Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

National Action Plan

Report by the Federal Ministry for the Environment,
Nature Conservation and Nuclear Safety (BMU) on
Topical Peer Review
Ageing Management of Nuclear Power Plants
and Research Reactor

September 2019

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1. INTRODUCTION

Article 8e (2) of Council Directive 2014/87/Euratom amending Directive 2009/71/Euratom establishing a community framework for the nuclear safety of nuclear installations stipulates that all Member States of the European Union shall ensure that a national assessment is performed and that, according to Article 8e (3), arrangements are in place to allow for a so-called topical peer review to start in 2017, and for subsequent topical peer reviews to take place at least every six years thereafter.

Peer reviews are carried out in several steps, based on a specific technical topic related to nuclear safety of the relevant nuclear installation. The relevant results will be published subsequently. The process is as follows:

- Member States of the EU shall perform a national self-assessment, based on a specific topic related to nuclear safety of the relevant nuclear installations on their territory and prepare a national report.
- All other Member States, and the European Commission as observer, are invited to peer review the national self-assessments.
- Follow-up measures are agreed if necessary.

Through the European Nuclear Safety Regulators Group (ENSREG), the Member States of the European Union have selected the topic of "ageing management" for the first peer review. This has been carried out for all nuclear power plants that were operating on 31 December 2017 as well as research reactors with a power equal to one MW_{th} or more. In addition to general aspects of ageing management, specific topics are adressed. These are:

- Electrical cables,
- Concealed pipework,
- Reactor pressure vessels, and
- Concrete containment structures.

To ensure the most uniform structure possible of all national reports, WENRA developed the technical specification for the peer review at the request of ENSREG /WEN 16/.

ENSREG published the final report and country specific findings of the 1st topical peer review on "Ageing Management" on October 29th, 2018. The TPR process provides for Member states to prepare a National Action Plan (NAcP) by September 2019, which addresses how to deal with the results of these reports.

Four findings allocated to Germany were classified as area for improvement by the TPR Board.

Three of them are related to the Overall Ageing Management Programme (OAMP).

1. Methodology for scoping the SSCs subject to ageing management: The scope of the OAMP is reviewed and, if necessary, updated, in line with the new IAEA Safety Standard after its publication.
2. Delayed NPP projects and extended shutdown: During long construction periods or extended shutdown of NPPs, relevant ageing mechanisms are identified and appropriate measures are implemented to control any incipient ageing or other effects.

3. Overall Ageing Management Programmes of research reactors: A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, the applicable national requirements, international safety standards and best practices.

One finding concerns examination of the Reactor Pressure Vessel (RPV):

4. Non-destructive examination in the base material of beltline region: Comprehensive NDE is performed in the base material of the beltline region in order to detect defects

The Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) and the competent nuclear licensing and supervisory regulating bodies of the *Länder* have drawn up and harmonized the following National Action Plan for Germany. Federal and *Länder* authorities have consulted their respective experts within the process. Licensees operating Nuclear Power Plants and research reactors have been involved by the *Länder.*

The National Action Plan has been published on the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) website in September 2019 and is available under the following link https://www.bmu.de/download/erstes-themenbezogenes-peer-review-tpr/.

2. FINDINGS RESULTING FROM THE SELF-ASSESSMENT

In the German National Report (NAR), no findings to be addressed in this section were expressed. The overall assessment on the ageing management of the nuclear installations under review have been summarised as follows in the German NAR:

1. In Germany, consideration of ageing effects of safety-related SSCs already began with the design/layout of the nuclear power plants still in operation today. By appropriate design and construction as well as the operation of the nuclear power plants, precautions against undue impairment from ageing effects known at that time have been taken, which were also laid down plant-specifically in the construction and operating licences.
2. Identification, documentation and consideration of ageing effects has been continuously expanded based on the progressing state of knowledge. For this purpose, various sources were used and, where necessary, appropriate measures have been implemented for the control of ageing phenomena, including the replacement of affected parts and various constructive improvements.
3. The requirements of safety standard KTA 1403, in which international practice is also fully taken into account, led to a further systematisation of ageing management. In addition, KTA 1403 created a standardised assessment basis.
4. The knowledge required for effective ageing management is summarised in a knowledge base and regularly updated so that the identification of safety-related degradation mechanisms is ensured and appropriate measures are derived.
5. Ageing management in German nuclear power plants is essentially characterised by a proactive approach. Extensive monitoring of the known causes and consequences of degradation mechanisms reliably ensures that the safety margins provided for in the design are maintained.
6. Where possible, conditions have been created in German nuclear power plants to prevent ageing of safety-related SSCs on the basis of extensive research and development work. So, for example, the occurrence of various corrosion mechanisms on pressure-retaining components could be prevented by optimising these components and the operating conditions.
7. In summary, it can be concluded that the ageing management practised in German nuclear power plants provides an effective instrument for the detection and monitoring of ageing-related phenomena. The measures are suitable for identifying and controlling ageing-related mechanisms and thus maintaining the condition of the SSCs meeting the requirements.
8. In German research reactors, ageing management takes place within the framework of maintenance by appropriately applying safety standard KTA 1403. Previous operating experience confirms the effectiveness of measures for the control of ageing mechanisms also for research reactors.
9. Ageing management in German nuclear power plants is reviewed by the nuclear supervisory authorities of the Länder and the effectiveness of ageing management is confirmed, i.e. the practised procedure ensures that for German nuclear power plants and research reactors the high level of safety during operation is maintained.

3. Country specific findings resulting from the TPR

In the following, all areas of improvement allocated by the TPR for Germany are discussed.

3.1. Overall Ageing Management Programmes (OAMPs)

3.1.1. *TPR expected level of performance: Methodology for scoping SSCs subject to ageing management*

Expected level of performance: „Methodology for scoping the SSCs subject to ageing management: The scope of the OAMP is reviewed and, if necessary, updated, in line with the new IAEA Safety Standard after its publication."

This expected level of performance comprises two substantial issues: on the one hand, the methodology for scoping safety-related SSCs subject to ageing management, on the other hand, a review of this scope upon further development of international standards.

In section 3.1.2, first, the overall requirements regarding ageing management specified in German nuclear rules and regulations are outlined, containing also the methodology for scoping the systems subject to ageing management. Subsequently, the process for updating nuclear rules and regulations including requirements regarding ageing management is described. Moreover, questions and comments to Germany with respect to the scoping of the ageing management are compiled. Based on this, the implementation of the recommendation is assessed.

3.1.2. *Country position and action (licensee, regulator, justification)*

Requirements in the German rules and regulations regarding ageing management

In Germany, the general requirements for the quality of safety-related SSCs are laid down in the Atomic Energy Act (AtG) /ATG 16/, the Safety Requirements for Nuclear Power Plants (SiAnf) /SIC 15/, and the safety standards of the Nuclear Safety Standards Commission (KTA). The measures for long-term maintenance of the required quality (ageing management) are an integral part of the quality requirements specified in the German nuclear rules and regulations.

The Safety Requirements for Nuclear Power Plants /SIC 15/ include requirements for an integrated management system (IMS) that shall also take into account objectives and requirements in terms of ageing. Thus, for measures and SSCs necessary for levels 1 to 4 of the defence-in-depth concept, against internal and external hazards as well as very rare human-induced external hazards it is required to apply safety promoting principles during planning, implementation and execution of measures and during the design, manufacture and operation of equipment, e.g. it is required to draw up a monitoring concept for the early detection of ageing degradation. Furthermore, it is required that precautions are to be taken against failure due to fatigue, corrosion and other ageing mechanisms, as far as ISIs cannot be performed to the required extent.

The Interpretations of the Safety Requirements for Nuclear Power Plants /INT 15/ also include requirements for ageing management. Accordingly, they stipulate to use operating experience for ageing management. The central requirement is laid down in Section 2.5.1 (9) of the Interpretation I-2 of the Safety Requirements for Nuclear Power Plants: *"An ageing management system shall be implemented for the systematic detection, monitoring or prevention of ageing effects on the integrity of the components*."

In the Safety Requirements for Nuclear Power Plants /INT 15/ Ageing is defined as *"Time- and use-dependent changes of function-related features and characteristics of*

- *technical equipment (structures, systems and components, including electrical systems and instrumentation and control),*
- *the specification and other reference documents,*
- *the plant concept and technological procedures,*
- *of administrative regulations, as well as*
- *of operating personnel.*"

The safety standards of the Nuclear Safety Standards Commission (KTA) have the task of specifying the safety requirements laid down in the superordinate regulations and further concretize them for the corresponding area of application. The general requirements for the integrated management system from the safety requirements are concretised in safety standard KTA 1402 /KTA 17e/ The special requirements for ageing management were defined in safety standard KTA 1403 /KTA 17/.

Regarding the scope of SSCs in ageing management KTA 1403 applies to the safety-related SSCs, including the respective auxiliary and operating supplies, specified in the plant-specific licensing documents and operating procedures, of nuclear power plants still in operation.

The Safety Requirements for Nuclear Power Plants /SIC 15/ defines safety-related SSCs (or safety relevant equipment, item important to safety) as:

"*Equipment required for the safe shutdown of the reactor and keeping it in a shutdown state, for the residual heat removal, the prevention of uncontrolled criticality as well as necessary precautions against damage and to keep any radiation exposure or contamination of man, material goods, or the environment as low as achievable, with due regard to the current state of the art in science and technology even below the limits stipulated, at any time during normal or abnormal operation, accidents, very rare events and in case of internal and external hazards, as well as very rare human induced external hazards.*"

KTA 1403 deals with physical ageing taking into account new findings with regard to ageing processes. This safety standard applies, furthermore, to the procedures of ageing-management regarding the basic qualification and maintenance of competence and know-how of the personnel and, also, to the documentation and the data from information and operation management systems. Accordingly, a systematic and knowledge-based ageing management system as part of the integrated management system shall be implemented, which shall be organised, documented, assessed and updated. Ageing management shall be implemented in a process-oriented manner and integrated into the operational processes. For this purpose, the following basic requirements shall be implemented by the operator:

- The extent of ageing related observations shall be defined and documented. The observations shall include
    - ageing of the auxiliary and operating supplies of the respective SSCs, and
    - ageing related influences on the data from information and operation management systems including documentation.
- The procedures of ageing management shall ensure that safety-related degradation mechanisms are identified. The causes and/or consequences of these degradation mechanisms shall be controlled by appropriate measures.
- The further development of the state of the art in science and technology shall be monitored and assessed.
- The measures taken with respect to ageing management and the results achieved shall be documented and assessed. Corresponding reports shall be drawn up at regular intervals. Ageing-management shall be continuously optimised based on the assessments carried out. Impermissible deviations from the required quality shall be eliminated.
- Ageing management shall be implemented in a process-oriented manner and integrated into the operational processes. The processes involved (e.g. servicing, maintenance), the interrelated activities as well as their interactions shall be identified, directed and controlled. This overall process shall be designed according to the principles of a PDCA cycle (Plan-Do-Check-Act) (see Figure 3.1).
- Ageing management shall be performed on the basis of a structured knowledge base. In particular, this knowledge base shall contain sufficient information on the respective design concept, ageing-related requirements from the rules and regulations, on the design and manufacture as well as the operating history of the SSCs, on the potential degradation mechanisms and, with respect to the relevant degradation mechanisms, the designated and possible monitoring, testing and corrective measures, including assessment of the results.

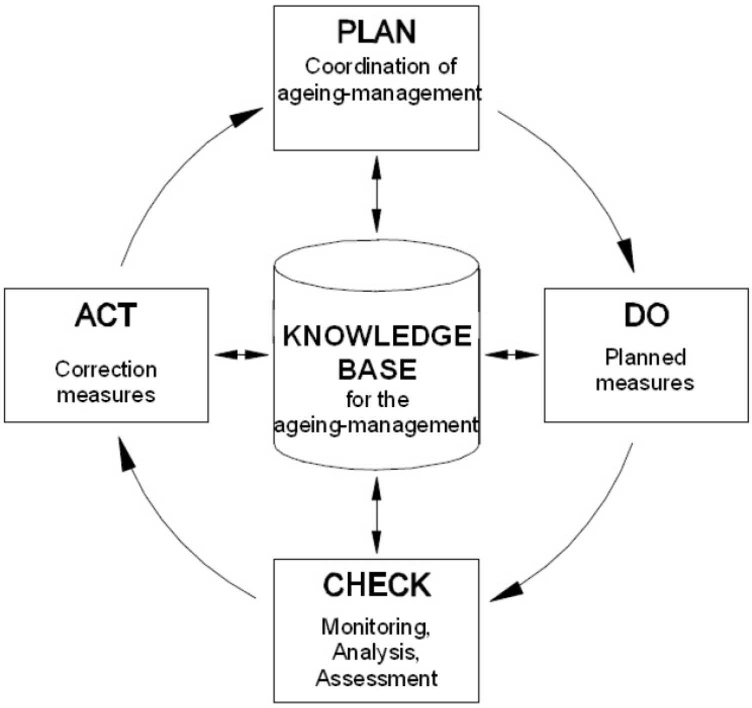

Fig. 3.1 PDCA cycle of ageing management /KTA 17/

Process orientation and relevant aspects of a PDCA cycle are dealt with in safety standard KTA 1402 “Integrated Management Systems for the Safe Operation of Nuclear Power Plants”.

If ageing effects are detected on non-safety-related technical installations that are applicable to similar SSCs considered within ageing management, these findings shall be integrated into the ageing management.

KTA 1403 contains further specific requirements for various groups of SSCs, such as mechanical systems and components, components of electrical and instrumentation and control (I&C) systems, structural elements and auxiliary and operating supplies.

Further detailed requirements for maintaining the quality of SSCs that meets the specified requirements (hereinafter referred to as required quality) are also part of component-specific KTA safety standards, such as KTA 3201.4 or KTA 3211.4.

In addition to ageing management, the periodic safety review, which has been carried out in all German nuclear power plants since the mid-nineties and has been introduced in the AtG as mandatory in 2002, comprehensively assesses the aspects of conceptual ageing.

Update of the requirements regarding ageing management – further development of international standards

The regulatory bodies regularly assess and review the nuclear regulations to ensure they are up to date. This concerns the Safety Requirements for Nuclear Power Plants, as well as the KTA safety standards, which set pertinent requirements for the ageing management of nuclear power plants. The KTA safety standards are reviewed regularly to ensure that they are up to date and revised if necessary. Here, in particular, the further development of the international rules and regulations is taken into account systematically. The corresponding processes are displayed in the “Handbuch über die Zusammenarbeit zwischen Bund und Ländern im Atomrecht” (Handbook on Cooperation between the Federal Government and the *Länder* in Nuclear Law). These consider the international standards by the IAEA – and thus the IAEA standard mentioned within the recommendations, as soon as it is published. The preparation and implementation of IAEA rules and regulations is a discrete process in the aforementioned handbook (cf. process 17 in Handbuch über die Zusammenarbeit zwischen Bund und Ländern im Atomrecht).

Thus, the German answer to question no. 124 /TPR 18/ describes the incorporation of international rules and regulations in the review process of national rules and regulations:

"Germany closely follows the development of international requirements such as the IAEA safety standards and the WENRA Safety Reference Levels. Newly published international requirements are systematically compared with the German rules and regulations to identify gaps in national nuclear rules and regulations and supervisory practices. Furthermore, Experts from Germany participate in the international development of nuclear rules and regulations. On the one hand, the aim is to ensure with the help and support of the international nuclear rules and regulations best possible protection against damages and to effect a comparable further development of the national regulatory framework. On the other hand, these international developments are to make a contribution to European harmonisation."

The international requirements, which have already been considered in the national rules and regulations are subsequently mentioned. On European level the WENRA Safety Reference Level Issue I "Ageing Management" /WEN 14/ sets the basic requirements concerning ageing management.

Moreover, relevant requirements on ageing management are given in the following IAEA standards: Safety Requirements SSR 2/1 "Safety of Nuclear Power Plants: Design" /IAE 16a/, SSR 2/2 „Safety of Nuclear Power Plants: Commissioning and Operation" /IAE 16b/ und SSR-3 "Safety of Research Reactors"/IAE 16c/. Specific recommendations for implementing ageing management are given in Safety Guide NS-G-2.12 "Ageing Management for Nuclear Power Plants" /IAE 09a/ as well as in Safety Guide SSG-10 "Ageing Management for Research Reactors" /IAE 10/.

The new IAEA standard, which is stated in the above-mentioned expected level of performance, is SSG-48 "Ageing Management and development of programmes for long term operation of nuclear power plants" /IAE 18/. This standard, published in November 2018, superseded NS-G-2.12 "Ageing management for nuclear power plants" (published 2009). According to SSG-48 the scope of ageing management for SSC is defined in chapters 5.16 and 5.17 as follows:

"5.16. The following SSCs should be included in the scope of ageing management:

a) SSCs important to safety that are necessary to fulfil the fundamental safety functions [1]:
   - *Removal of heat from the reactor and from the fuel store;*
   - *Confinement of radioactive material, shielding against radiation and control of planned radioactive releases, and limitation of accidental radioactive releases.*

b) Other SSCs whose failure may prevent SSCs important to safety from fulfilling their intended functions. Examples of such potential failures are:
   - *Missile impact from rotating machines;*
   - *Failures of lifting equipment;*
   - *Flooding;*
   - *High energy line break;*
   - *Leakage of liquids (e.g. from piping or other pressure boundary components).*

c) Other SSCs that are credited in the safety analyses (deterministic and probabilistic) as performing the function of coping with certain types of event, consistent with national regulatory requirements, such as:
   - *SSCs needed to cope with internal events (e.g. internal fire and internal flooding);*
   - *SSCs needed to cope with external hazards (e.g. extreme weather conditions, earthquakes, tsunamis, external flooding, tornados and external fire);*
   - *SSCs needed to cope with specific regulated events (e.g. pressurized thermal shock, anticipated transient without scram and station blackout);*
   - *SSCs needed to cope with design extension conditions [1] or to mitigate the consequences of severe accidents."*

"5.17. Structures and components that satisfy both of the following conditions can be excluded from the scope of ageing management:

a) Structures and components subject to periodic replacement or to a scheduled refurbishment plan on the basis of predefined rules (based on a manufacturer's recommendation or other basis and not on an assessment of the condition of the structure or component, which would comprise implementation of ageing management for the structure or component); and

b) Structures and components that are not required by national regulatory requirements to be included in the scope."

Questions and comments to Germany with respect to the scoping of the ageing management

Question 124 /TPR 18/, which relates to incorporation of international rules and regulations in the review process of national rules and regulations has been referred to already due to its thematic relevance. Further relevant questions addressed to the overall ageing management programme in Germany are subsequently illustrated.

Question 24 /TPR 18/ concerns the method of identifying the SSC, which need to be considered in ageing management. In addition to referring to KTA 1403, it is further explained:

"…By definition, the SSCs include all safety-related mechanical components and systems, electrical and instrumentation and control equipment and components as well as structural components."

Furthermore, the General AMP expert group made following comments regarding the scope setting for SSCs /TPR 18/:

Question-ID	Topic	Question, Comment
DE - 98	02. Overall Ageing Management Programme requirements and implementation	Interesting that this standard also includes "basic qualification and maintenance of competence and know-how of the personnel" in ageing management The general requirements for the integrated management system from the safety requirements are concretised in safety standard KTA 1402 /KTA 12/ The special requirements for ageing management were defined in safety standard KTA 1403 /KTA 17/. KTA 1403 applies to the safety-related SSCs, including the respective auxiliary and operating supplies, specified in the plant-specific licensing documents and operating procedures, of nuclear power plants still in operation. It deals with physical ageing taking into account new findings with regard to ageing processes. This safety standard applies, furthermore, to the procedures of ageing-management regarding the basic qualification and maintenance of competence and know-how of the personnel and, also, to the documentation and the data from information and operation management systems.
DE - 100	02. Overall Ageing Management Programme requirements and implementation	It is important to also exploit experiences gained outside the area of nuclear safety components and systems Process orientation and relevant aspects of a PDCA cycle are dealt with in safety standard KTA 1402 "Integrated Management Systems for the Safe Operation of Nuclear Power Plants". If ageing effects are detected on non-safety-related technical installations that are applicable to similar SSCs considered within ageing management, these findings shall be integrated into the ageing management. KTA 1403 contains further specific requirements for various groups of SSCs, such as mechanical systems and components, components of electrical and instrumentation and control (I&C) systems, structural elements and auxiliary and operating supplies.
DE - 101	02. Overall Ageing Management Programme requirements and implementation	Good practice having included ageing in the PSRs as a specific issue In addition to ageing management, the periodic safety review, which has been carried out in all German nuclear power plants since the midnineties, comprehensively assesses the aspects of conceptual ageing.
DE - 102	02. Overall Ageing Management Programme	Albeit outside the scope of the TPR, this is a good practice In addition, KTA 1403 deals with non-technical aspects. These include the basic qualification and maintenance of competence and know-how of the personnel

Question-ID	Topic	Question, Comment
	requirements and implementation	and, ageing of the documentation and the data from information and operation management systems.
DE - 110	02. Overall Ageing Management Programme requirements and implementation	The plant-specific scope of the SSCs that are subject to systematic ageing management has also been described in basic reports on ageing management in accordance with the requirements of KTA 1403. The plant operators have assigned a plant-specific programme of measures to control ageing-related degradation mechanisms to the correspondingly defined categories or groups of SSCs. The quality requirements have also been already available in the required form in the German nuclear power plants. The related specifications are contained in the operating manuals and other plant-specific documents on the issue-related and administrative procedures.
DE - 119	02. Overall Ageing Management Programme requirements and implementation	In the case of modifications to the nuclear power plant or its operation, all affected organisational units will be involved in accordance with safety standard KTA 1402 /KTA 12/. In addition, modifications to SSCs and the operation of safety systems are generally subject to approval in Germany and are thus assessed by the nuclear supervisory authority and by any authorised experts consulted by them prior to implementation. The entirety of the measures ensures that all safety-related aspects are taken into account in planned modifications. In this respect impacts from plant modifications on the ageing management are also considered.

Table 1 Comments of the General AMP expert group regarding the scope setting for SSCs

Moreover, the following question on scope setting of SSCs was raised by the General AMP expert group: "Section 2.3.1.a confirms that KTA 1403 applies to mechanical components and systems, electrical, instrumentation and control and structural elements. Please could you explain how ageing of equipment and facilities provided for emergency response at NPPs is considered within the framework established by KTA 1403.", question 137 /TPR 18/. Germany stated that this mobile equipment is not within the scope established by KTA 1403, but that it is included in the periodic test programme. Further information on corresponding regulatory requirements at the legislative level is provided below.

Assessment of the implementation of the recommendation and derivation of measures

According to German nuclear rules and regulations ageing management applies to the safety-related SSCs, including the respective auxiliary and operating supplies, specified in the plant-specific licensing documents and operating procedures. These comprise passive as well as active SSCs. Thereby, relevant findings (ageing effects) from non-safety related SSCs that are applicable to similar SSCs considered within the scope of ageing management have to be considered. Additionally, ageing related influences on the data from information and operation management systems, including documentation are in the scope of the ageing management, according to KTA 1403. In its comments, the General AMP expert group basically recognised the scope of ageing management according to the German nuclear rules and regulations and here the consideration of non-technical aspects.

The process-oriented approach (PDCA-cycle) and the ageing management being part of the integrated management system (IMS) ensures the scope of ageing management is regularly reviewed with respect to it being up to date and complying with the state of the state-of-the-art in science and technology.

The regular review and update processes of German nuclear rules and regulations considers international rules and regulations, such as IAEA standards. Corresponding processes for review and update of rules and regulations are described in the "Handbuch über die Zusammenarbeit zwischen Bund und Ländern im Atomrecht" (Handbook on Cooperation between the Federal Government and the *Länder* in Nuclear Law).

The review of the required scope of ageing management according to IAEA SSG-48 "Ageing management and development of programmes for long term operation of nuclear power plants" /IAE 18/ showed that it is largely covered by the existing requirements in the German nuclear rules and regulations.

With regard to the consideration of SSCs needed to cope with design extension conditions, for prevention or mitigation of consequences of severe accidents (IAEA Safety Guide SSG-48 last bullet point in chapter 5.16) the Atomic Energy Act (AtG) contains provisions for testing their operability.

Regular functional tests take place for these SSCs. The frequency and scope of the functional tests depends on the safety significance of the systems, manufacturer recommendations and operating experience. E.g., mobile emergency diesel generators ("SBO-diesel generators") are tested by functional tests with a specific load profile on a regular basis or mobile emergency feed-water pumps are also inspected and functional tested on a regular basis. According to §7c (3) AtG the licensee is obligated to guarantee the functionality of the installations for preventive and mitigative emergency response by maintenance and in-service-inspections, and to use the installations periodically in exercises.

> *„7 c (3) The licensee shall be obliged to provide for adequate procedures and precautions for the on-site emergency preparedness. The licensee shall provide for preventive and mitigative measures of the on-site emergency preparedness,*
>
> *…*

3. the operability of which is ensured by maintenance and in-service inspections,
4. which are regularly used and inspected in training exercises and
5. which are regularly reviewed and updated, taking into account the knowledge gained from the training exercises and accidents."

Thus, the area for improvement 1 for checking the scope of SSCs to be considered in ageing management is taken into account, considering further development of international rules and regulations too.

From the point of view of the nuclear licensing and supervisory regulatory authorities (federal and state), no further measures may be derived.

3.1.3. *TPR expected level of performance: Delayed NPP projects and extended shutdowns*

Expected level of performance: "Delayed NPP projects and extended shutdown: During long construction periods or extended shutdown of NPPs, relevant ageing mechanisms are identified and appropriate measures are implemented to control any incipient ageing or other effects."

In Section 3.1.4, relevant requirements in the German rules and regulations regarding the consideration of changed operating conditions in the ageing management are compiled. Based on this, the implementation of the recommendation is assessed, and measures are derived.

3.1.4. *Country position and action (licensee, regulator, justification)*

Requirements in the German rules and regulations regarding the consideration of changed operating conditions in the ageing management

Since no further licenses will be issued for the construction and operation of NPPs according to the German Atomic Energy Act, the topic of delayed NPP projects does not apply to Germany. However, extended shutdowns are possible in German NPPs, too. The ageing management programme therefore needs to cover all ageing related aspects due to altered environmental or operational conditions. Corresponding requirements are given in German nuclear standard KTA 1403. The ageing management is part of the integrated management system, as described in chapter 3.1.2 and thus integrated into the operational processes and subject to continuous review and improvement.

With the introduction of KTA 1403 /KTA 10/ in 2010, the essential technical requirements were summarised in a generally formulated, higher-level management process. Overall, KTA 1403 represents a catalogue of requirements that enables and ensures a continuous assessment of the functional features of the SSCs and their ageing-related degradation mechanisms in a closed cycle. All measures are implemented in a process-oriented manner and are organisationally integrated into the operational procedures. Changes in operational procedures are thereby taken account of.

The process orientation of ageing management ensures defined responsibilities for SSCs also across different technical departments. This allows for effective action and leads to continuous improvement of ageing management quality through the recurrent assessment of the effectiveness of the process. The responsibilities across different technical departments support a multidisciplinary assessment and thus ensure ageing relevant effects are detected during unplanned shutdowns and the corresponding measures are taken.

In the case of modifications to the nuclear power plant or its operation, all affected organisational units will be involved in accordance with safety standard KTA 1402 /KTA 17e/. In addition, modifications to SSCs and the operation of safety systems are generally subject to approval in Germany and are thus assessed by the nuclear supervisory authority and by any authorised experts consulted by them prior to implementation. The entirety of the measures ensures that all safety-related aspects are taken into account in planned modifications. In this respect, impacts from plant modifications on the ageing management are also considered.

Since the entry into force of KTA 1403, the processes of ageing management have been uniformly implemented in German nuclear power plants. If necessary, the processes are adapted or further developed and implemented in the organisational process and workflow.

The non-technical requirements contained in KTA 1403 have also been integrated into the ageing management process so that ageing-related impairments can also be identified and controlled in these areas in a timely manner.

The continuous assessment and review are stated in KTA 1403, chapter 3 e) and f), and the assessment of the effectiveness is stated in chapter 4.1.4:

e) *"The measures taken with respect to ageing-management and the respective results shall be documented and assessed. In regular intervals, reports shall be written summarizing these measures and results. Ageing-management shall be continuously optimized based on the performed assessments. Impermissible deviations from the required quality condition shall be eliminated.*

f) *The ageing-management shall be translated into practice in a process-oriented way and shall be integrated into the operational procedures. It shall be part of an integral management system. The processes involved (e.g., servicing, maintenance), the intertwined activities as well as the mutual interactions shall be identified, directed and controlled. This overall process shall be designed in accordance with the principles of a PDCA-cycle (PLAN-DO-CHECK-ACT-cycle).*

4.1.4 Assessment of the effectiveness

(1) *The effectiveness of the existing and of possibly taken additional measures for detecting and mitigating relevant damage mechanisms shall be assessed in regular intervals. The length of these intervals shall be chosen in accordance with the expected ageing behaviour. This assessment may be based on a comparison of the specified and the actual conditions or on trend analyses.*

(2) *The comparison between the specified and the actual conditions shall be based on, e.g.:*

   a. *initial condition during commissioning,*
   b. *expected value in case of continuous development,*
   c. *assessed results,*
   d. *requirements in standards.*

(3) *The trend analyses shall be based on, e.g.:*

   e. *statistical evaluation of failures, damages or findings,*
   f. *projections of the developments into the future (prognoses),*
   g. *adherence to an anticipated value in case of continuing development.*

(4) *If the assessment of the effectiveness shows that the measures taken did not suffice, these measures shall be optimized or supplemented."*

Conservation of systems during extended shutdown is an established procedure in Germany (dry or wet conservation). Mainly, procedures provided by the component suppliers and plant manufacturer are used, which specify requirements on the conservation and testing of components, for example testing fluids to be used, pressure- and functional testing procedures and conservation measures. Furthermore, plant specific so-called "chemistry manuals" exist, which give detailed description on component-specific conservation procedures. There are further procedures, which ensure functionality of safety-related systems and components during shutdowns. Relevant ageing mechanism were identified in this respect. The availability and function of safety systems is tested after a failure prior to returning to service. These tests are performed under regulatory supervision. Further, before restart after a shutdown, either normal or extended, the authorized party must also provide the proof of specified state and conditions of all systems relevant for safety.

Questions and comments to Germany with respect to the consideration of changed operating conditions in the ageing management

Concerning this topic, no questions or comments have been received by Germany.

Assessment of the implementation of the recommendation and derivation of measures

From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state) the existing requirements in the German nuclear rules and regulations are appropriate in order to take ageing relevant effects even during longer shutdowns into account and to take the corresponding measures. This results mainly from the process-oriented approach of the ageing management and its subsequent integration into operational processes. Thus, modifications to operational processes are considered. The responsibilities covering different technical departments are supported by a multi-disciplinary assessment and the fact that ageing relevant effects during extended shutdowns are identified and suitable measures are taken. So far, the efficiency of the approach is confirmed by the operating experience with German NPPs.

However, in order to take into account the findings from the TPR and the further development of international rules and regulations (cf. review of WENRA RL ISSUE I), the nuclear licensing and supervisory regulatory bodies (federal and state) will assess the need of concretizing German nuclear rules and regulations in this respect.

Furthermore, research programmes concerning specific ageing related aspects due to altered environmental or operational conditions during extended shutdowns have been initiated in order to enhance the corresponding knowledge base.

From the point of view of the German nuclear licensing and supervisory regulatory bodies (federal and state) further actions are not necessary.

3.1.5. *TPR expected level of performance: Overall Ageing Management Programmes of research reactors*

Expected level of performance: „ A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, the applicable national requirements, international safety standards and best practices."

In section 3.1.6, first, relevant requirements in the German rules and regulations regarding research reactors are compiled. Then the current German practice of ageing management of research reactors is outlined. Further, relevant international standards are considered. Finally, the implementation of the recommendation is discussed, and actions are derived.

3.1.6. *Country position and action (licensee, regulator, justification)*

Requirements in the German rules and regulations regarding research reactors

The general regulatory requirements for ageing management are stated in chapter 3.1.2.

The safety standards of the Nuclear Safety Standards Commission (KTA) apply to nuclear power plants, but are principally applied to research reactors too, as stated in the answer to question no. 49 /TPR 18/. However, there are no regulatory requirements for a specific ageing management programme in research reactors, as is the case for nuclear power plants.

Question-ID	Topic	Question, comment	Country Response
DE - 49	02. Overall Ageing Management Programme requirements and implementation	Please elaborate on the appropriate application of KTA1403 to RR. Why has there been no application of KTA1402 and or SSG-10 allthough mentioned in 2.2?	The KTA safety standards are principally also applied by the operators of research reactors (see Figure 2-1 "National regulatory pyramid"). While they are primarily applicable to nuclear power plants, the competent licensing and supervisory authorities require the operators of research reactors to apply the KTA safety standards as appropriate. Accordingly, the research reactors have implemented ageing management according to KTA 1403. Likewise, an "Integrated Management System for the Safe Operation of Nuclear Power Plants"according to KTA 1402 or "Safety Requirements for Nuclear Power Plants" has been implemented in the research reactors, as it is also required by § 7c(2)(1) of the Atomic Energy Act (AtG).

Table 2 Question DE-49 and the response of the German regulator

In the German research reactors FRM II, BER II and FRMZ, ageing management takes place within the framework of maintenance. By corresponding application of KTA 1403, a possible need for modification is identified and the compliance with the state of the art in science and technology is ensured.

All research reactors are obligated to perform a periodic safety review every 10 years since 2010, as the nuclear power plants, according to §19a (3) of the Atomic Energy Act. The research reactors FRM II and BER II were already obligated to perform it by their license.

The periodic safety review in research reactors is performed in principal application of the corresponding regulatory requirements. The ageing analyses of SSCs is part of the deterministic safety status analysis (see answer to question no. 88 /TPR 18/).

Question-ID	Topic	Question, comment	Country Response
DE - 88	02. Overall Ageing Management Programme requirements and implementation	The Aging Management is considered a part of the Periodic Safety Review for the NPP. Are the same requirements for PSR applicable for research reactors??	Since 2010, all research reactors (including homogeneous zero-power reactors) are required by law to carry out a PSR every ten years (according to § 19a(3) of the Atomic Energy Act – AtG). Larger facilities (FRM II and BER II) have already been required before to carry out periodic safety reviews according to specific requirements/ancillary provisions from the licensing procedure. For the German research reactors, periodic safety reviews are carried out in analogous application of the corresponding regulatory guidelines of the Federation and the Länder. Here, the ageing analysis of SSCs is part of the deterministic safety status analysis.

Table 3 Question DE-88 and the response of the German regulator

German practice of ageing management of research reactors

German research reactors ageing management takes place within the framework of maintenance (KTA 3301 and 3501). Ageing is assessed within the ISI programme and regular plant inspections. The results of the inspections provide essential information for plant maintenance in terms of ageing management. The programme of ISIs and of plant walk downs is specified in the licenses of the research reactors.

Here, the assessment criteria are based on nuclear and conventional rules and regulations to be applied mutatis mutandis. Applied criteria for ageing assessment are e.g. change in material properties of components due to neutron irradiation, change in insulation resistance or operational irregularities.

For the assessment of the ageing behaviour, e.g. when determining the permissible operating times, the manufacturer's documentation is also used. Furthermore, operations monitoring and the consideration of operating records serve to identify and assess ageing effects. For instance, the relevant fluence levels for the respective components are recorded within the framework of ISIs for the assessment of ageing processes induced by neutron irradiation. At the FRM II, for example, embrittlement of near-core and far-core main components made of AlMg3 alloy (EN AW-5754) is monitored and assessed by means of a comprehensive irradiation programme with regular experimental analysis of the irradiation specimen. These investigations, in particular of the components near the core, are expanded and supplemented by a detailed simulation and calculation program.

Comprehensive monitoring of ageing processes is ensured by operational monitoring of the required safety-related conditions of components, regular plant inspections as well as comprehensive in-service inspections. Measurements and inspections of the technical components are carried out in accordance with the testing manuals. The inspection records to be completed and the test instructions describe the test methods and the test equipment to be used in detail.

Experience feedback from external sources, such as the GRS information notices, is also taken into account after having been forwarded to the operator. For example, an inspection of the emergency power diesel for ageing effects (here: mounting of the stator and testing of the insulation resistance) was initiated at the FRMZ in the context of GRS information notice WLN 2014/11. Although no findings were made, the test manual was updated, and an ISI interval specified in agreement with the regulatory supervisory authority.

Question-ID	**Topic**	**Question, comment**	**Country Response**
DE - 143	02. Overall Ageing Management Programme requirements and implementation	FRMII, BER II and FMRZ research reactors: Do all the research reactors within the scope of the TPR have an ISI programme specified in their license? What kind of SSC requires an authorized expert to perform an inspection or a test? Are they similar for the three research reactors? Is the need to involve an authorized expert to perform an inspection or a test determined by the regulator? What is the amount of this kind of tests (which involve an authorized expert) compared to the routine inspections?	For the FRM II, for example, three manuals have been developed, reviewed and assessed for in-service inspections (ISI) within the framework of the licensing procedure: the testing manual and the checklist according to KTA 1202 for tests according to nuclear law, the manual for conventional tests (HKP) and the manual for internal tests (HIP). The HKP and HIP have been reviewed by the authorised expert within the framework of the licensing procedure and must be sent to the supervisory authority and the expert for information (licensing provision). Changes to the checklist must be submitted to the supervisory authority and the authorised expert consulted according to § 20 AtG and require approval by the supervisory authority (licensing provision). The authorised experts according to § 20 AtG are involved in the ISIs according to the checklist (testing manual) and conventional experts in the tests according to the HKP. The BER II and FRMZ basically apply the same approach.

Table 4 Question DE-143 and the response of the German regulator

The maintenance programmes of FRM II, BER II and FRMZ are subject to continuous improvement processes and are reviewed by the nuclear supervisory authorities and their authorised experts consulted, see also answer to question no. 143 /TPR 18/.

The results of quality assurance and the operating experience from the operator's plant and from other plants – e.g. from GRS information notices, from participation in expert committees, from participation in international conferences, from regular exchange of experience with other operators – are incorporated into his improvement process. The servicing and maintenance programme is adjusted as needed. If e.g. compared to the past, a higher degree of monitoring of individual components in terms of their ageing is identified, this is taken into account by a revision of the test specification with a possibly shortened test interval.

Plant modifications are carried out within the framework of the modification procedure defined in the BHB (maintenance rules), also taking into account impacts regarding the required ISI.

The ageing management of the operators of the research reactors is considered in the context of the periodic safety review adapted to current requirements and also compared with the requirements of the nuclear rules and regulations (e.g. KTA safety standards).

Consideration of international Standards

The IAEA Specific Safety Requirement SSR-3 “Safety of Research Reactors” /IAE 16c/ contains requirements with reference to ageing management. Requirement 4 stipulates: *“Integrated management system: The operating organization for a research reactor facility shall establish, implement, assess and continuously improve an integrated management system”.* An ageing management programme shall be part of this IMS. According to SSG-10 /IAE 10/, Section 2.1. *“A documented management system that integrates the safety, health, environmental, security, quality and economic objectives of the operating organization of a research reactor is required to be in place […]. The documentation of the management system should describe the system that controls the planning and implementation of all activities at the research reactor throughout its lifetime, including ageing management activities.”*

Requirement 37 relates to the design for ageing management: *“The design life of items important to safety at a research reactor facility shall be determined. Appropriate margins shall be provided in the design to take due account of relevant mechanisms of ageing, such as neutron embrittlement and wear-out, and of the potential for age related degradation, to ensure the capability of items important to safety to perform their necessary safety functions in operational states and accident conditions in case of demand throughout their design life. The life cycles of the technology utilized and the possible obsolescence of the technology shall be considered.”*

Requirement 6.113. explains the content of an ageing management programme: “*An ageing management programme that includes inspection and periodic testing of materials shall be put in place, and the results that are obtained in this programme shall be used in reviewing the adequacy of the design at appropriate intervals”*. As mentioned in the answer to question DE-48 /TPR 18/ is such a programme, which includes inspections, periodic material testing and using test results for reviewing the adequacy of the testing intervals is in place in Germany.

Further specific requirements regarding the implementation of ageing management in research reactor are given in Safety Guide SSG-10 “Ageing Management for Research Reactors” /IAE 10/:

> *“5.1 Ageing management programmes for research reactors should be aimed at identification and implementation of effective and appropriate ageing management actions and practices that provide for timely detection and mitigation of ageing effects in SSCs.*
>
> *5.2 A systematic ageing management programme for the research reactor should be applied, comprising the following elements:*
>
> - *Screening of SSCs for ageing management review;*
> - *Identification and understanding of ageing degradation;*
> - *Minimization of ageing degradation;*
> - *Detection, monitoring and trending of ageing degradation;*
> - *Mitigation of ageing degradation;*
> - *Continuous improvement of the ageing management programme;*
> - *Record keeping.*
>
> *5.3 The ageing management programme should be applied at all stages during the lifetime of the research reactor, including the design stage.”*

Question-ID	Topic	Question, comment	Country Response
DE - 48	02. Overall Ageing Management Programme requirements and implementation	Please explain in sufficient detail how SSG-10 has been implemented in the German system of AM.	In Germany, ageing management for research reactors takes place within the scope of maintenance (in-service inspections, plant inspections) as described in the NAR, following safety standard KTA 1403 "Ageing Management for Nuclear Power Plants" using the aspects of ageing management mentioned therein as a basis to identify a possible need for modification and for ensuring compliance with the state of the art in science and technology. The requirements of safety standard KTA 1403 is basically in line with the recommendations in the IAEA Specific Safety Guide No. SSG-10 "Ageing Management for Research Reactors".

Table 5 Question DE-48 and the response of the German Licensees and Regulator

The Specific Safety Guide "Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors" (SSG-22) explains how the graded approach is to be applied with reference to ageing management /IAE 12/:

> *"7.63. While selection of materials and the effects of the operating environment on their properties should be taken into account in the design of all research reactors, the grading can be applied to development of the ageing management programme, including in-service inspection, throughout the operating lifetime of the facility.*
>
> *7.64. Grading can be applied in determining the appropriate frequency of inspections, in selecting detection methods, as well as in establishing measures for prevention and mitigation of ageing effects, which could be based on the estimated service lives of the SSCs, their complexity and their ease of replacement. In most research reactors, it is feasible to inspect most SSCs periodically and to replace components if necessary. Particularly important material ageing concerns are corrosion in reactor tanks and vessels, where leak detection can be difficult and repair or replacement might not be practicable. Similarly, the management of corrosion of inaccessible primary coolant piping and associated components is of key importance for reactor longevity. An important knowledge management area, which supplements the appropriate selection of materials and the management of ageing related effects, is the need for human resources management to address the ageing of re-search reactor personnel. Other key knowledge management areas are configuration management, document control and programmes for feedback of operating experience.*
>
> *7.65. Grading may also be applicable to the resources necessary to implement the ageing management programme. While a dedicated organizational unit may be needed to implement such a programme for higher power research reactors, the ageing management activities for research reactors having a low power might be performed by the maintenance personnel of the facility*."

Thus far there are no WENRA requirements concerning research reactors. However, currently an ad-hoc working group is preparing Safety Reference Levels (SRL) for research reactors. These are based on the SRL for NPPs, which includes Issue I for ageing management. When these SRL are published by WENRA, they will be taken into account for German research reactors by applying the graded approach. Although the WENRA SRL for research reactors have already been graded in comparison to the NPP SRL, the different designs and large spectrum of thermal power of research reactors still necessitate a graded approach in their application based on the underlying potential hazards.

External reviews by IAEA, such as the „Integrated Safety Assessment for Research Reactors (INSARR)", which comprises ageing of reactors, or the "Safety Aspects of Long Term Operation (SALTO)" missions, which is meanwhile being applied to German research reactors too, are considered as good practice. Thus far no German research reactor has been considered as subject of review in terms of long term operation. BER II will be shut down at the end of 2019. FRM II went into operation in 2004. An external review for FR MZ, a TRIGA reactor with a thermal power rating of 100 kW is currently not planned and not necessary in terms of safety, taking into account the low level of risk associated with it. Furthermore, it needs to be noted, the TRIGA is out of scope of the Topical Peer Review, given its thermal power rating of 100 kW, but the licensee voluntarily participated in the review.

Assessment of the implementation of the recommendation and derived actions

A graded approach to the ageing management requirements of German rules and regulations, as they are stated in chapter 3.1.2, is admissible due to the research reactors low risk potential and varies with the research reactor type. From the point of view of the competent nuclear licensing and supervisory authorities, the entirety of the measures taken by the operators of the FRM II, BER II and FRMZ are appropriate to identify and address ageing-related degradation mechanisms at an early stage. The current operating experience proves the effectiveness of measures taken against ageing-related degradation mechanisms (cf. answer to question 129 /TPR 18/).

Question-ID	Topic	Question, comment	Country Response
DE - 129	02. Overall Ageing Management Programme requirements and implementation	In the description is stated: 'An independent ageing management programme, as implemented in nuclear power plants, does not exist for German research reactors. In the German research reactors FRM II, BER II and FRMZ, ageing management takes place within the framework of maintenance (safety standards KTA 3301 and 3501).' Are there plans in Germany the ageing management programme, as implemented in nuclear power plants, to implement in the research reactors in future?	Currently, there are no plans for the research reactors to implement an ageing management programme as implemented in nuclear power plants. It has been shown that from the point of view of the competent nuclear licensing and supervisory authorities the entirety of the measu-res presented by the operators of the FRM II, BER II and FRMZ are appropriate to identify and address ageing-related degradation mechanisms at an early stage

Table 6 Question DE-129 and the response of the German Regulator

However, ageing management in research reactors is not applied on the same systematic level, as for NPPs. This systematic application of ageing management needs to be improved in accordance with the graded approach. According to KTA 1403 it shall be implemented in a process-oriented manner and integrate organizational and operational processes. The processes involved (e.g. servicing, maintenance), the interrelated activities as well as their interactions shall be identified and controlled. This overall process shall be designed according to the principles of a PDCA cycle (Plan-Do-Check-Act). This approach would cover the requirements concerning ageing management for research reactors as stated in SSG-10.

The research reactor operators are requested to apply ageing management standard KTA 1403 to research reactors in accordance with the graded approach as stated above. When applying the comprehensive and systematic ageing management to research reactors, the low risk of potential hazards needs to be considered. Ageing management shall be considered as part of the Integrated Management System (IMS). When the corresponding measures have been introduced, the requirement for a comprehensive and systematic ageing management programme may be considered as fulfilled. In addition, the WENRA requirements for ageing management of research reactors have to be taken into account once they are approved and published.

Furthermore, research programs concerning ageing-mechanisms of research reactor components have been initiated in order to simultaneously enhance the corresponding knowledge base.

3.2. Reactor pressure vessel

3.2.1. *TPR expected level of performance: Non-destructive examination in the base material of beltline region*

Expected level of performance: "Non-destructive examination in the base material of beltline region: Comprehensive NDE is performed in the base material of the beltline region in order to detect defects."

The defects in Doel-3 are not due to ageing. This view is shared by ENSREG and elaborated in the report:

> *"**Non-destructive examination in the base material of beltline region***
>
> *Recent operating experience feedback has highlighted that some manufacturing defects were not detected in the base material during fabrication or previous inspections. For example, under-clad defects in France in the late 1990s, hydrogen flakes in Belgium in 2012 and non-metallic inclusions in Switzerland in 2015 were highlighted during in-service inspection. These are not ageing related degradation, but the presence of defects has to be taken into account in mechanical analyses and the ageing phenomena of RPV. These defects have been highlighted with the implementation of NDE using the most recent techniques. In early 2014, WENRA recommended a comprehensive review of the manufacturing and inspection records of the forgings of the RPV and an examination of the base material of the vessels if considered necessary. In the summary note on this recommendation, WENRA highlights that most countries considered at that time that comprehensive NDE in the base material of the beltline region is not necessary, based on the manufacturing and inspection records of the forgings of the RPV. However, taking into account the experience from the Swiss case in Beznau where another type of defect was discovered, it is considered during the TPR as an insufficient standard to not perform a comprehensive NDE in the base material of the beltline region at least once in order to detect any defects. It is also highlighted that standard qualified techniques for cracking type defect detection in the welded zones are not necessarily suitable for defect detection in the belt-line regions. The use of qualified techniques and adequate recording limits for NDE are necessary for comprehensive NDE of the base material of the beltline region in order to detect defects."*

3.2.2. *Country position and action (licensee, regulator, justification)*

Assessment of the implementation of the recommendation and derivation of measures

The BMU requested the Reactor Safety Commission (RSK) to discuss the results of the TPR with regard to whether, according to state of the art in science and technology, additional measures for the testing of the base metal of the RPV are necessary in German nuclear power plants. The discussions are ongoing.

Questions and comments to Germany with respect to the test of the base material of the RPV

No questions concerning this topic have been addressed to Germany in the TPR.

4. GENERIC FINDINGS RELATED TO ELECTRICAL CABLES

Concerning the expected levels of performance related to electrical cables the BMU asked the RSK to discuss the results of the TPR with regard to whether additional measures for the ageing management of electrical cables are required in German nuclear power plants according to the state of the art in science and technology.

The RSK has adopted its statement. The BMU endorses the conclusions of the RSK. The assessment of the RSK has been incorporated into the text. The statement of the RSK is expected to be published in October 2019. The document is not yet available in English.

4.1. Good practice: characterize the state of the degradation of cables aged at the plant

In /ENS 18a/ chapter 5.2.2. it is identified as a "good practice" that "cables are aged within the actual power plant environment and tested to assess cable condition and determine residual lifetime". Two different approaches are referenced: the deposition of cable pieces in areas of high stress or the in-situ ageing of inactivated cables.

4.1.1. Country implementation

The National Report /BMU 17/ refers on pages 37-38 to elongation at break (EAB) measurements on cables aged at the plant and the utilisation of cable deposits. Every three years cables are withdrawn from the deposit for EAB- and LOCA tests in order to derive a service life curve. The ageing relevant stressors are temperature and dose rate. According to the licensee's answers to the questions DE-152 and DE-175 in /ENS 18b/ the cable samples in the deposit are representative for German pressurized and boiling water reactors. Environmental conditions are approximately 40°C and 3500 Gy per year.

4.1.2. Country planned action if relevant

The arrangements identified as a good practice are already pursued in German nuclear power plants. From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state), further measures are not necessary.

4.2. TPR expected level of performance: documentation of the cable ageing management program

In /ENS 18a/ chapter 5.2.3. it is identified as a "expected level of performance" that the AMP is sufficiently well-documented to support any internal or external reviews in a fully traceable manner.

The AMP of cables should be documented in a complete way (including identification number, manufacturer documentations, materials, characteristics, degradation mechanisms, diagnostic methods, remedial actions, new international experience for the material, measurement methods and complete / periodical review schedule). All investigations, calculations, type-tests and procedures must be traceable to the installed cables in the plant.

4.2.1. Country implementation

The regulatory requirements for the documentation of the ageing management are set forth in KTA 1403 /KTA 17/.

KTA 1403 3.3 e) demands generically, that „ The measures taken with respect to ageing-management and the respective results shall be documented and assessed. In regular intervals, reports shall be written summarizing these measures and results. Ageing-management shall be continuously optimized based on the performed assessments. Impermissible deviations from the required quality condition shall be eliminated."

Specifically, for electrical and Instrumentation and Control equipment KTA 1403 requires in paragraph 4.2.3 (5) and (6) that "in the case of Technical Facilities of the electrical and instrumentation and control equipment […] an analysis founded on the structured knowledge base […] shall be performed with respect to possible ageing-related effects from relevant damage mechanisms. This analysis shall take the operational and environmental conditions at the assigned locations of these Technical Facilities into account. The analytical proofs […] shall be comprehensibly documented and assessed."

Regarding the reporting system KTA 1403 6 (1) stipulates that a plant specific basis report and yearly status reports shall be drawn up. KTA 1403 6 (2) d) specifies that regarding to the "ageing-management of the Technical Facilities including auxiliary and operating media" the basis report shall comprise information about the "extent of ageing-related observation and classification, [the] potential relevant damage mechanisms, [the] mitigating measures regarding these damage mechanisms and [the] monitoring [of] the effectiveness." Along the same lines KTA 1403 6 (3) specifies that the status report "shall normally contain quantitative and qualitative information gathered within its respective reporting period on ageing-related activities and measures as well as findings and results from in-plant surveillance and from external sources. This includes, e.g., special examinations performed, insights gained from information notices and from modifications of standards."

In addition to the plant-specific basis reports the National Report /BMU 17/ also refers to component-specific documentation (e.g. inspection certificates, design documentation) and the operational documentation which are used for ageing management. For cables in particular, experience from non-safety relevant cables is also used.

4.2.2. Country planned action if relevant

By complying with KTA 1403 the expected level of performance is fulfilled. Basis reports and status reports are part of the knowledge base for ageing management and are reviewed by independent experts during the supervisory procedures of the authorities. From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state), further measures are not necessary.

4.3. TPR expected level of performance: methods for monitoring and directing all AMP-activities

In /ENS 18a/ chapter 5.2.3. it is identified as a "expected level of performance" that "methods to collect NPP cable ageing and performance data are established and used effectively to support the AMP for cables." It is further emphasised that "broadening the sources of information is highly relevant" and the international cooperation of different power plants of the same plant manufacturer is highlighted as positive.

4.3.1. Country implementation

A wide range of testing methods are applied in German nuclear power plants at periodical inspections as part of the ageing management. Further testing methods are employed for special inspections.

Regulatory requirements about the subject can be found in KTA 1403 /KTA 17/. KTA 1403 paragraph 4.2.3 (7) to (9), 4.2.4 (1) and 4.2.4 (2) describe a general approach (not specific for cables):

KTA 1403 4.2.3

(7) If the analysis […]of required operation of a safety-related Technical Facility of the electrical and instrumentation and control equipment leads to the result that an unavailability cannot be precluded, then, corresponding to their safety-related significance and under consideration of the operational and environmental conditions, measures for the mitigation of the relevant damage mechanisms […]shall be specified. […]

(8) When specifying these measures, the knowledge base shall normally be expanded by including experience feedback from the operation and maintenance of plant-internal facilities and from other plants.

(9) The measures for the mitigation of relevant damage mechanisms shall be specified for the type of the equipment, for the type of the equipment system or for the individual level of the component. With regard to ageing-management, the summary treatment of comparable equipment and components is permissible. [...]

KTA 1403 4.2.4

(1) *The effectiveness of the existing and other possibly taken measures for detecting and mitigating relevant damage mechanisms shall be assessed in regular intervals. The length of the intervals shall be chosen to correspond to the expected ageing behaviour.*

(2) *This assessment may be based on comparisons between the specified and the actual conditions or on trend analyses.*

The ageing of cables is systematically monitored in German nuclear power plants and the procedures to enable systematic monitoring are well established. Applying these procedures, it is determined whether the cables furthermore meet their application-specific requirements. In addition, to demonstrate the LOCA resistance of cables the AUREST methodology to determine the qualified service life is used. The AUREST methodology is an analytical approach to calculate the service life depending on material and operating conditions. The cable deposit is used in the context of the verification of the LOCA resistance. In predefined intervals cable samples are withdrawn from the cable deposit for corresponding testing in order to derive a statement about the continued operability of the cable. All in all, a broad spectrum of information sources is available and assessed.

Ageing effects of cables are monitored effectively in German nuclear power plants. The National Report /BMU 17/ describes the testing procedures used in periodical inspections in German plants grouped by cable type. These measurement methods and the implemented tests are verified by independent - experts. Tables 7 to 11 provide an overview of the relevant degradation mechanisms and the testing methods used to detect these. The Tables give a general attribution of cable component to degradation mechanism and testing method used for detection. However not all of these testing methods are in use in all German plants for all cables all the time. Some of these tests are only performed in case of need (e.g. to determine a cause of failure after deviations have been detected during functional testing or repairs). The testing procedures given in the tables are applicable for all cable types unless explicitly restricted by a corresponding label (High- and Medium voltage cables (1), Low voltage cables (2), I&C cables (3) and special cables (4)).

Functional characteristic	Degradation mechanism	Ageing effect	Testing procedure
Mechanical endurance for external mechanical protection	Abrasion, Vibration Hardening, Embrittlement, Cracking, thermally/radiation induced Oxidation, Diffusion	Loss of integrity of the cable sheath	Visual inspection on accessible parts
Flexibility of movable cables	Hardening, Embrittlement, Cracking, thermally/radiation induced Oxidation, Diffusion	Loss of integrity of the cable sheath	Elongation at break testing Haptic testing on accessible parts (2), (3), (4)

Table 7 Cable Ageing – Degradation mechanisms, Ageing effects and testing procedures for monitoring them – Component: Cable sheath

Functional characteristic	Degradation mechanism	Ageing effect	Testing procedure
Mechanical durability for the permanent preservation of the insulation capability	Hardening, Embrittlement, Cracking, thermally/radiation induced Oxidation, Diffusion Moisture, Partial Discharges, Decomposition, Ion Migration	Loss of Insulation of the conductor insulation	Haptic testing on accessible parts (2), (3), (4)
Electrical insulation strength	Hardening, Embrittlement, Cracking, thermally/radiation induced Oxidation, Diffusion Moisture, Partial Discharges, Decomposition, Ion Migration	Loss of Insulation of the conductor insulation	Insulation resistance measurement Partial Discharge measurement (1) Verification of signal transmission behaviour (3), (4) Elongation at break testing Functional testing LOCA testing Calculation of the remaining service life (AUREST) (2), (3), (4)
Specific electrical properties (e.g. characteristic impedance)	Hardening, Embrittlement, Cracking, thermally/radiation induced Oxidation, Diffusion Moisture, Partial Discharges, Decomposition, Ion Migration	Loss of Insulation of the conductor insulation Distortion of signals by increased contact resistance or leakage currents	Line resistance measurement Verification of signal transmission behaviour (3), (4) Functional testing LOCA testing Calculation of the remaining service life (AUREST) (2), (3), (4)
Flexibility of movable cables	Hardening, Embrittlement, Cracking, thermally/radiation induced Oxidation, Diffusion	Loss of Insulation of the conductor insulation	Elongation at break testing Haptic testing on accessible parts (2), (3), (4) Calculation of the remaining service life (AUREST) (2), (3), (4)

Table 8 Cable Ageing – Degradation mechanisms, Ageing effects and testing procedures for monitoring them – Component: Conductor insulation

Functional characteristic	Degradation mechanism	Ageing effect	Testing procedure
Low-resistive conductivity of a sufficient cross-section	Fatigue	Distortion of signals by increased contact resistance or leakage currents Limitation of the current carrying capacity in power cables	Line resistance measurement Verification of signal transmission behaviour (3), (4) Functional testing LOCA testing
Specific electrical properties (e.g. characteristic impedance)	Hardening, Embrittlement, Cracking, thermally/radiation induced Oxidation, Diffusion Moisture, Partial Discharges, Decomposition, Ion Migration Corrosion, Surface Deposits, Soiling	Loss of Insulation of the conductor insulation Distortion of signals by increased contact resistance or leakage currents	Line resistance measurement Verification of signal transmission behaviour (3), (4) Functional testing LOCA testing Calculation of the remaining service life (AUREST) (2), (3), (4)

Table 9 Cable Ageing – Degradation mechanisms, Ageing effects and testing procedures for monitoring them – Component: Conductor / Shielding

Functional characteristic	Degradation mechanism	Ageing effect	Testing procedure
Low-resistive conductivity of a sufficient cross-section	Corrosion, Surface Deposits, Soiling Fatigue	Distortion of signals by increased contact resistance or leakage currents Limitation of the current carrying capacity in power cables Loss of Insulation	Line resistance measurement Verification of signal transmission behaviour (3), (4) Thermography (1), (2) Functional testing LOCA testing
Insulation strength	Corrosion, Surface Deposits, Soiling Fatigue	Distortion of signals by increased contact resistance or leakage currents Loss of Insulation	Insulation resistance measurement Functional testing
Specific electrical properties (e.g. characteristic impedance)	Hardening, Embrittlement, Cracking, thermally/radiation induced Oxidation, Diffusion Moisture, Partial Discharges, Decomposition, Ion Migration Corrosion, Surface Deposits, Soiling	Loss of Insulation of the conductor insulation Distortion of signals by increased contact resistance or leakage currents	Line resistance measurement Verification of signal transmission behaviour (3), (4) Functional testing LOCA testing Calculation of the remaining service life (AUREST) (2), (3), (4)

Table 10 Cable Ageing – Degradation mechanisms, Ageing effects and testing procedures for monitoring them – Component: Connectors, Terminals

Functional characteristic	**Degradation mechanism**	**Ageing effect**	**Testing procedure**
Low-resistive conductivity of a sufficient cross-section	Corrosion, Surface Deposits, Soiling Fatigue	Limitation of the current carrying capacity	Line resistance measurement Thermography (1), (2) Functional testing
Insulation strength	Corrosion, Surface Deposits, Soiling Fatigue	Loss of Insulation	Insulation resistance measurement Partial Discharge measurement (1) Thermography (1), (2) Functional testing

Table 11 Cable Ageing – Degradation mechanisms, Ageing effects and testing procedures for monitoring them – Component: Cable termination

Further testing methods that have been mentioned in /ENS 18a/ but are not used by default in German nuclear power plants within the framework of ageing management are:

- Tan-Delta-Measurements: The results of these tests are covered by insulation resistance and partial discharge measurements.
- Time Domain Reflectometry: This is a method to locate the fault in a defective cable.
- Line Resonance Analysis (LIRA): The results of these tests are covered by elongation at break measurements with respect to insulation.
- Isothermal Relaxation Current measurements: This method is primarily suitable for the detection of Water-Treeing. In German nuclear power plants only VPE-Cables of the 2nd generation are in use. As these are not susceptible to Water-Treeing, this testing method is not considered relevant for German plants (see chapter 4.5.1 and 4.5.2).

4.3.2. Country planned action if relevant

It has to be ensured that ageing processes on cables are detected by the established methods. In accordance with KTA 1403 paragraph 3 (3) d) the development of the state of the art in science and technology in national and international publications regarding ageing-related findings shall be pursued and assessed. Currently no degradation mechanisms relating to cables are known that cannot be tracked by the testing methods which are regularly applied in Germany.

If anomalies are detected during cable inspections, special inspections can and will be performed in order to find the cause. These special inspections may include some of the additional testing methods mentioned above. From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state), further measures are not necessary.

4.4. TPR expected level of performance: Systematic identification of ageing degradation mechanisms considering cable characteristics and stressors

In /ENS 18a/ chapter 5.2.3. it is identified as a “expected level of performance” that “degradation mechanisms and stressors are systematically identified and reviewed to ensure that any missed or newly occurring stressors are revealed before challenging the operability of cables.” It is further noted, despite the generally consistent identification and analysis of the various degradation mechanisms, some degradation mechanisms/stressors or their actual intensity and effects on cables may have been missed when establishing the initial qualification programme (for example water trees for cables qualified in the early 1980s). These need to be addressed in EQ verification and/or cable requalification.

4.4.1. Country implementation

A similar requirement is given in KTA 1403 /KTA 17/. Regarding the identification of relevant degradation mechanisms in technical facilities of the electrical and instrumentation and control (I&C) equipment, paragraphs 4.2.2 (1) and (2) stipulate:

(1) *For all safety-related Technical Facilities of the electrical and instrumentation and control equipment, the relevant damage mechanisms shall be determined that may be detrimental to the required functional features specified under Section 4.2.1 para. 2."*

(2) *When determining the relevancy of the relevant damage mechanisms to be compiled in the Basis Report […] the following data shall be taken into consideration:*

- *the sensitivity of the materials or components of those safety-related Technical Facilities of the electrical and instrumentation and control equipment that are subject to assessment, and*
- *the intensity, frequency and duration of the influential events during specified normal operation and within the respective Technical Facilities of the electrical and instrumentation and control equipment (e.g., self-heating).*

The National Report /BMU 17/ describes which sources of information are taken into account for identifying relevant degradation mechanisms. These sources comprise manufacturer specifications, national and international standards, insights/findings from monitoring, inspections and maintenance, failure reports, outage reports, German Information Notices, reported events from German and international NPPs, national and international research projects, operational experience from manufacturers, suppliers, as well as the exchange of experience among licensees.

4.4.2. Country planned action if relevant

Basis reports have been prepared according to KTA 1403, which contain a systematic analysis regarding the ageing of cables. The potentially occurring degradation mechanisms and the corresponding measures to cope with these degradation mechanisms are stated in these reports. In the status reports, which have to be prepared annually, changes in the state of knowledge regarding ageing of cables are covered among other things. Correspondingly the existing procedures are amended if necessary.

Overall, the requirements for cables set forth by the expected level of performance are covered by the cable deposit(s) (LOCA -resistant cables) and the testing according to requirements (all other cables) in connection with the monitoring of the state of the art in science and technology with regard to ageing effects.

From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state), further measures are not necessary.

4.5. TPR expected level of performance: prevention and detection of water treeing

In /ENS 18a/ chapter 5.2.3. it is identified as a "expected level of performance" that "approaches are used to ensure that water treeing in cables with polymeric insulation is minimised, either by removing stressors contributing to its growth or by detecting degradation by applying appropriate methods and related criteria." It is further emphasised that water trees are one of the major causes of premature ageing and failure of high-voltage polymeric cables without water-impermeable barriers.

4.5.1. Country implementation

The KTA standards, German Information Notices, as well as statements by the RSK do not address water treeing as a specific degradation mechanism.

However, the National Report /BMU 17/ describes influences of water and humidity as stressors, which are taken into account regarding the ageing behavior of cables.

An evaluation of the German database of reportable events in NPPs taking into account reportable events since the year 2000 showed that no cable failures due to water treeing have occurred since then.

For PVC cables the degradation mechanism water treeing is irrelevant. For VPE cables consultations regarding the „diagnosis and trending of PE/VPE cables" have been conducted in 2011 already. In

German NPPs only 2nd generation VPE cables are installed, which have been manufactured after 1985. For these 2nd generation VPE cables the water treeing phenomena is negligible.

4.5.2. Country planned action if relevant

Since only 2nd generation VPE cables are installed in German NPPs, for which the water treeing phenomena is negligible, the expected level of performance is considered irrelevant for German NPPs.

From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state), further measures are not necessary.

4.6. TPR expected level of performance: consideration of uncertainties in the initial EQ

In /ENS 18a/ chapter 5.2.3. it is identified as a “expected level of performance” that “the accuracy of the representation of the stressors used in the initial Environmental Qualification is assessed with regard to the expected stressors during normal operation and Design Basis Accidents.”

Thereby it shall be evaluated to which extent the initial qualification methods are covering the actual conditions that cables will experience during their qualified lifetime. Furthermore, insights gathered from ageing management shall be used to improve the (environmental) qualification process. The following measures are explicitly stated in /ENS 18a/: simultaneous thermal and radiation ageing, application of low thermal acceleration factors and dose rates, use of accurate activation energy values, and feeding oxygen into test chambers during LOCA tests.

4.6.1. Country implementation

Cables need to be considered as parts of components, which are qualified integrally and thus are subject to qualification processes according to different KTA standards.

The National Report /BMU 17/ refers to the utilisation of cable deposits, from which test objects are taken on a regular 3-year-basis for EAB- and LOCA-testing in order to derive service life curves. The relevant ambient conditions for ageing in the cable deposits are temperature and dose rate. The cable deposits are kept at a temperature of approximately 40 °C at a dose rate of approximately 3500 Gy/a (~0,4 Gy/h). The selection of stored cables is representative for German PWRs and BWRs. Cable deposit ageing basically takes place without acceleration and under simultaneous radiation and thermal ageing.

The German licensees are currently qualifying a database called AUREST for the utilisation in nuclear facilities by which the qualified lifetime of components resistant to LOCA accidents may be determined according to the ambient conditions existing at their place of installation. Additionally, calculation methods are used to consider corresponding sources of uncertainty, e.g. dose rate.

4.6.2. Country planned action if relevant

By utilizing the cable deposits, the uncertainties remaining from the initial qualification of LOCA-resistant cables were assessed and reduced. Overall a verification of the LOCA-resistance is performed concurrently with NPP operation in accordance with KTA 3706 /KTA 17a/. Further measures are not necessary. Potential uncertainties of the initial qualification of cables, which are not resistant to LOCA conditions, are compensated by testing them for the specific conditions of use,, by recurrent testing during operation as well as maintenance measures. From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state), further measures are not necessary.

4.7. TPR expected level of performance: determining cables’ performance under highest stressors

In /ENS 18a/ chapter 5.2.3. it is identified as a “expected level of performance” that “cables necessary for accident mitigation are tested to determine their capabilities to fulfil their functions under Design

Extension Conditions and throughout their expected lifetime." Furthermore, the TRP determined that an adequate evaluation of the magnitude of the high stressor environment is essential to ascertain that the cables are able to perform their functions under Design Extension Conditions and that such an evaluation needs to consider the cables that have been subject to stressors in their operating environment, and justifying through tests.

4.7.1. Country implementation

In the following the expected level of performance is interpreted as a requirement with regard to emergency measures (DEC A and B).

In the German rules and standards are no specific requirements for verification of suitability of emergency equipment in the German Rules and Standards. However, specific equipment is required, the functionality of which must be ensured in the event of demand. The verification of LOCA-resistance for cables covers this requirement for DEC A.

A statement by the RSK for the Evaluation of the implementation of RSK recommendations in response to Fukushima /RSK 17/ contains regarding DEC B in chapter B1.12 for the introduction of Severe Accident Management Guidelines and the Accident mitigation manual (Handbuch für mitigative Notfallmaßnahmen, HMN) of German PWRs the following statement by the VGB with regard to instrumentation:

(The document /RSK 17/ is not yet available in English. For all corresponding quotes in the following chapter a provisional English translation has been provided.)

„Concerning the robustness of the instrumentation, the VGB states […], the qualification of the instrumentation according to KTA 3502 guarantees the LOCA-resistance of the measurements. In the VGB´s opinion a systematic analysis showed that the measurements within the containment are reliable up to the point of RPV failure, since the expected pressures, temperatures, radiation levels and humidity are covered by the qualification as LOCA-resistant. The VGB further states, that the qualification of the measurements utilized at least are able to determine the core damage status C (molten core outside RPV, RPV failed) for the expected loads and a subsequent failure of measurements after reaching the core damage status C is taken into account in the accident analyses."

A similar statement is made in chapter C2.12 regarding BWRs

„For each measurement referenced in the Accident mitigation manual the measuring and display range as well as its function for the ambient conditions (e.g. pressure, temperature, humidity, radiation) given in case of core meltdown has been assessed. In those cases, where the reliability of a measurement is not certain, appropriate alternative measurements or simple auxiliary means are given in the Accident mitigation manual to verify the corresponding plant parameters. Information that can be obtained indirectly or by unconventional means from measured values of other measurement points is also used."

Thus, RSK devised the following "advices, which should be considered in the optimization process of the licensees". The first advice quoted is only applicable to PWRs, the second advice is applicable to PWRs and BWRs:

- *"In the opinion of the RSK the availability of the measurements, which indicate parameters that are relevant for the Accident mitigation manual is of particular importance. The extent to which the availability of the measurements referenced in the Accident mitigation manual is given under consideration of the ambient conditions of the different scenarios and core damage states should be assessed in detail for each plant specifically. […]"*
- *The ramifications on the availability of infrastructure for the core damage states, which are covered in the Accident mitigation manual should be systematically analyzed in the sense of a worst-case approach. The impact of unavailability identified therein should be taken into account in the measures outlined by the Accident mitigation manual."*

4.7.2. Country planned action if relevant

The implementing of the RSK recommendation is part of the plant specific assessment of the robustness in the supervisory processes.

From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state), further measures are not necessary.

4.8. TPR expected level of performance: techniques to detect the degradation of inaccessible cables

In /ENS 18a/ chapter 5.2.3. it is identified as a “expected level of performance” that “based on international experience, appropriate techniques are used to detect degradation of inaccessible cables.”

Possible methods stated are: Insulation resistance measurement, Conductor resistance/impedance measurement, Line Resonance Analysis (LIRA), Isothermal Relaxation Current Analysis for all types of cables. Specific measurements for medium voltage cables include Dielectric loss factor measurement (Tan-delta-measurement), Partial discharge measurement and Isothermal Relaxation Current Analysis. For I&C cables Signal transmission behaviour assessment (e.g. Time Domain Reflectometry) is an additional method stated.

4.8.1. Country implementation

In the German rules and standards are no specific requirements regarding the examination of inaccessible cables. In general, the requirements for assessment of ageing phenomena of cables, as stated in chapters 4.3 still apply. The methods and measurement values used to determine the state of cables are given in Tables 7 to 11in Chapter 4.3.1.

4.8.2. Country planned action if relevant

For cables which are difficult to access or inaccessible, the detection of the relevant ageing effects is ensured by the tests listed in Tables 7 to 11. The test methods additionally mentioned by ENSREG to Table 1-5 have already been dealt with by the previous ELPs, especially the ELP described in chapter 4.3. ..

From the point of view of the nuclear licensing and supervisory regulatory bodies (federal and state), further measures are not necessary.

5. ALL OTHER GENERIC FINDINGS

5.1. Overall Ageing Management Programmes (OAMPs)

5.1.1. *Good practice: External peer review services*

External peer review services (e.g. SALTO, OSART-LTO, INSARR-Ageing) are used to provide independent advice and assessment of licensees' ageing management programmes.

5.1.1.1. Allocation by the TPR

Not allocated for Germany.

5.1.1.2. Country position

From the point of view of Germany, this good practice does not concern Germany. The mentioned peer review missions are focused on LTO. LTO is not an issue for German NPP due to the phase out decision. Moreover, LTO is out of scope of the TPR.

5.1.2. *TPR expected level of performance: Data collection, record keeping and international cooperation*

Participation in international R&D projects, experience exchange within groups of common reactor design and the use of existing international databases are used to improve the effectiveness of the NPPs OAMP.

5.1.2.1. Allocation by the TPR

For Germany, a good performance is allocated by the TPR for this expected level of performance.

5.1.2.2. Country position and action

This topic is described in chapter 3 of the German National Report. As an example, representatives of German institutions (operators, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)) have actively been participating in the IAEA Extra Budget Programme on International Generic Ageing Lessons Learned (IGALL) from the very beginning to contribute their experience in ageing management of German nuclear power plants and to be able to follow relevant new findings and developments in ageing management in nuclear power plants abroad.

Furthermore, the information of international research projects is, amongst others, used to build up the knowledge base of ageing management.

5.1.3. *TPR expected level of performance: Methodology for scoping the SSCs subject to ageing management*

The scope of the OAMP for NPPs is reviewed and, if necessary, updated, in line with the new IAEA Safety Standard after its publication.

See chapter 3.1.1. and 3.1.2

5.1.4. *TPR expected level of performance: Delayed NPP projects and extended shutdown*

During long construction periods or extended shutdown of NPPs, relevant ageing mechanisms are identified and appropriate measures are implemented to control any incipient ageing or other effects.

See chapter 3.1.3 and 3.1.4

5.1.5. ***TPR expected level of performance: Overall Ageing Management Programmes of research reactors***

A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, the applicable national requirements, international safety standards and best practices.

See chapter 3.1.5 and 3.1.6

5.2. Concealed pipework

5.2.1. ***Good practice: use of results from regular monitoring of the condition of civil structures***

In addition to providing information on soil and building settlement, the results from regular monitoring of the condition of civil structures are used as input to the ageing management programme for concealed pipework.

5.2.1.1. Allocation by the TPR

This good practice is allocated by the TPR for Germany.

5.2.1.2. Country position

Pipework penetrations of the safety relevant cooling pipework are designed with a high flexibility in order to allow soil and building settlement within a certain range. Within the ageing management of the civil structures it is checked that the settlements do not exceed the allowed range. In line with KTA 1403 relevant information from the monitoring of civil structures serves as an input for the AMP of other relevant SSCs including pipework.

5.2.2. ***Good practice: performance checks for new or novel materials***

In order to establish the integrity of new or novel materials, sections of pipework are removed after a period of operation and inspected to confirm the properties are as expected.

5.2.2.1. Allocation by the TPR

According to the TPR, Germany is not concerned by this expected level of performance.

5.2.3. ***TPR expected level of performance: inspection of safety-related pipework penetrations***

Inspection of safety-related pipework penetrations through concrete structures are part of ageing management programmes, unless it can be demonstrated that there is no active degradation mechanism.

5.2.3.1. Allocation by the TPR

For Germany, a good performance is allocated by the TPR for this expected level of performance.

5.2.3.2. Country position and action

In Germany safety-related pipework penetrations through concrete structures are included in the AMP. The German philosophy for concealed pipework is described in chapter 4 of the German National Report.

Ageing management includes mainly proactive ageing management through design. Therefore:

- In principle, systems with safety-relevant functions are either directly accessible or installed in covered trenches, usually made of concrete. This pipework in trenches is generally accessible from the outside and passable. The exception of concealed pipework that is most important according to their safety-related significance belongs to the secured service water system required for the removal of residual heat after an accident. This pipework is partially buried in soil. This pipework is mostly made of steel pipes, in a few cases also from prestressed concrete.

- Due to operating experience in conventional concealed pipework systems and research results in degrading environments appropriate material, lining, coating, pipe-in-pipe design for the concealed pipes has to be chosen to mainly avoid aging issues,
- Systems with concealed pipes are typically designed due to environmental conditions (e.g. pressure, temperature) and equipped with leakage monitoring so that local leakage or degradation has no impact on protective goals.

5.2.4. *TPR expected level of performance: scope of concealed pipework included in AMPs*

The scope of concealed pipework included in ageing management includes those performing safety functions, and also non-safety-related pipework whose failure may impact SSCs performing safety functions.

5.2.4.1. Allocation by the TPR

According to the TPR, Germany is not concerned by this expected level of performance.

5.2.5. *TPR expected level of performance: opportunistic inspections*

Opportunistic inspection of concealed pipework is undertaken whenever the pipework becomes accessible for other purposes.

5.2.5.1. Allocation by the TPR

For Germany, a good performance is allocated by the TPR for this expected level of performance.

5.2.5.2. Country position and action

The German philosophy for concealed pipework is described in chapter 4 of the NAR.

It is already practice in German NPP that opportunistic inspections of concealed pipework are performed when uncovered for any reason on a case-by-case basis. This was mentioned during the workshop.

5.3. Reactor pressure vessel

5.3.1. *Good practice: Hydrogen water chemistry*

Hydrogen Water Chemistry (HWC) is used in BWRs which may be sensitive to Intergranular Stress Corrosion Cracking

5.3.1.1. Allocation by the TPR

According to the TPR, Germany is not concerned by this expected level of performance.

5.3.2. *Good practice: Implementation of a shield*

Shielding in the core of PWRs with relatively high fluence is implemented to preventively reduce neutron flux on the RPV wall.

5.3.2.1. Allocation by the TPR

This good practice is allocated by the TPR for Germany.

5.3.2.2. Country position

In German NPP the RPV is shielded by a large water gap by design. Due to the large water gap between the core and the RPV wall, the neutron fluence of the German RPVs is extremely low (EOL fluence of the PWR is in the range of 2.5 – 3 •E18 n/cm² (E > 1MeV)). Therefore, there is no need for additional shielding. Reducing the neutron flux by design of the RPV is considered as good practice.

5.3.3. *TPR expected level of performance: Volumetric inspection for nickel base alloy penetration*

Periodic volumetric inspection is performed for nickel base alloy penetrations which are susceptible to Primary Water Stress Corrosion Cracking for PWRs to detect cracking at as early a stage as possible.

5.3.3.1. Allocation by the TPR

According to the TPR, Germany is not concerned by this expected level of performance.

5.3.4. *TPR expected level of performance: Non-destructive examination in the base material of beltline region*

Comprehensive NDE is performed in the base material of the beltline region in order to detect defects

See chapter 3.2.1. and 3.2.2

5.3.5. *TPR expected level of performance: Environmental effect of the coolant*

Fatigue analyses have to take into account the environmental effect of the coolant.

5.3.5.1. Allocation by the TPR

For Germany, a good performance is allocated by the TPR for this expected level of performance.

5.3.5.2. Country position and action

Based on the analyses of dominant transients in German plants, the maximum environmental factor for fatigue is about 2.5. Therefore, the effect of the coolant is considered in German plants for the whole reactor coolant pressure boundary at all locations with a cumulative usage factor (CUF) ≥ 0.4 (=1/2.5) in accordance with KTA 3201.2. I.e. CUF = 0.4 can be considered as a screening criterion. So environmental fatigue for all primary components is already covered in the German AMP. All the parts of the RPV in contact with the coolant have a CUF lower than 0.4, so there is no need for additional measures.

5.3.6. *TPR expected level of performance: Suitable and sufficient irradiation specimens*

For new reactors, suitable and sufficient irradiation specimens and archive materials are provided to support the reactor through its full operational life.

5.3.6.1. Allocation by the TPR

According to the TPR, Germany is not concerned by this expected level of performance.

5.4. Concrete containment structure and pre-stressed concrete pressure vessel

5.4.1. *Good practice: monitoring of concrete structures*

Complementary instrumentation is used to better predict the mechanical behaviour of the containment and to compensate for loss of sensors throughout the life of the plant.

5.4.1.1. Allocation by the TPR

Not allocated for Germany.

5.4.1.2. Country position

Ageing monitoring of the concrete structures of pressurised and boiling water reactors relies essentially on the visual checks for cracking. Based on the recorded characteristics, an assessment by the expert personnel doing the walk-downs is already carried out on-site as part of ageing management. The regular inspections of the relevant concrete structure surfaces showed no signs of damage-relevant cracking.

In 2002, one-off additional strain measurements were carried out on the prestressed concrete containment of a BWR (see NAR chapter 7).

5.4.2. ***Good practice: assessment of inaccessible and/or limited access structures***

A proactive and comprehensive methodology is implemented to inspect, monitor and assess inaccessible structures or structures with limited access

5.4.2.1. Allocation by the TPR

Not allocated for Germany.

5.4.2.2. Country position

Information related to limited access structures is given in NAR Chapter 7.1.2.a "In accordance with KTA 1403, the structure condition report, which must be produced every ten years, proves that all safety-relevant structures, partial structures, systems and structural component parts have been assessed with regard to their ageing condition." Inaccessible and limited access structures are part of this assessment.

As there are the same ageing phenomena in structures with limited access, conclusions are drawn regarding these structures based on observations of inspected structures.

5.4.3. ***TPR expected level of performance: monitoring of pre-stressing forces***

Pre-stressing forces are monitored on a periodic basis to ensure the containment fulfils its safety function.

5.4.3.1. Allocation by the TPR

According to the TPR, Germany is not concerned by this expected level of performance.

6. TABLE: SUMMARY OF THE PLANNED ACTIONS

Installation	Thematics	Finding	Planned action	Deadline	Regulator's Approach to Monitoring
NPP (all)	OAMP	During long construction periods or extended shutdown of NPPs, relevant ageing mechanisms are identified and appropriate measures are implemented to control any incipient ageing or other effects.	The nuclear licensing and supervisory regulatory bodies (federal and state) will assess the need of concretizing German nuclear rules and regulations in respect of extended shutdowns.	2020	
RR (all)	OAMP	A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, the applicable national requirements, international safety standards and best practices"	The systematic application of ageing management needs to be improved in accordance with the graded approach.	2021	During supervisory process

Table 12 Planned actions

7. References

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