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ENSREG 1st TOPICAL PEER REVIEW

SWISS NATIONAL ACTION PLAN

AGEING MANAGEMENT IN NUCLEAR POWER PLANTS

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Swiss National Action Plan on Ageing Management

(Ageing management in nuclear power plants)

September 2019

Contents

1 Introduction

According to the ENSREG Terms of Reference /1/ and the WENRA Technical Specification /2/ of the first Topical Peer Review (TPR), the peer review focused on the Ageing Management Programmes (AMPs) at Nuclear Power Plants (NPPs) and Research Reactors (RRs) above 1 MWth. In addition to reviewing the Overall Ageing Management Programmes (OAMPs), the peer review process examined the application of the AMPs to the selected systems, structures and components (SSCs) in four thematic areas, namely; concealed pipework, reactor pressure vessel, or equivalent structures, concrete containment structures and electrical cables.

The objective of the first TPR was to examine how well AMPs in participating countries meet international requirements on ageing management. Moreover, the objectives of the TPR were to:

- Enable participating countries to review their provisions for ageing management, to identify good practices and to identify areas for improvement.
- Undertake a European peer review to share operating experience and identify common issues faced by Member States.
- Provide an open and transparent framework for participating countries to develop appropriate follow-up measures to address areas for improvement.

In the first phase of the review process national self-assessments were conducted against the WENRA Technical Specification /2/. Results of the self-assessments were documented in the National Assessment Reports (NARs), published at the end of 2017. In the Swiss NAR /3/ three findings resulting from the self-assessment were documented.

The second phase started in January 2018 when the NARs were made available for questions and comments from stakeholders. Subsequently, in May 2018, ENSREG organized a one-week workshop to discuss the results of the self-assessments, the questions and comments on the NARs, as well as the replies to the questions, with a goal to identify and discuss both generic and country-specific findings on AMPs.

In the third and final phase of the TPR, a Topical Peer Review Report /4/ has been compiled. The results of the peer review on ageing management are summarised addressing the generic findings of the review process. The main findings are presented in terms of good practices, expected levels of performance and challenges. In addition, these findings were allocated to the participating countries and the resulting country specific findings were documented in a separate report /5/. The TPR expected levels of performance are considered as a good performance for those countries which meat the level and as an area for improvement for the others.

In accordance with the ENSREG decision of the 25 March 2019, countries that participated in the first TPR process should establish National Action Plans (NAcPs) for NPPs and RRs to address the results of the Peer review. In particular, the following issues should be addressed in the NAcPs:

- Country position for each finding from the self-assessment as expressed in the NARs
- Country position for the specific findings resulting from the TPR process related to the OAMPs and the thematic areas except electrical cables

- Country position for each generic finding resulting from the TPR process related to electrical cables
- Country position for all other generic findings resulting from the TPR process related to the OAMPs and the thematic areas except electrical cables

In order to facilitate the follow-up process the planned actions to further improve the ageing management of both NPPs and RRs should be compiled in a summary table. The NAcPs should be delivered by the end of September 2019 as part of the follow-up process.

The four issues mentioned above are addressed in Sections 2 to 5 of the present Swiss NAcP report. According to the ENSREG decision of the 25 March 2019 the national positions in Sections 3 to 5 are focused on main findings of the peer review presented in terms of good practices and expected levels of performance. The challenges identified by the peer review are not addressed because these are Europe-wide. Section 7 of the present NAcP report contains a summary table of the national actions derived from the peer review process.

In line with the requirements of the WENRA Technical Specification and the statements in section 1.1 of the Swiss NAR the presentation of the NAcP is restricted to the AMPs of the Swiss NPPs.

According to the ENSREG decision of the 25 March 2019 participating countries are asked to add Section 6 of the NAcP report on AMPs for other significant nuclear installations on a voluntary basis during 2020. The Swiss Federal Nuclear Safety Inspectorate (ENSI) will take the opportunity to add this Section until the end of 2020 with focus on the OAMPs implemented in the intermediate storage facilities for radioactive waste operated in Switzerland.

2 Findings resulting from the Self-Assessment

The focus of this chapter is on the actions derived from the findings resulting from the self-assessment of the existing AMPs in the Swiss NPPs as documented in the Swiss NAR /3/.

2.1 Overall Ageing Management Programmes (OAMPs)

2.1.1 Finding No. 1

According to Section 2.6 of the Swiss NAR /3/ the licensees of Swiss nuclear power plants are obliged to notify ENSI periodically about modifications and extensions of the existing OAMPs which are derived from evaluations of plant-specific and external operating experience as well as analysis of the state-of-the-art of science and technology. Thus, based on the 2012 revision of guideline ENSI-B02 /7/, each licensee must present the state of the ageing management in the civil, electrical and mechanical engineering fields, as well as the condition of fatigue-relevant components as part of the annual safety report. Whenever the documents on ageing management, including the field-specific guides, plant-specific fact sheets, ageing dossiers and structural inspection programmes, are changed, these also must be submitted to ENSI. ENSI reviews this information, approves the field-specific guides for further use and informs the licensees within the framework of the annual meeting between ENSI and the GSKL coordination team of the review results in respect of the other documents.

Irrespective of the preceding assessment, ENSI has identified the following area for improvement within the scope of the Topical Peer Review.

Further harmonisation of reporting on the state of the OAMPs among the Swiss nuclear power plants is necessary. This especially concerns the overview of the updated fact sheets, the evaluation of the international operating experience and the assessment of the effectiveness of the AMP based on trends from maintenance findings.

2.1.2 Country position and action on finding No. 1

From ENSI's point of view, the annual reporting clearly shows that the OAMPs in the Swiss nuclear power plants are continuously updated and has proven its worth. However, ENSI reviews revealed that further harmonisation of reporting among the Swiss NPPs is necessary.

Therefore, guideline ENSI-B02 shall be revised until the end of 2020. The required content of the annual reporting shall be defined more precisely in order to get more consistent information from the Swiss NPPs concerning the updated fact sheets, the evaluation of the international operating experience and the assessment of the effectiveness of the OAMPs especially (Action 1).

Subsequently, the 2021 annual safety reports have to be adapted by the Swiss NPPs according to the revised guideline ENSI-B02.

2.2 Electrical cables

No area for improvement has been identified within the self-assessment process.

2.3 Concealed pipework

2.3.1 Finding No. 2

According to Section 4.1 of the Swiss NAR /3/ the licensees of the Swiss NPPs have investigated safety-classified systems that are part of the AMP according to of the regulatory guideline on ageing management for NPPs (ENSI-B01 /6/) for the presence of concealed pipe sections.

Irrespective of the preceding assessment, ENSI has identified the following area for improvement within the scope of the Topical Peer Review.

ENSI will extend the focus of its regulatory efforts regarding ageing management in order to make sure that all safety-relevant concealed piping systems are included and are covered by suitable maintenance and inspection programmes.

2.3.2 Country position and action on finding No. 2

As an immediate action ENSI conducted focused inspections on site in all Swiss NPPs from November 2018 until January 2019 in order to gain detailed information on the AMPs for concealed pipework.

During these inspections, the licensees demonstrated their processes for identifying concealed areas for the individual systems and presented details on internal operating experience regarding ageing management, maintenance and inspection efforts and results, as well as evaluation of external operating experience. In addition, each of the licensees addressed the options for future measures for maintenance and in-service inspections, including evaluation of new inspection methods. The inspections also included an on-site review of the systems with areas of concealed pipework.

ENSI concluded that the implemented programmes for maintenance and inspection of concealed pipe sections reflect the current state of technology. ENSI will assign special attention to new developments of methods which support the supervision and assessment of concealed pipework. Consequently, at this point, no further action is needed.

2.4 Reactor pressure vessel

No area for improvement has been identified within the self-assessment process.

2.5 Concrete containment structure

2.5.1 Finding No. 3

In Section 7.3 of the Swiss NAR /3/ ENSI pointed out that the GSKL civil engineering guide /12/ was extended with respect to the monitoring of inaccessible or difficult to access structural components, as for example the outer surfaces of earth-covered components, groundwater seals or concrete-encased tendons. Based on five application examples, the guide illustrates, how condition information can be collected for inaccessible components using indirect investigation methods.

Irrespective of the preceding assessment, ENSI has identified the following area for improvement within the scope of the Topical Peer Review.

ENSI has required the monitoring of inaccessible or difficult to access structural components. However, to date such methods have hardly been used. Therefore, there is still no reliable experience for the condition assessment of inaccessible civil engineering structures. ENSI has pointed out this monitoring gap to the licensees on a number of occasions, and in its future inspections ENSI will increasingly demand corresponding tests.

2.5.2 Country position and action on finding No. 3

As an immediate action ENSI has arranged focused inspections related to inaccessible or difficult to access structures on site in all Swiss NPPs. These inspections were carried out from November 2018 until January 2019 with special focus on:

- Status of implementation of the AMP for inaccessible structural components;
- Operator's procedure concerning the selection and inspection of accessible structural components that are representative for inaccessible structural components;
- Condition of the accessible structural components that are representative for inaccessible structural components.

During the focused inspections the operators were able to demonstrate that the AMP for inaccessible structural components was correctly implemented, in accordance with the requirements of the GSKL Guide for civil engineering fact sheets /12/. Based on the on-side review ENSI came to the conclusion that

- operator's inspections of inaccessible structural components are carried out on time according to inspection planning,
- construction work is consistently used to inspect normally inaccessible structural components (opportunistic inspections),
- accessible structural components are in good condition and are representative for the inaccessible structural components.

The continuous updating of the aging management data base is specified as a key task in order to ensure structural integrity. ENSI will assign special attention to new developments of methods which support the supervision and assessment of inaccessible structures or structural elements. Consequently, at this point, no further action is needed.

3 Country specific findings resulting from the TPR

The focus of this chapter is on the actions that have been derived from the areas for improvement allocated to Switzerland as a result of the TPR workshop /5/. The country specific areas for improvement rest on the expected level of performance defined in the TPR-Report /4/.

3.1 Overall Ageing Management Programmes (OAMPs)

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

According to the TPR-Report /4/ this level of performance is defined as follows:

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

3.1.2 Country position and action

In Section 2.1 of the Swiss NAR /3/ it was shown that at the time of development of the regulatory guideline on ageing management for NPPs (ENSI-B01 /6/), the latest requirements from the IAEA Safety Guide NS-G-2.12 /8/ were incorporated in the OAMPs. In the meantime, the IAEA Safety Guide NS-G-2.12 has been replaced by the new IAEA Safety Guide SSG-48 /9/. Since guideline ENSI-B01 specifically refers to recommendations in the IAEA Safety Guide NS-G-2.12, guideline ENSI-B01 must be adapted. Furthermore, the guideline has to be checked if the approach of scoping SSCs is in line with the new IAEA Safety Guide.

Guideline ENSI-B01shall be revised until the end of 2021. Subsequently, the scope of the OAMPs have to be adapted by the Swiss NPPs, if necessary, in accordance with the revised guideline ENSI-B01 (Action 2).

A first evaluation by ENSI showed that new or expanded topics in the IAEA Safety Guide SSG-48, such as the interface between ageing management, other plant programmes, and the periodic safety review or the role of ageing management in long-term operation, are to a large extent already covered by the guidelines in Switzerland.

3.2 Concealed pipework

3.2.1 TPR expected level of performance: Scope of concealed pipework included in the AMPs

According to the TPR-Report /4/ this level of performance is defined as follows:

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.

3.2.2 Country position and action

From November 2018 until January 2019, ENSI conducted focused inspections on site in all Swiss NPPs in order to gain detailed information on the AMPs for concealed pipework.

During these inspections, the licensees demonstrated their processes for identifying concealed areas for the individual systems and presented details on internal operating experience regarding ageing management, maintenance and inspection efforts and results, as well as evaluation of external operating experience. In addition, each of the licensees addressed the options for future measures for maintenance and in-service inspections, including evaluation of new inspection methods. The inspections also included an on-site review of the systems with areas of concealed pipework.

As a follow-up measure, ENSI will explicitly address requirements for concealed pipework in the next revision of its regulatory guideline on ageing management for NPPs (ENSI-B01 /6/). The requirements for the content of fact sheets will be updated to include a statement on safety-relevant concealed pipework sections for each system. Guideline ENSI-B01 shall be revised until the end of 2021 (Action 3).

Subsequently, the GSKL guide for the development of fact sheets for ageing management of mechanical engineering components /11/ and the content of the fact sheets for mechanical systems have to be extended by the Swiss NPPs in accordance with the revised guideline ENSI-B01.

3.2.3 TPR expected level of performance: Opportunistic inspections

According to the TPR-Report /4/ this level of performance is defined as follows:

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

3.2.4 Country position and action

From November 2018 until January 2019, ENSI conducted focused inspections on site in all Swiss NPPs in order to gain detailed information on the AMPs for concealed pipework.

During these inspections, the licensees demonstrated their processes for identifying concealed areas for the individual systems and presented details on internal operating experience regarding ageing management, maintenance and inspection efforts and results, as well as evaluation of external operating experience. In addition, each of the licensees addressed the options for future measures for maintenance and in-service inspections, including evaluation of new inspection methods. The inspections also included an on-site review of the systems with areas of concealed pipework.

From the results of its focused inspections, ENSI concluded that all Swiss NPPs have implemented appropriate opportunistic inspections of concealed pipework as part of the maintenance programme. The planning of these measures reflects the current state of technology. In ENSI’s view, the Swiss NPPs have implemented adequate opportunistic inspection programmes for concealed pipework and, consequently, at this point, no further action is needed.

3.3 Reactor pressure vessel

No area for improvement has been allocated to Switzerland as a result of the TPR workshop.

3.4 Concrete containment structure

No Area for improvement has been allocated to Switzerland as a result of the TPR workshop.

4 Generic findings related to electrical cables

The focus of this chapter is on the findings from the self-assessment of the existing AMP for electrical cables in the Swiss NPPs taking into account the good practices and expected levels of performance defined in the TPR-Report /4/. As long as an area for improvement has been detected an action has been defined in accordance with the TPR-workshop procedure.

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

According to the TPR-Report /4/ this good practice is defined as follows:

Cables are aged within the actual power plant environment and tested to assess cable condition and determine residual lifetime.

4.1.1 Country implementation

The current state of the AMP concerning the characterization of the degradation of cables at the Swiss NPPs is documented in Section 3.1.3 of the Swiss NAR /3/.

A wide spectrum of recognised and effective diagnostic methods is used in the Swiss NPPs plants to identify the relevant ageing mechanisms. In particular, all Swiss NPPs evaluate experience from accelerated ageing tests, which enable a proactive assessment of cable ageing under extreme ambient conditions. Beyond that, targeted, condition-orientated assessment of the insulation resistance of selected cable types is performed using the advanced measuring methods of Line Resonance Analysis (LIRA) and Time Domain Reflectometry (TDR).

In addition to ageing management, a policy of replacing cables during the numerous backfittings is consistently followed in the Swiss NPPs.

From ENSI`s point of view a good practice could be allocated to Switzerland.

4.1.2 Country planned action if relevant

From ENSI`s point of view no further action is needed.

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

According to the TPR-Report /4/ this level of performance is defined as follows:

The AMP is sufficiently well-documented to support any internal or external reviews in a fully traceable manner.

4.2.1 Country implementation

The documentation of the ageing AMPs for electrical components (including cables) at the Swiss NPPs is described in Sections 3.2 and 3.3 of the Swiss NAR /3/.

The GSKL team of electrical engineering ageing management experts inspects, evaluates and documents the completeness and assessment of known ageing mechanisms, taking into consideration the state-of-the-art of science and technology and the world-wide experience in NPPs. Necessary adjustments and developments are permanently implemented. In order to ensure the state-of-the-art of science and technology in the plant-specific fact sheets including in the years after fact sheet creation, the generic fact sheets Part 1 and Part 2 ("Basis Documentation") are continually checked by the GSKL AMP electrical engineering team at least every ten years and updated as necessary.

The Swiss NPPs have systematic ageing management processes and programmes for safety-relevant cables that will ensure the functionality of the electrical cables under long-term normal operating conditions and accident conditions. The Swiss approach follows the IAEA Technical Documents 1188 and 1402. The AMP documentation will be yearly where necessary updated. ENSI gets this documentation, proofs it and gives a statement back to the NPPs.

From ENSI`s point of view a good performance could be allocated to Switzerland.

4.2.2 Country planned action if relevant

From ENSI`s point of view no further action is needed.

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

According to the TPR-Report /4/ this level of performance is defined as follows:

Methods to collect NPP cable ageing and performance data are established and used effectively to support the AMP for cables.

4.3.1 Country implementation

The applied methods used to collect relevant data for cable ageing at the Swiss NPPs are documented in Sections 3.2 and 3.3 of the Swiss NAR /3/.

New findings from internal and external operating experience are presented and discussed within the framework of the GSKL working group "Electrical Engineering Ageing Management" and if necessary followed up and integrated in the AMP. In the context of checking and updating of fact sheets and ageing dossiers, the existing sources/references are scrutinized and current information identified which could be used to update the fact sheets.

The GSKL team of electrical engineering ageing management experts inspects, evaluates and documents the completeness and assessment of known ageing mechanisms, taking into consideration the state-of-the-art of science and technology and the world-wide experience in NPPs. Necessary adjustments and developments are permanently implemented. In order to ensure the state-of-the-art of science and technology in the plant-specific fact sheets including in the years after fact sheet creation, the generic fact sheets Part 1 and Part 2 ("Basis Documentation") are continually checked by the GSKL AMP electrical engineering team at least every ten years and updated as necessary.

From ENSI`s point of view a good performance could be allocated to Switzerland.

4.3.2 Country planned action if relevant

From ENSI`s point of view no further action is needed.

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

According to the TPR-Report /4/ this level of performance is defined as follows:

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.

4.4.1 Country implementation

The current identification and review of degradation mechanisms and stressors for cables at the Swiss NPPs are documented in Section 3.1.1 of the Swiss NAR /3/. In the Swiss NPPs, generic Part 1 and Part 2 fact sheets have been created for the ageing management of electrical cables that serve as a basis for the plant-specific Part 3 fact sheets.

Fact sheet Part 1 contains all potential ageing mechanisms in respect of the relevant cable types obtained from the monitoring of the technical literature, while fact sheet Part 2 contains possible diagnostics methods, with which the potential ageing mechanisms can be detected. Plant-specific fact sheet Part 3 describes the applicable diagnostics methods that are used in the plant-specific maintenance programme and in the procedures for the periodic testing of cables. This closes the circle from ageing management to maintenance. The fact sheets are revised every 5 to 10 years (at the latest). New findings from science and technology, from internal and external operating experience are thus regularly incorporated in the AMP and the maintenance programme. If plant changes affect fact sheet Part 3, then the fact sheets are adapted.

From ENSI`s point of view a good performance could be allocated to Switzerland.

4.4.2 Country planned action if relevant

From ENSI`s point of view no further action is needed.

4.5 TPR expected level of performance: Prevention and detection of water treeing

According to the TPR-Report /4/ this level of performance is defined as follows:

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.

4.5.1 Country implementation

The current approach of supervising water treeing in medium-voltage cables with polymeric insulation at the Swiss NPPs is documented in the plant-specific fact sheet Part 3 according to IAEA TEDOC 1402. As illustrated in the licensee reports published with the national assessment report at the end of 2017 appropriate diagnostic methods for detecting water treeing like Tan delta and IRC-Analysis are applied in the Swiss NPPs.

In general, a wide spectrum of recognised and effective diagnostic methods is used in the Swiss NPPs to identify the relevant ageing mechanisms. In addition to ageing management, a policy of replacing cables during the numerous backfittings is consistently followed in the Swiss NPPs. Existing experience shows that with the AMP implemented in the Swiss NPPs, the occurrence of ageing effects in electrical cables would be promptly detected and preventive measures implemented in a timely manner.

From ENSI`s point of view a good performance could be allocated to Switzerland.

4.5.2 Country planned action if relevant

From ENSI`s point of view no further action is needed.

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

According to the TPR-Report /4/ this level of performance is defined as follows:

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.

4.6.1 Country implementation

According to Section 2.3.2 of the Swiss NAR /3/ the accuracy of the environmental qualification including LOCA resistance (testprofile) is assessed at least every 10 years by a review of the fact sheets and at every cable replacement measure. Part 1 fact sheets contain a list of the most important ageing mechanisms affecting function and qualification. Part 2 fact sheets contains possible diagnostics and testing methods, as well as characteristics by which the ageing progress can be identified.

From ENSI`s point of view a good performance could be allocated to Switzerland.

4.6.2 Country planned action if relevant

From ENSI`s point of view no further action is needed.

4.7 TPR expected level of performance: Determining cables' performance under highest stressors

According to the TPR-Report /4/ this level of performance is defined as follows:

Cables necessary for accident mitigation are tested to determine their capabilities to fulfil their functions under Design Extension Conditions and throughout their expected lifetime.

4.7.1 Country implementation

At the Swiss NPPs cables necessary for accident mitigation (e.g. in case of a total station blackout scenario) are tested periodically during emergency exercises to demonstrate that their functions are fulfilled. The cables are stored together with the alternate emergency diesels in containers or boxes on side which are protected against flooding and harsh environmental conditions.

From ENSI`s point of view a good performance could be allocated to Switzerland.

4.7.2 Country planned action if relevant

From ENSI`s point of view no further action is needed.

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

According to the TPR-Report /4/ this level of performance is defined as follows:

Based on international experience, appropriate techniques are used to detect degradation of inaccessible cables.

4.8.1 Country implementation

According to Section 3.3 of the Swiss NAR /3/ a wide spectrum of recognised and effective diagnostic methods is used in the Swiss NPPs to identify the relevant ageing mechanisms. In particular, ENSI emphasises that all Swiss nuclear power plants evaluate experience from accelerated ageing tests, which enable a proactive assessment of cable ageing under extreme ambient conditions. Beyond that, targeted, condition-oriented assessment of the insulation resistance of selected cable types is performed using the advanced measuring methods of Line Resonance Analysis (LIRA) and Time Domain Reflectometry (TDR). These measuring methods are also suitable to detect degradation of inaccessible cables.

In addition to ageing management, a policy of replacing cables during the numerous backfittings is consistently followed in the Swiss NPPs.

From ENSI`s point of view a good performance could be allocated to Switzerland.

4.8.2 Country planned action if relevant

From ENSI`s point of view no further action is needed.

5 All other generic findings

The objective of this chapter is to demonstrate that the good practices and good performances allocated to Switzerland as a result of the TPR workshop /5/ and documented in the TPR-Report /4/ are justified.

5.1 Overall Ageing Management Programmes (OAMPs)

5.1.1 Good practice: External peer review services

According to the TPR-Report /4/ this good practice is defined as follows:

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

As a result of the TPR workshop a good practice has been allocated to Switzerland.

5.1.1.2 Country position

In Section 5.2 of the Swiss NAR /3/ it was stated that potential for improvement in the ageing management of Swiss NPPs was identified by the licensees through the periodic reviews performed by the WANO and IAEA. Within the second phase of the TPR-process (questions and answers on the NAR) ENSI pointed out that although the basic principles and scoping and screening processes of the Swiss AMP and SALTO are similar there are differences in the AMP approach itself which makes it difficult to review the AMP of the Swiss NPPs using the SALTO methodology. From ENSI`s point of view it is more promising to review the Swiss AMPs in the frame of an OSART mission (LTO modul) as already successfully performed for the Mühleberg NPP.

The detailed LTO findings of the mission team addressed several important issues of a comprehensive and effective AMP based on the respective IAEA requirements and recommendations. The mission team came to the overall conclusion that a satisfactory progress has been achieved by the Mühleberg NPP to expand the scope of the existing AMP and to complete the revalidation of the environmental qualification of originally installed safety relevant cables.

From ENSI`s point of view the allocation of the good practice is justified. ENSI does plan to encourage all other licensees to invite such a review in the future.

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

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

As a result of the TPR workshop a good performance has been allocated to Switzerland.

5.1.2.2 Country position

In Section 2.3.2 of the Swiss NAR /3/ it was shown that international research programmes were monitored and internal and external operating experience were evaluated systematically by the licensees and by ENSI.

Depending on the design type, Swiss NPPs participate in the on-going research programmes of the Electric Power Research Institute (EPRI), the VGB PowerTech, swissnuclear (sn) and the Paul-Scherrer Institute.

Furthermore, the GSKL expert teams check and evaluate new findings from external sources and committees, information from plant suppliers, or from exchange of technical experience with foreign nuclear power plants. The IAEA's IGALL programme /13/ is of particular importance here. On the basis of this evaluation, it is decided whether these findings will be taken into account in the AMP and whether it is necessary to update the specific technical documents (fact sheets, ageing catalogue, ageing dossiers). In addition, operation-induced degradation that has occurred in Swiss NPPs is discussed and evaluated in respect of its relevance for the AMP. The results of this review are presented in summary in the annual reports of the Swiss NPPs.

In addition, Swiss NPPs have access to the results of specific ageing management projects financed by ENSI.

Embedding the AMP in the national and international activities of GSKL's coordination team ensures that the state-of-the-art of science and technology in materials and structural ageing as well as analysis and diagnostic technology will continue to be considered in the future.

From ENSI`s point of view the allocation of the good performance is justified.

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

According to the TPR-Report /4/ the expected level of performance is defined as follows:

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

5.1.3.1 Allocation by the TPR

As a result of the TPR workshop an area for improvement has been allocated to Switzerland.

5.1.3.2 Country position and action

Please refer to the assessment in Section 3.1.2 of this report.

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

According to the TPR-Report /4/ the expected level of performance is defined as follows:

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.

5.1.4.1 Allocation by the TPR

As a result of the TPR workshop a good performance has been allocated to Switzerland.

5.1.4.2 Country position

In one of the comments on the preliminary findings as presented at the end of the TPR workshop on 18th May 2018 ENSI pointed out that this level of performance have not been addressed in the Swiss NAR /3/ because it was not required by the WENRA Technical Specification /2/ explicitly. However, during the relatively long outage of Beznau-1 NPP, the licensee has taken measures to protect components (such as keeping vessels filled to prevent exposure to oxygen) and set up an extensive maintenance program. Before restart, numerous inspections and functional tests were carried out. The program for restart was approved and closely monitored by ENSI. With the experience gained through this process, the Swiss licensees have developed a good general understanding of how to handle potential ageing phenomena during long outages.

From ENSI`s point of view the allocation of the good performance is justified.

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

According to the TPR-Report /4/ the expected level of performance is defined as follows:

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.

5.1.5.1 Allocation by the TPR

As a result of the TPR workshop this expected level of performance was of no concern for Switzerland.

5.1.5.2 Country position

As pointed out in Section 1 of this report the NAcP is restricted to the AMPs of the Swiss NPPs.

5.2 Concealed pipework

5.2.1 Good practice: Use of results from regular monitoring of the condition of civil structures

According to the TPR-Report /4/ this good practice is defined as follows:

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

As a result of the TPR-Workshop no good practice has been allocated to Switzerland.

5.2.1.2 Country position

Soil and building settlements are measured at regular intervals in Swiss NPPs. At this time, there is no systematic transfer of data into the AMP for concealed pipework. However, the targeted inspections in 2018/2019, which covered inaccessible civil structures and concealed pipework, have shown that there is cooperation between the different sections in the Swiss NPPs. Furthermore, the typical range of soil and building settlement is small compared to displacements considered in dynamic analyses, for example in seismic analyses for buildings, supports and pipework. From ENSI`s point of view this suggests a robust design of junctions and penetrations.

5.2.2 Good practice: Performance checks for new or novel materials

According to the TPR-Report /4/ this good practice is defined as follows:

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

As a result of the TPR workshop a good practice has been allocated to Switzerland.

5.2.2.2 Country position

Section 4.1 of the Swiss NAR /3/ describes different approaches in the Swiss NPPs to confirm that the properties of pipework sections are as expected. For example:

- Gösgen NPP refers to the already performed replacement of ferritic pipe sections with austenitic stainless steel where pipes are buried. Moreover, for selected, originally uncoated pipes, the inner surface has been protected by a polyethylene (PE) liner or by an epoxy resin coating.
- Beznau NPP also carried out a partial replacement of ferritic pipe sections with austenitic stainless steel for the service water system.
- In Mühleberg NPP, for the plastic pipes of the emergency cooling water system, compliance with the required material properties is checked annually using retained samples from the manufacturing batch which were stored in the river water. It is therefore possible to detect ageing-induced changes in the material properties in a timely manner.

From ENSI`s point of view the allocation of the good practice is justified.

5.2.3 TPR expected level of performance: Inspection of safety-related pipework penetrations

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

As a result of the TPR workshop a good performance has been allocated to Switzerland.

5.2.3.2 Country position

In Section 4.1 of the Swiss NAR /3/ it was stated that concrete-embedded classified piping sections, especially in the area of building penetrations, were not given further consideration because the inaccessible sections are very short and the external surfaces are not subject to relevant ageing mechanisms. In the plant-specific AMP, these pipe sections are not handled any differently from the accessible pipe sections of the respective systems. No safety-relevant oil, fuel or compressed air lines are routed such that they are inaccessible.

Furthermore the results of the targeted inspections carried out in 2018 and 2019 indicated that safety-related pipework penetrations are covered by periodic walk downs of the individual systems.

From ENSI`s point of view the allocation of the good performance is justified.

5.2.4 TPR expected level of performance: Scope of concealed pipework included in AMPs

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

As a result of the TPR workshop an area for improvement has been allocated to Switzerland.

5.2.4.2 Country position and action

Please refer to the assessment in Section 3.2.2 of this report.

5.2.5 TPR expected level of performance: Opportunistic inspections

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

5.2.5.1 Allocation by the TPR

As a result of the TPR workshop an area for improvement has been allocated to Switzerland.

5.2.5.2 Country position

Please refer to the assessment in Section 3.2.4 of this report.

5.3 Reactor pressure vessel

5.3.1 Good practice: Hydrogen water chemistry

According to the TPR-Report /4/ this good practice is defined as follows:

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

As a result of the TPR workshop a good practice has been allocated to Switzerland.

5.3.1.2 Country position

In Section 5.2 of the Swiss NAR /3/ it was stated that, as a preventive measure, both Swiss BWR (Mühleberg and Leibstadt) are operated with optimised water chemistry, in that a hydrogen operating mode with additional noble metal injection is applied. Consequently, the susceptibility to stress corrosion cracking of components made of austenitic steels and nickel based alloys is reduced. Both NPPs consider the use of the hydrogen operating mode as effective.

According to Section 5.1 of the Swiss NAR /3/ the BWR plants switched to hydrogen water chemistry control (HWC) around 2000, which since 2005 has been supplemented by noble metal injection with platinum (OLNC™ process - Online Noble Chem).

From 2010 to 2018 the OLNC-procedures were optimized based on results from PSI (Paul Scherrer Institute) research projects NORA I to III. It is worth mentioning that these optimized ONLC strategies significantly increased the effectiveness of hydrogen injection, while the simple HWC was not yet fully satisfactory. The higher effectiveness of optimized OLNC can be demonstrated by the measurement of the electrochemical potential. The nearly complete stagnation of core shroud crack propagation at the Mühleberg NPP after 2009 is further evidence of its effectiveness.

From ENSI`s point of view the allocation of the good practice is justified.

5.3.2 Good practice: Implementation of a shield

According to the TPR-Report /4/ this good practice is defined as follows:

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

As a result of the TPR-Workshop no good practice has been allocated to Switzerland.

5.3.2.2 Country position

From ENSI`s point of view usage of shielding rods is not considered an effective measure to reduce neutron flux on the RPV wall of the Swiss NPPs. Instead, according to Section 5.2 of the Swiss NAR /3/, all Swiss NPPs started early with the usage of low leakage core configurations.

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

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

As a result of the TPR workshop a good performance has been allocated to Switzerland.

5.3.3.2 Country position

In Section 5.1 of the Swiss NAR /3/ it was stated that the in-service inspection programme includes ultrasonic testing (UT) and eddy current testing (ET) of the RPV circumferential welds and, where present, also the vertical welds of the cylindrical shell and on the head and bottom, the nozzle welds, dissimilar metal welds and welds of the ‘safe ends’.

Within the second phase of the TPR-process (questions and answers on the NAR) ENSI pointed out that as long as there is no active ageing mechanism identified, inspection intervals are applied as specified in SVTI specification NE-14, which is based on international Codes and Standards (in particular ASME XI). When evidence of potentially progressing damage is found, inspection intervals may be adjusted as necessary to ensure that existing flaws do not exceed the acceptability limits before the next inspection.

As example, in the Leibstadt NPP, after detection of stress corrosion cracking at a feed water nozzle and repair by a full structural weld overlay (FSWOL), an updated maintenance concept was prepared, which includes according to Section 5.2 of the Swiss NAR /3/ shorter inspection intervals and special mitigative actions (MSIP, Mechanical Stress Improvement Process).

In Beznau NPP the RPV closure heads were replaced. The replacement heads consist of the less susceptible Inconel 690 and Inconel 52 for the head penetrations.

From ENSI`s point of view the allocation of the good performance is justified.

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

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

5.3.4.1 Allocation by the TPR

As a result of the TPR workshop a good performance has been allocated to Switzerland.

5.3.4.2 Country position

In 2015, ultrasonic measurements were carried out on the RPV base metal in all Swiss NPPs.

In Section 5.1 of the Swiss NAR /3/ it was stated that in the RPV of unit 1 of Beznau NPP indications were detected. Between 2015 and 2018 the root cause and the characteristics of the inclusions and their potential effects on structural integrity and embrittlement behaviour were investigated comprehensively within the framework of a safety case. The indications can be traced back to aluminium oxide non-metallic inclusions from manufacture.

Within the second phase of the TPR-process (questions and answers on the NAR) ENSI pointed out that the review of the safety case for Beznau unit 1 by ENSI and its external experts was completed early in 2018. It was concluded that the non-metallic inclusions do not have a negative impact on RPV integrity or irradiation embrittlement.

In 2022, a follow-up UT inspection in the base material of beltline region of Beznau unit 1 is planned to confirm stability of the high-amplitude indications.

From ENSI`s point of view the allocation of the good performance is justified.

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

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

5.3.5.1 Allocation by the TPR

As a result of the TPR workshop a good performance has been allocated to Switzerland.

5.3.5.2 Country position

In Appendix 6 of the regulatory guideline on ageing management for NPPs (ENSI-B01 /6/) the requirements for fatigue monitoring and assessment are defined.

In Section 5.1 of the Swiss NAR /3/ it was stated that guideline ENSI-B01 specifies the cases in which the influence of the reactor coolant must be considered according to NUREG/CR-6909 /10/. The next update of guideline ENSI-B01 will take into account the recently revised version of NUREG/CR-6909 /14/.

From ENSI`s point of view the allocation of the good performance is justified.

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

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

As a result of the TPR workshop this expected level of performance was of no concern for Switzerland.

5.3.6.2 Country position

As pointed out in Section 1 of this report the NAcP is restricted to the AMPs of the Swiss NPPs.

5.4 Concrete containment structure

5.4.1 Good practice: Monitoring of concrete structures

According to the TPR-Report /4/ this good practice is defined as follows:

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

As a result of the TPR-Workshop no good practice has been allocated to Switzerland.

5.4.1.2 Country position

The concrete containment structures in Swiss NPPs are not part of the primary containment. They protect the reactor coolant systems against external loads, such as wind, flooding, impact forces or earthquakes. The pressure boundaries are formed by steel shells. Monitoring by leak rate tests and instrumentation is focused on the steel containment structures.

The concrete structures in the Swiss NPPs are not equipped with embedded strain gauges or instrumentation for permanent settlement measurements. The aging management of the concrete structures is based mainly on visual inspections, complemented with non-destructive on-site and laboratory measurements of structural properties. Settlements of concrete structures are measured by conventional survey systems in the scope of AMP every 5 to 10 years.

From ENSI`s point of view the installation of sensors, embedded in or on the surface of concrete structures, may be taken into consideration for new concrete structures in operating plants if exceptionally high demands are specified.

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

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

As a result of the TPR workshop a good practice has been allocated to Switzerland.

5.4.2.2 Country position

In Section 7.3 of the Swiss NAR /3/ ENSI pointed out that the GSKL civil engineering guide /12/ was extended with respect to the monitoring of inaccessible or difficult to access structural components, as for example the outer surfaces of earth-covered components, groundwater seals or concrete-encased tendons.

As described in chapter 2.5.2 of this report ENSI had performed inspections related to inaccessible structures at the site of all Swiss NPPs. The results of those inspections confirmed that

- operator's inspections of inaccessible structural components are carried out on time according to inspection planning,
- construction work is consistently used to inspect normally inaccessible structural components (opportunistic inspections),
- accessible structural components are in good condition and are representative for the inaccessible structural components.

From ENSI`s point of view the allocation of the good performance is justified.

5.4.3 TPR expected level of performance: Monitoring of pre-stressing forces

According to the TPR-Report /4/ this expected level of performance is defined as follows:

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

As a result of the TPR workshop this expected level of performance was of no concern for Switzerland.

5.4.3.2 Country position

From ENSI`s point of view this expected level of performance is of less significance for the Swiss NPPs because the containment structures are not equipped with pre-stressing systems.

A partial exception exists in the reactor buildings of units I and II of Beznau NPP. Here the reinforced concrete ring between the dome and the outer cylinder is pre-stressed. The tendons and the anchor heads are grouted in the concrete. The annular girder is pre-stressed with 14 tendons, has a height of approximately 6 m and a thickness of 1.70 m. The anchor heads are arranged at 8 circumferential points. The anchor heads with the lowest measured potentials (and therefore the highest probability of corrosion) were exposed. The observed condition of the anchor heads confirmed the results of the potential field measurements and supported conclusions concerning the condition of the non-exposed steel parts. The condition is fine and no further measures are implemented. There is no need for a live monitoring system.

6 Status of the regulation and implementation of AMP to other risk significant nuclear installations

This topic was excluded from the original scope of the TPR. As mentioned in Section 1 of this report ENSI will take the opportunity to add this Section until the end of 2020 with focus on the OAMPs implemented in the intermediate storage facilities for radioactive waste operated in Switzerland.

7 Table: Summary of the planned actions

Installation	Thematics	Finding	Planned action	Deadline	Regulator’s Approach to Monitoring
All NPPs	OAMPs	Further harmonisation of the annual reporting on the state of the OAMPs among the Swiss NPPs.	Guideline ENSI-B02 shall be revised (see Section 2.1.2).	End of 2020	The 2021 annual safety reports have to be adapted by the Swiss NPPs in accordance with the revised guideline.
All NPPs	OAMPs	The scope of the OAMPs is reviewed and, if necessary, updated, in line with the new IAEA Safety Guide SSG-48.	Guideline ENSI-B01 shall be revised (see Section 3.1.2).	End of 2021	The scope of the OAMPs have to be adapted by the Swiss NPPs, if necessary, in accordance with the revised guideline.
All NPPs	Concealed pipework	Extension of the regulatory efforts regarding ageing management in order to make sure that all safety-relevant concealed piping systems are included and are covered by suitable maintenance and inspection programmes.	Requirements for ageing management of concealed pipework shall be explicitly addressed in the next revision of guideline ENSI-B01 (see Section 3.2.2).	End of 2021	The GSKL Guide for the development of fact sheets for ageing management of mechanical engineering components and the content of the fact sheets for safety relevant systems have to be adapted by the Swiss NPPs in accordance with the revised guideline.
All NPPs	Concealed pipework	The scope of concealed pipework shall include those performing safety functions, and also non-safety-related pipework whose failure may impact SSCs performing safety functions.			

8 Abbreviations

ASTM: American Society for Testing and Materials

AMP: Ageing Management Programme

PWR: Pressurised Water Reactor

ENSI: Swiss Federal Nuclear Safety Inspectorate

EPRI: Electric Power Research Institute

GSKL: Group of Swiss NPP Managers

IAEA: International Atomic Energy Agency

IEEE: Institute of Electrical and Electronics Engineers

KTA: Nuclear Safety Standards Commission (Germany)

NAcP: National Action Plan

NAR: National Assessment Report

NDT: Non-Destructive Testing

OECD/NEA: Organisation for Economic Co-operation and Development/Nuclear Energy Agency

PSI: Paul Scherrer Institute (Switzerland)

PTS: Pressurized Thermal Shock.

RPV: Reactor Pressure Vessel

SSC: Structures, Systems and Components

SVTI: Swiss Association for Technical Inspections

BWR: Boiling Water Reactor

TPR: Topical Peer Review

WANO: World Association of Nuclear Operators

9 References

/1/ ENSREG, Topical Peer Review 2017, Ageing Management of Nuclear Power Plants, Terms of Reference for Topical Peer Review Process, Revision 3, November 2016

/2/ WENRA-RHWG, Report Topical Peer Review 2017, Ageing Management, Technical Specification for the National assessment reports, 21 December 2016

/3/ ENSI, Topical Peer Review, Swiss National Assessment Report, Ageing Management in Nuclear Power Plants, December 2017

/4/ ENSREG, 1st Topical Peer Review Report “Ageing Management”, October 2018

/5/ ENSREG, 1st Topical Peer Review “Ageing Management”, Country specific findings, October 2018

/6/ Guideline ENSI-B01, Ageing Management, August 2011

/7/ Guideline ENSI-B02, Periodic Reporting of Nuclear Installations, Revision 5, June 2015

/8/ IAEA Safety Guide NS-G-2.12, Ageing Management for Nuclear Power Plants, 2009

/9/ IAEA Safety Guide SSG-48, Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants, November 2018

/10/ NUREG/CR-6909, ANL-06/08, Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials, 2007

/11/ GSKL DA0909/AN060567, Guide for the development of fact sheets for ageing management of mechanical engineering components, Revision 5, June 2014

/12/ GSKL DA1101/AN1200215, Guide for civil engineering fact sheets, Revision 6, December 2015

/13/ IAEA Safety Report SRS No. 82, Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL), April 2015

/14/ NUREG/CR-6909, Rev. 1, Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials, 2018

Guideline ENSI-B06 defines no specific requirements for concealed pipework sections. However, findings from ageing management can lead to specific requirements for the inspection of concealed pipework.

In consultation with ENSI, the licensees of the Swiss nuclear power plants have investigated their safety related pipework for the presence of concealed sections. Taking into account the design characteristics of the Swiss nuclear power plants they came to the conclusion that the specific monitoring can be limited to of concealed pipework of safety-relevant cooling water systems which are in direct contact with river water.

As preventive remedial actions, pipe sections of such cooling water systems have been replaced or protected with anti-corrosion coating. However, with the exception of one nuclear power plant, in ENSI`s point of view, neither the background nor the effectiveness of already performed preventive and remedial actions on concealed pipework sections is presented in sufficient detail. Therefore, ENSI will extend the focus of its regulatory efforts regarding ageing management in order to make sure that all safety-relevant concealed piping systems are included and are covered by suitable maintenance and inspection programmes.

Reactor pressure vessels

All reactor pressure vessels (RPVs) in the Swiss nuclear power plants are classified as mechanical components of safety class 1 in accordance with guideline ENSI-G01. According to the requirements of guideline ENSI-B01, the RPVs must be treated in detail within the scope of ageing management, which means that the ageing mechanisms must be evaluated for the individual parts of the component.

Each Swiss nuclear power plant has a fact sheet for the RPV, which describes in detail, amongst other things, the materials used and the applied design codes, special design characteristics, the relevant ageing mechanisms and necessary maintenance measures. The ageing mechanisms are based on the GSKL catalogue of relevant ageing mechanisms prepared by the mechanical engineering departments of the Swiss nuclear power plants. From ENSI`s perspective, these fact sheets contain a systematic analysis of the internal and external operating experience with reference to the on-going research projects of ENSI relating to the relevant topics of RPV ageing management. Fatigue, neutron embrittlement and stress corrosion cracking are identified as the most important RPV ageing mechanisms.

In one Swiss nuclear power plant the fatigue usage factors are still determined manually. The other plants use integrated fatigue monitoring programmes with which temperature histories are recorded and evaluated at selected points on the RPVs. The results of the fatigue monitoring in the form of current fatigue usage factors and the corresponding levels extrapolated to 60 years of operation are submitted to ENSI annually. The existing results show that the long-term operation of the Swiss nuclear power plants is not subject to any limitations because of RPV material fatigue.

In the Swiss nuclear power plants, systematic neutron embrittlement monitoring of the RPVs is performed using irradiation surveillance specimens. The surveillance programmes cover at least 60 years of operation. ENSI agrees with the evaluation of the licensees that RPV neutron embrittlement is not a limiting factor for the long-term operation of the Swiss nuclear power plants up to 60 years of operation. The criteria of the DETEC ordinance for the provisional shutdown of nuclear power plants in respect of the minimum Charpy-V impact energy and the brittle fracture transition temperature at ¼ of the wall depth have not been reached.

Stress corrosion cracking is considered by the Swiss licensees to be a key ageing mechanism for inconel welds and austenitic welds in contact with reactor cooling water. In one Swiss nuclear power plant, an indication caused by stress corrosion cracking in a dissimilar metal weld of an RPV feedwater nozzle was identified through the in-service inspection programme. In response to this, the affected nuclear power plant adapted the maintenance programme for dissimilar metal welds and shortened the inspection intervals. As part of the regulatory process, ENSI will closely monitor the implementation of the maintenance programme for dissimilar metal welds.

In view of the above ENSI comes to the conclusion that the licensees of the Swiss nuclear power plants have so far adequately implemented specific measures for preventing or mitigating ageing effects on the RPVs based on ageing management findings.

Concrete structures of the reactor buildings

Based on guideline ENSI-B01, all structures classified according to guideline ENSI-G01 are to be included into the AMP. In line with their significance for nuclear safety and radiation protection, structures are assigned to two structure classes, BK I and BK II. Moreover, in guideline ENSI-B01, the general civil engineering requirements are specified as well as the requirements for the fact sheets related to individual buildings or building parts. Each fact sheet must comprise a general part, a structural component documentation, a description of the relevant component-specific ageing mechanisms and the inspections to be carried out, as well as the assessment of the civil engineering condition derived from the inspections. The general part denominates the substructures and structural components that are considered in the AMP. In particular, the structural component documentation must specify the design principles, properties of the materials used, operating conditions and extraordinary effects as well as the assessment of the underlying target conditions.

ENSI has reviewed and approved the GSKL civil engineering guide, which serves as a basis for the ageing management of the structures in the Swiss nuclear power plants. The guide contains the possible ageing mechanisms for the structures, specifies the type and frequency of inspections and defines the assignment of inspected structural components or materials to condition levels. In ENSI´s perspective, this guide has proven effective so far and fulfils the requirements of the guideline ENSI-B01.

With the introduction of guideline ENSI-B01 in 2011, the ageing management programme was especially expanded to include all safety-classified structures. Additionally, ENSI has initiated an important expansion of the GSKL civil engineering guide. This concerns the monitoring of inaccessible or difficult to access structural components. To date such methods have hardly been used. ENSI has pointed out this monitoring gap to the licensees on a number of occasions, and in its future inspections ENSI will increasingly demand corresponding tests.

From ENSI´s perspective, the fact sheets created for the outer reactor building envelope cover the relevant ageing mechanisms and fully evaluate the condition investigations carried out. The plant walk-downs performed by ENSI confirm the results of the condition investigations. Based on this and in agreement with the assessment of the licensees, ENSI rates the condition of the concrete structures of the outer reactor building envelopes in the Swiss nuclear power plants as good. The structural maintenance and the preventive measures conducted within the scope of the ageing management of the outer reactor building envelope have proven effective.

General conclusions

Overall, ENSI comes to the conclusion that the regulatory framework for a systematic ageing management in Swiss nuclear power plants is adequate and covers the internationally applicable requirements of the IAEA and the WENRA. The particular importance of ageing management for nuclear power plants is emphasised in Switzerland by the fact that there are statutory requirements for a provisional shutdown of a nuclear power plant for reasons related to ageing degradation. From ENSI´s perspective, with the specification of explicit ageing criteria in the DETEC ordinance for the provisional shutdown a high degree of transparency for the application of general acceptance criteria is achieved.

With the annual reporting, ENSI is promptly informed about changes in the AMPs of the Swiss nuclear power plants and based on this it is possible to conduct targeted inspections on findings and to evaluate the effectiveness of the AMP (potential good practice). From ENSI`s perspective, the annual reporting clearly shows that the ageing management programme in Swiss nuclear power plants is continuously updated based on new findings from the evaluation of internal and external operating experience as well as by monitoring the state-of-the-art of science and technology.

From the insights gained through the regulatory process in Switzerland, it can be concluded that the Swiss nuclear power plants have implemented a comprehensive AMP for safety-relevant SSCs which contains the attributes listed in the IAEA Safety Guide NS-G-2.12 for effective ageing management.

By establishing a common project of the GSKL, a standardised document structure has been achieved and a standardised implementation of the AMP in individual nuclear power plants is ensured through the specially-founded expert teams. In ENSI`s point of view, the required specifications for systematic ageing management and the information necessary for monitoring the safety-relevant SSCs are contained in the basic documents developed for implementing ageing management and the safety-relevant SSCs are being effectively monitored based on the systematic framework of the AMP (potential good practice).

In ENSI`s point of view the component-specific ageing management programmes for electrical cables, the reactor pressure vessels and the outer reactor building envelopes are based on a comprehensive recording and analysis of potential ageing mechanisms. A wide spectrum of diagnostic methods is used to identify the relevant ageing mechanisms in the Swiss nuclear power plants. The following should be mentioned in particular (potential good practices):

- The evaluation of experience from accelerated ageing investigations on cable samples, which enable a proactive assessment of cable ageing under extreme ambient conditions;
- The use of integrated fatigue monitoring programmes which record and evaluate temperature time series at selected points on the RPVs;
- The application of the master curve method as a complement to the classical approach for the analysis of the irradiation surveillance specimen used for the systematic neutron embrittlement monitoring of the RPVs, allowing direct determination of fracture toughness.

Existing experience gained from the regulatory process shows that the ageing management programmes implemented for electrical cables, the reactor pressure vessels and the outer reactor building envelope detect the relevant ageing effects in a timely manner and that effective counter-measures are adopted. As a result, these components are in a condition that permits the long-term operation of the Swiss nuclear power plants.

Irrespective of the preceding assessment, ENSI has identified the following areas of improvement within the scope of the Topical Peer Review.

- Further harmonisation of reporting among the Swiss nuclear power plants is necessary. This especially concerns the overview of the updated fact sheets, the evaluation of the international operating experience and the assessment of the effectiveness of the AMP based on trends from maintenance findings.
- ENSI will extend the focus of its regulatory efforts regarding ageing management in order to make sure that all safety-relevant concealed piping systems are included and are covered by suitable maintenance and inspection programmes.
- ENSI has required the monitoring of inaccessible or difficult to access structural components. However, to date such methods have hardly been used. Therefore, there is still no reliable experience for the condition assessment of inaccessible civil engineering structures. ENSI has pointed out this monitoring gap to the licensees on a number of occasions, and in its future inspections ENSI will increasingly demand corresponding tests.

Contents

1 General information

1.1 Nuclear installations identification

There is a total of five operating nuclear power plant units on four different sites throughout Switzerland (see Figure 1.1). They include the Beznau Nuclear Power Plant (KKB), which has two reactor units, and the Gösgen (KKG), Leibstadt (KKL) and Mühleberg (KKM) Nuclear Power Plants, each with just one unit. These plants generate approximately 40% of Switzerland's total electricity. Table 1.1 shows the licensees of the Swiss nuclear power plants.

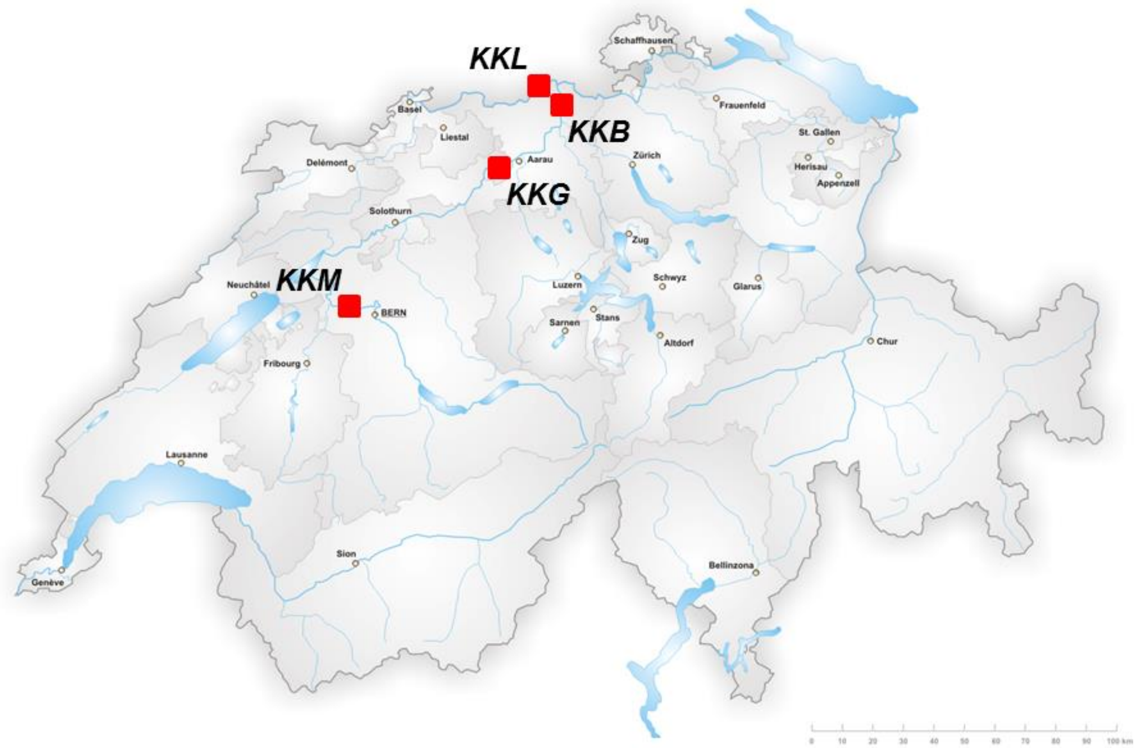

Figure 1.1: Swiss Nuclear Power Plant Sites

Three of the reactors in the Swiss nuclear power plants are pressurised water reactors, including two US designs and one German design. The other two Swiss nuclear power plants are different generations of US boiling water reactors. The reactor units in the Beznau Nuclear Power Plant and the reactor in the Mühleberg Nuclear Power Plant have been operating for over 40 years, while the Gösgen Nuclear Power Plant reactor is approaching 40 years. The Mühleberg Nuclear Power Plant will finally terminate power operation at the end of 2019. Table 1.1 below shows key technical data for these nuclear power plants.

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Confédération suisse
Confederazione Svizzera
Confederaziun svizra

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