findings on a technical level such as demonstration, testing and monitoring methods should be incorporated into the relevant ageing management parts.

For a specific package design, ageing management should be carried out by means of design-related measures. These design-related measures shall take into account the specific design and all possible relevant operating phases until decommissioning. The measures shall be designed in such a way that they

- Capture the ageing effects from the evidence with respect to compliance with the specification,
- Identify the monitoring and control of ageing effects within the framework of an ageing monitoring program and
- Describe the procedure for changes within the technical regulations and verification/evidence methods

The design-related measures of ageing management are defined in the ageing management plan.

3. The ageing management of a package design

The requirements for the ageing management plan of a package design are mainly determined by the intended use of the packages. That means the requirements for single usage packages differ in comparison to the repeated use of packages. In addition to the intended use of a package, the accessibility and replaceability of the package components play an important role in determining the requirements for the package design.

In an ageing monitoring program, relevant changes to the package design which have already been predicted and assessed during the design approval are recorded and controlled by adequate measures. The measures for monitoring ageing can be integrated into the operating documents of the package design e.g., test plans, or test and maintenance regulations. The measures of ageing monitoring are generally aimed at the recognition, monitoring, avoidance, reduction and evaluation of ageing effects. Different measures can be applied to achieve these goals e.g., continuous monitoring of packages, monitoring or testing of outsourced components under comparable operating conditions, periodic testing, maintenance or repair.

The extent of the measures is directly linked to the requirements of the ageing management plan and therefore influenced by the intended use of the packages and the accessibility of their components. For packages for multiple use, for example, accessibility can be assumed for most components. In this case, measures such as periodic inspection and maintenance or defined replacement of components can be applied. These measures form the essential part of the ageing monitoring program.

The state-of-the-art technology applies to the methods of monitoring. These can be, for example, visual inspections, material tests, stress test, leak test or activity measurements. In the ageing monitoring program, the parameters to be monitored shall be explained, meaning their correlation to the meeting specification and their possible impact to the protection measurements. should be shown, if applicable.

The results of the ageing monitoring shall be transferred into the ageing management documentation. To illustrate the effect of ageing effects on the component, inventory or operating condition, adequate representations shall be created over the operating period. The results shall be compared with the defined specific package design values.

For packages for transport after interim storage, the SSR-6 /1/ provides a systematic procedure, gap analysis program, for a recurrent assessment of changes in the regulatory framework, changes in the state-of-the-art technology and changes in the state of the package design.

Changes to the regulations, rules and standards contained in the package design documents shall be considered. Depending on their relevance to ageing management, these regulatory changes should be reviewed and evaluated. If necessary, these changes shall be incorporated into the package design documents.

The ageing management documentation shall ensure the systematic continuous documentation of compliance with package design specification in the packaging documentation. This includes, for example, relevant protocols to be completed for each packaging in accordance with the operating instructions of the package design. The ageing monitoring program with the monitoring measures included and the resulting protocols and records is also part of the documentation.

The documentation system must be transparent and comprehensible. This is to ensure that decisions and actions remain comprehensible even in retrospect.

Based on the ageing management documentation, a feedback of experience should be provided. That includes all relevant operating phases e.g., handling, loading, unloading, transport, or interim storage which have been carried out with the packages since they are put into service. A regular feedback of experience enables an optimization of the ageing management program down from each single package up to the requirements of the package design.

4. Conclusion

Packages for the transport of radioactive material shall fulfill the IAEA regulations [1]. With the current version of IAEA regulations, the consideration of ageing mechanisms is now obligatory for all kind of package design type. The draft of the BAM guideline describes a way of implementing the necessary measures for ageing to fulfill the regulations. According to this guideline all relevant operating phases of a package shall be considered to identify all relevant ageing mechanisms. In order to focus in the most important components of maintaining the protection measurements, the guideline offers a gradual approach. Based on the factors of accessibility, replaceability and intended usage, the requirements for the ageing assessment of the components are defined.

Therefore, to ensure this assessment, the organization of the ageing management is subdivided into the technical and organizational measures. Design specific measures shall be created and carried out for a specific package design. The requirements for the ageing management of a package design will be mainly determined by the intended use and the amount of accessible and replaceable components. The developed measures to identify and deal with ageing effects will be done within the ageing monitoring program.

Finally, the systematic documentation of all ageing management measures with regard to the meeting specification shall ensure a continuous control and analysis of the measures carried out. Due to new requirements and feedback of experience, the ageing management shall be continuously checked and adapted to ensure an adequate optimized ageing management system.

List of tables

Table 1 : Requirements for the extent and quality of the evidence on ageing for components classified in grade 1 and 2 according to BAM-GGR 011 /3/	3
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References

- /1/ International Atomic Energy Agency (IAEA).
Regulations for the Safe Transport of Radioactive Material, 2018 Edition. Specific Safety Requirements No. SSR-6 (Rev. 1), Vienna, 2018.
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- /3/ BAM-GGR 011: Quality Assurance Measures of Packagings for Competent Authority Approved Package Designs for the Transport of Radioactive Material (BAM-GGR 011) Rev. 1 dated 1st October 2018, published in Amts- und Mitteilungsblatt by BAM, Band 48, 3/2018, p. 109-121.