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Final Follow up of ENSREG 1st Topical Peer Review Swedish National Action Plan for Swedish Nuclear Facilities

SSM perspective of the Swedish licensee´s final progress with ENSREG 1st Topical Peer Review, Ageing Management, Swedish National Action Plan.

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1. Executive Summary

The European Union's Nuclear Safety Directive 2014/87/EURATOM (NSD) requires the member states to undertake topical peer reviews (TPR) every 6 years with the first starting in 2017. The member states, acting through the European Nuclear Safety Regulators Group (ENSREG), decided that the topic for the first TPR was ageing management.

The Swedish National Assessment Report (NAR) issued by the Swedish Radiation Safety Authority (SSM) was based on the licensee's assessments as well as the results from SSM's review. According to the specification from WENRA, each licensee has performed an assessment for electrical cables, concealed pipework, reactor pressure vessels and concrete containment structures. Calandria/pressure tubes (CANDU) and pre-stressed concrete pressure vessels (AGR) is not applicable to the Swedish NAR. The report was completed and distributed to ENSREG in December 2017.

The Swedish National Action Plan (NAcP) was completed during 2019 in accordance with the template *ENSREG 1st Topical Peer Review Template National Action Plan on Ageing Management*. The plan addressed the results from the Swedish nuclear power plants self-assessment and responded to the country specific findings allocated to Sweden in order to reach the TPR expected level of performance. Furthermore, the Swedish licensee took into account all generic findings from the peer review in order to improve the Ageing Management Programmes at each nuclear power plant. Information on actions and their planned end dates was included together with SSM´s assessment and the report was distributed to ENSREG in September 2019.

A follow-up of the actions was made which also included other risk significant nuclear installations. The Swedish Central Interim Storage Facility for Spent Nuclear Fuel (Clab) submitted their self-assessment as well as all generic findings by using the same procedure as the nuclear power plants had done previously according to the TPR process. A self-assessment with results from the progress of the identified actions in the NAcP was thereafter submitted by SSM to ENSREG in 2021.

Swedish licensee have pursued slightly different paths to develop their respective overall ageing management programmes, all with the goal to ensure the availability of required safety functions throughout the service life of the plant. SSM introduced the requirement to develop overall programmes for ageing management in late 2004. The programmes are interdisciplinary and link the ageing perspective in a range of other programmes. Results from TPR and SSM´s supervisory programme show that the licensee have implemented overall ageing management programmes which are continuously and systematically updated with new experiences gained both nationally and internationally.

The nuclear power plants follow the IAEA SALTO-process systematically by considering the recommendations and suggestions and taking actions in order to close identified gaps. Results from SSM´s supervisory programme are in line with the SALTO results.

Overall, SSM concludes that the Swedish licensee´s work on the action plans has been good and that the remaining measures in the action plans do not have a significant impact on radiation safety. These will be handled by the licensee in relevant programmes and followed up by SSM within the framework of the supervision programme. SSM therefore considers that the TPR process for aging management is now finalized.

Contents

2. Introduction

The European Union's Nuclear Safety Directive 2014/87/EURATOM (NSD) requires the member states to undertake TPR every 6 years with the first starting in 2017. For each review the directive requires the following:

a) a national assessment is performed, based on a specific topic related to nuclear safety of the relevant nuclear installations on their territory;
b) all other Member States, and the Commission as observer, are invited to peer review the national assessment referred to in point (a);
c) appropriate follow-up measures are taken of relevant findings resulting from the peer review process;
d) relevant reports are published on the above mentioned process and its main outcome when results are available.

The member states, acting through ENSREG, decided that the topic for the first TPR is ageing management.

SSM by the provision of the act of nuclear activities (1984:3) can decide by injunction that the licensee take the necessary measures required in individual cases for compliance with the act. Based on this legislation SSM in February 2017 decided that licensees operating nuclear reactors should report relevant information according to the technical specification (RHWG Report to WENRA – TPR Technical Specification, 21 December 2016).

Sweden has previously submitted NAR [1] and NAcP [2] to ENSREG for the Swedish nuclear power plants in accordance with NSD.

The Swedish licensee have also submitted a self-assessment in 2021 with results from the progress of the identified actions in the NAcP and the results of the assessments are reported "as is" in the report. Status of Progress of Implementation of Ageing Management Programmes (AMP) to other Risk Significant Nuclear Installations was incorporated by SSM into the TPR process in January 2021. Clab submitted their self-assessment accordingly and also submitted an assessment of all generic findings from the TPR process; the information submitted was included in the status report [3].
Licensee are:

- Forsmark Kraftgrupp AB, FKA NPP
- OKG AB, Oskarshamn NPP
- Ringhals AB, RAB NPP
- Clab

This report is the final follow up report of the Status of Progress of Implementation of AMP for the Swedish nuclear power plants as well as other risk significant nuclear installations. With this report SSM concludes that the TPR process for Ageing Management is finalized and closed. The identified actions still remaining open in the NAcP will be followed up in the supervisory programme.

3. Overall Ageing Management Programme

3.1. FKA

3.1.1. Systematic Quality Management of the overall Ageing Management Programme

Planned action
Implement key performance indicator for ageing related failures.
Deadline: 2020-12-31

Current progress
Forsmark has implemented key performance index (KPI) for ageing management related issues and failure reports attributed to ageing degradation, KPI Ageing", "to assess the effectiveness of the overall ageing management programme in a systematic manner. "KPI Ageing" measures the number of Corrective Actions linked to aging-related failures in the last 12-month period for Structures, Systems and Components (SSCs) that are included in the defined scope of aging management. The assessment covers the failures that have had a potential safety impact on the function of a system and whether the failure has been processed for root cause analysis in the CAP system with the aim of improving the management of aging. This assessment of reported failures is performed monthly in a technical area group and, if ageing degradation related, listed in the action programme for further processing in the AMP group.
The progress of ageing management related actions managed via the CAP system is monitored and evaluated in the technical area groups and managing decisions are performed in the AMP group, consisting of managers and representative engineering specialists from respective involved departments.
A new maintenance IT tool will be launched in year 2021 and will support development of further dedicated indicators for recorded failures due to ageing related degradation when reporting on repairs and restorations.
Ageing management programmes, including CAP, are implemented according to IAEA standards and will be reviewed and fully assessed by IAEA SALTO review services in 2023.
Further cooperation on ageing management between the Swedish licensee is implemented through a common ageing management development forum. The forum intends to further elaborate on future common key performance index development. The common forum also has a continuous discussion through the Swedish licensees' participation in IAEA - IGALL Phase 5 projects, which includes an update of the present IGALL Safety Report No.82. The updated report will include chapters on the evaluation of the effectiveness of ageing management programmes and associated examples of useful KPIs.

Forsmark considers the action resolved.

3.1.2. TLAA not fully updated

Planned action F3
Complete the work with the remaining TLAA's of Forsmark Unit 3 to be valid for 60 years of operation.
Deadline: 2024-12-31

Current progress
The remaining work to complete the TLAAs covering ageing effects of low-cycle fatigue inclusive of the reactor coolant environment factors for the reactor pressure vessel, internals and primary system for Forsmark Unit 3 is on-going and is scheduled to be finalized during 2024.
The updated TLAAs for low-cycle fatigue will cover the time period up to 60 years of operation.
Since the licensing basis documents contain these TLAAs, they must be updated as a vital part of the periodic safety review (PSR) for Forsmark Unit 3 and will be reviewed and commented on by the regulatory body no later than year 2024.

Forsmark considers this action in progress according to plan.

Planned action
Forsmark will by October 31/2019 present a plan on how to manage identified deficiencies and remaining TLAA's in a timely manner before entering LTO period.
Deadline: 2019-10-31

Current progress
Since the regulatory review in 2019 of the periodic safety review (PSR) for the period of Long Term Operation (LTO) (60 years) for Forsmark Unit 1 & 2, and the subsequent regulatory injunction, Forsmark formed and announced an action plan for managing the specific identified deficiencies which resulted from the regulatory review of the PSR.
The identified deficiencies have resulted in re-work and update of the identified TLAAs for LTO for Unit 1 & 2, in accordance with the regulatory findings. The re-worked and updated TLAAs in question has been re-evaluated and approved by the Regulatory Body (RB) which thereby fulfilled the injunction.
As part of the injunction, the RB further concluded that the methodology for identifying relevant TLAAs was inadequate. The methodology has been revised as part of the action plan and was approved by the regulatory review.
The Environmental Qualification of electrical and I&C components is managed by an AMP which has been further reviewed by the Regulatory Body supervisory programme, which concluded that Forsmark has an environmental qualification process that is appropriate for further work with environmental qualification.
The re-work of TLAAs has also included re-work and update of some TLAAs valid for Forsmark Unit 3, which will enter LTO in 2025. Further work to complete the remaining set of TLAAs for Unit 3 is commenced as scheduled and is due to be completed in 2023 and will be included in the regulatory processing of Unit 3 PSR for LTO.
Updated TLAA documentations for LTO:

- Low-cycle fatigue, including environmental factors. (Unit 1 & 2)
- Irradiation embrittlement of RPVs.
- Manufacturing defects for RPVs.
- Thermal ageing of cast stainless steel.
- Irradiation assisted stress corrosion cracking.
- Fatigue of concrete containment steel linear and penetrations.
- Relaxation of containment pre-stress tendons.
- Fatigue of cranes.

A good example of implementing the results of updated TLAAs for LTO was the results and conclusions of the fatigue analysis, inclusive of environmental factors, of the primary coolant system. The specific results of the analyzes for a T-piece intercoupling between the feedwater system and the shutdown cooling system of Unit 1 demonstrated a utilization factor beyond the acceptance criteria regarding future period of long-term operation. A balanced assessment of available non-destructive evaluation methods, as

compensatory action, resulted in the alternative decision to replace the T-piece intercoupling and thereby re-setting the ageing degradation curve.
A synergy to the fatigue analyzes of the primary coolant systems was also an increased knowledge and awareness of the thermal influence from mass flow in various states of plant operation, further identification of governing points with respect to fatigue and subsequent discussions of operational changes to mitigate future unnecessary transients affecting fatigue utilization.

Forsmark considers the action resolved

3.1.3. Methodology for scoping the SSCs subject to ageing management

Planned action
Fully implement SSG-48 and evaluate the original SR-57 based scoping accordingly. Any discrepancies will be managed in accordance with ongoing routines for managing the scope of AM and LTO in Forsmark.
Deadline: 2020-12-31

Current progress
To further update the scope of Ageing Management, Forsmark has implemented an IAEA SSG-48 defined scoping methodology. Deficits regarding scope setting methodology was identified as an issue by the IAEA pre-SALTO review team in the peer review reported results of year 2019, which prompted a systematic evaluation of the latest IAEA guidance for scoping methodology.
The evaluation of the deficits and the assessment of the new specific guidance (SSG-48) has implied revised definitions of in-scope Structures, Systems and Components (SSCs) according to the revised formulation of in-scope criteria in the new specific guidance. As consequence, the scope setting is currently augmented to include also SSC:s previously out of scope by criteria and definitions in the previous IAEA guidance (SR-57).
To comply with new post Fukushima regulatory requirements for internal and external events, Forsmark has recently designed, constructed and commissioned independent core cooling facilities able to supply all three reactor vessels with cooling water in case of certain deterministic accident scenarios. The SSC:s serving these safety functions as design extension are, by the revised definitions, included in the SSG-48 augmented scope for ageing management.
Forsmark intends to further analyze the augmented scope and to revise the comprehensive review of ageing management and the ageing management programmes to fully cover the re-worked scope of Systems Structures and Components.
As a part of a living ageing management programme, the scope of ageing management will continuously be evaluated and updated during the life of the plant, either due to findings regarding present plant systems structures or components or due to managing of obsolescence or system upgrades, thus securing a living programme for upholding the managing of ageing over time.

Forsmark considers this action resolved.

3.1.4. Delayed NPP projects and extended shutdown

Planned action
Implement the aspect of ageing management due to prolonged shutdowns in the instruction for outage management.
Deadline: 2020-03-31

Current progress
For each in-scope Structure, System and Component or Group of components, there is a review of ageing management performed and documented by the technical area responsible part of the operating organisation in Forsmark. The technical area groups have one constellation for each relevant working area: mechanical, electrical, instrument & control and civil structures. Each technical area group includes relevant knowledge representatives from the line organisation of engineering, maintenance and operations.
The documented reviews of the ageing management are continuously kept up to date with current knowledge and experience feedback through the technical area groups. Managing the continuous validity of the ageing management review documentation also includes feedback on changes in operational and environmental conditions. Such change in operational and environmental conditions would include also the ageing degradation consequences of long construction periods or extended shutdown of a system or the entire plant.
To further manage any comprehensive needs of enhanced ageing management actions or introduction of preserving environments as a consequence of prolonged shutdown conditions, the outage management instruction is supplemented with requirements for this specific operational condition.

Forsmark considers the action resolved.

3.2. OKG

The overall AMP in OKG follows the principles described in IAEA SSG 48. For the living ageing management, OKG created a joint organisation, “coordination group-ageing” in order to coordinate the overall ageing management. To assist this group OKG also created several AMP groups divided into concrete, electrical/I&C, mechanical, In-Service-Inspection and obsolescence. All these groups have regular meetings which follow an approved agenda in order to improve the ageing management at OKG.

When OKG started the implementation of the ageing management it was also decided to base the ageing management on the IAEA guides, SSG 48 (former NS-G2.12). OKG also decided that peer reviews by IAEA (SALTO) should be carried out as a tool to make sure that OKG ageing management is in line with the IAEA guides. So far there have been two peer reviews:

Pre-SALTO	2017
expert mission	2019

The issues from these peer reviews are important information in the coming work to improve the ageing management at OKG. All issues are recorded in the CAP system and will be handled either by the LTO project or the line organisation.
OKG must also pay attention to a completely new set of regulations that was communicated to the Swedish nuclear power plants last year and make sure that these requirements are incorporated in the new methods.
As an additional aid in making sure that the new methods are in line with IAEA SSG48, OKG will also perform additional peer reviews as shown below (preliminary)

Q3 2022	pre-SALTO
Q3 2024	SALTO
Q3 2026	follow up SALTO

3.2.1. Systematic Quality Management of the overall Ageing Management Programme

Planned action
In the AM instruction, include an obligatory update every 5 year for all AMPs.
Deadline: 2019-12-31

Current progress
According to OKG's overall ageing management the AMP groups are responsible for the AMPs. In June 2020 the instruction for the AMP groups was revised with an additional text describing that the AMPs must at least be updated once every five years.

This task has also been addressed in several meetings in the OKG's joint organization for overall ageing management and will also be followed up during the future meetings.

All AMPs will be reviewed during 2023/2024 by the ongoing LTO project, since this is included in the AMR work.

OKG considers the action resolved.

3.2.2. Systematic Quality Management of the overall Ageing Management Programme

Planned action
Enlarge the number of KPIs.
Deadline: 2024

Current progress
OKG has one KPI in ageing management, since a couple of years, which is followed up on regular basis every other month. This KPI is based on the amount of fault reports caused by ageing in relation to the total amount of fault reports.
In the beginning of this year a work has been finalized to expand the number of "root causes codes" used in the fault reports when defining the root cause for the fault. This means that ageing related faults have got some additional "root cause codes" such as corrosion as an example.
Since more ageing related "codes" are available the number of KPI:s will also increase, so instead of having one KPI based on ageing related faults in general there will also be KPI:s for type of ageing effects, such as corrosion as an example.

Several attempts have been made in the past few years trying to find additional KPIs to measure the effectiveness of the ageing management. The subject has also been discussed with other Swedish power plants in FORSAMP (a Swedish joint organisation for overall ageing management) as well as with IAEA in an attempt to find a suitable way to measure the effectiveness of ageing management

However, in the beginning of 2021 OKG initiated a pilot study with a method to measure the "programme health" according to a bulletin from NEI. The idea is to measure all programmes (maintenance, ISI, chemistry, etc.) and AMPs to produce a scorecard for each one and use this as a KPI. This new method has also been discussed with the other licensees in Sweden.

OKG is involved in IAEA IGALL work and is specifically following the progress with developing KPIs for IGALL AMPs in order to get input for improvement for the OKG AMPs.

Within the framework of OKG LTO project that will be finalized in 2024, the AMPs will also be reviewed and updated. Improvements, if possible, of KPIs are included in this task.

OKG considers this action in progress according to revised time plan.

3.2.3. Use of more Specified Criteria to Define Conditional Acceptance Criteria

Planned action
Improvement of AMPs acceptance criteria if necessary.
Deadline: 2024

Current progress
The AMPs will be revised at least once every five years including updating the acceptance criteria if necessary. They will also be revised in OKGs LTO project 2021-2023 including acceptance criteria. Improvements of acceptance criteria is also included in OKG's living ageing management which purpose is to always look for improvements in the ageing management.

Within the framework of OKG LTO project that will be finalized in 2024, the AMPs will also be reviewed and updated including acceptance criteria.

OKG considers this action in progress according to revised time plan.

3.2.4. Review and Updating of the Overall Ageing Management Programme

Planned action
Review and update of TLAA
Deadline: 2024

Current progress
The updating of TLAAs is an ongoing task and has been going on for a couple of years. According to an injunction, all TLAAs will be revalidated and presented to the regulator in the end of 2021. OKG have mainly focused on the area related to fatigue analyses, thus working with the following TLAAs:

TLAA 101 Low-Cycle Fatigue Usage
TLAA 106, Environmentally Assisted Fatigue
TLAA 113 Thermal Stratification

OKG reported a methodology for identification of TLAA and verification of identified areas where TLAA is used, to the regulator in December 2021. OKG received a response from the regulator in June 2023. Work is underway to revise verification so that it complies with IAEA guidelines. The result will be reported to the regulator in early 2024. Checks are made of the load bases, which are applied to fatigue analyses, against measurements in the plant to ensure the validity of the analyses, TLAA 101. The preliminary measurements show a relatively large conservatism in the load bases.

OKG considers this action in progress according to revised time plan

3.3. RAB

3.3.1. Systematic Quality Management of the overall Ageing Management

Planned action
Implement main key performance indicator.
Deadline: 2020-12-31

Current progress
Originally Ringhals planned to measure the number of Corrective Maintenance actions linked to aging-related failures but found that to obtain consistent data would be hard when there are many user of the system. This would also be a reactive way to deal with inherent problems and a more proactive way would also be needed.
Instead Ringhals started to use two other measurements, number of aging-related Licensee event Report (LER)/Production Loss (PL) and Programme Health Assessments. These have been deemed to be more effective and have been chosen by Ringhals to be the main key performance indicators in the field of ageing management.
The analysis of LER/PL started 2020 for Ringhals 3 and 4 but it have been employed for events two years before that. The number of LER/PL have over the last three years slowly reduced. More use will assure consistency of the analyses.
Programme Health assessments corresponding to NEI Programme Health Reporting have been adopted to Swedish standards by the power plants within the ageing management forum FORSAMP. It is a method that is proactive in its form and give a good understanding of what efforts is needed to make the programme more effective. Ringhals begun doing these assessments in 2020, these indicators will be better over time as more assessments are done.
Further cooperation on ageing management between the Swedish licensee is implemented through a common ageing management development forum. The forum intends to further elaborate on future common key performance index development. The common forum also has a continuous discussion through the Swedish licensee's participation in IAEA - IGALL Phase 5 projects, which includes an update of the present IGALL Safety Report No.82. The updated report will include chapters on the evaluation of the effectiveness of ageing management programmes and associated examples of useful KPIs.

Ringhals considers the action resolved.

3.3.2. Review and update of overall Ageing Management Programme

Planned action
All TLAA's are updated and presented in the PSR for R3 and R4. The PSR was submitted to SSM April 2019. Extend Ringhals 3 pressurizer shell weld and also Low-Cycle Fatigue TLAA from 50 to 60 years of operation.
Deadline: 2023-12-31

Current progress
The progress in the pressurizer shell weld project is according to plan and results indicates that it will be possible to validate Ringhals Unit 3 pressurizer for 60 years of operation. A revised analysis package regarding thermal aging has been compiled and internal reviews are ongoing. According to an agreement with the authority, this analysis package will be submitted during Q2 2024 for their review.

Ringhals considers the action resolved

3.3.3. Methodology for scoping the SSCs subject to ageing management

Planned action
Evaluate the original scoping based on SR-57 with regards to SSG 48. Any discrepancies will be evaluated and managed in accordance with Ringhals ongoing routines for managing the scope.
Deadline: 2021-12-31

Current progress
To fulfill SSG48 Ringhals has included waste management to the scope. The work to sort out the valid SSC have started and will be completed during 2021.
To comply with new post Fukushima regulatory requirements for internal and external events, Ringhals has recently commissioned independent core cooling facilities able to supply the reactor vessels with cooling water in case of certain deterministic accident scenarios. These safety functions as design extension are parts of the SSG-48 scope.
As a part of a living programme, the scope of ageing management will continuously be evaluated and updated, either due to findings regarding present plant systems structures or components or due to managing of obsolescence or system upgrades, thus securing a living programme for upholding the managing of ageing over time.

Waste management was included in the scope in 2021.

Ringhals considers the action resolved.

3.4. Clab

In 2020, SKB was ordered by WENRA through SSM to implement the TPR process for ageing management at the Clab facility. Clab found that the process was applicable in four areas:

- Overall Aging Program Requirements and Implementation
- Electrical cables
- Hidden piping
- Concrete storage basins and connecting channels

The aim and goal for Clab was to identify areas for improvement in the existing programme and to propose measures and action plans in order to implement these improvements. Actions for improvement were found mainly in the overall ageing program.

3.4.1. Measure the overall improvement/impact of the introduction of the ageing programme on radiation safety.

The authorities required the development of ageing management programs in order to identify proactive methods that prevent ageing-related degradation of SSC. The requirement included documenting the implementation, results and effects. However, it was not clear how the effects would be assessed or measured.

Planned action
Develop KPIs or indicators to measure improvements and the effects of the ageing management programme.
Deadline: 2023

Current progress

By classification and prioritization of failure reports (FA) an indication of the effectiveness of the ageing programme can be obtained.
Failure reports are categorised into three different areas:

- Safety related errors, classification S
- Availability related errors, classification T.
- Other errors, classification Z.

With each classification being prioritized by:

- High priority, priority 1, where the FA is considered to have a major impact or risk.
- Normal prioritisation, priority 2 when the FA is considered to have a minor or insignificant impact or risk.

If the implementation of the aging program has a positive impact on the plant, it should be seen in a reduced number of safety-related FAs of both high and normal priority. That is, FA assessed as S1 and S2. It should also be able to provide some effect on accessibility-related FAs assessed as T1 and possibly T2. A follow-up of the fault report classified S1, T1 and S2 and T2 has been carried out and documented. The follow-up extends from 2010, i.e. before the introduction of the Ageing Programme, until 2023.

Clab considers the action resolved.

3.4.2. Use of more specified criterion to define conditional acceptance criteria.

Acceptance criteria should ensure that SSC can maintain intended functions during the planned period. These criteria are set to indicate when corrective action is to be taken performed and before a malfunction occurs. Clab has developed acceptance criteria based on internal experience, recommendations from suppliers, standards and environment, where it has been deemed possible and is relevant. On several SSC´s that are part of the ageing program, measurements are carried out continuously. Plant parameters are measured and acceptance criteria exist but a systematic method to visualize for example with diagrams needs to be implemented.

Planned action
View trends of measured results on SSC that are affected by ageing-related degradation, for example in diagrams, and compare these with acceptance criteria at an overall level.
Deadline: 2024

Current progress
A number of appropriate systems will be identified where it is possible to measure the function of SSC where trending enables detecting whether the function/component is approaching specified acceptance criteria, for example systems:

- System 662 Process network 660 V, resistance measurement circuit breaker.
- System 677 Battery-Secured AC Mains, Battery Capacity Check.
- System 723 Intermediate Cooling System, Cooling Capacity Check

A template (Excel spreadsheet) has been developed to enter measurement values and acceptance criteria as well as show it in diagrams. Four pilot cases will be established and results will be evaluated in 2024.

Clab considers this action in progress according to the time plan.

3.4.3. Improve knowledge and skills in the Ageing Programme at an overall level

SKB intend to improve knowledge and skills in the AM-programme by:

- Learning from work and design in other companies.
- Inform themselves about upcoming requirements and regulations.
- Networking nationally and internationally.

The aim is to learn from others in the industry and develop the ageing programme and contribute to with their own experience and methods.

Planned action
Participate in national and international forums, conferences, congresses, trainings or workshops, such as FORSAMP, WENRA, WANO, IAEA, IGALL or EPRI. The SKB Ageing Programme is part of the national cooperation group FORSAMP together with other licence holders in Sweden (FCCA). Clab plans to seek other suitable forums, conferences and workshops.
Deadline: 2023

Current progress
The SKB Ageing Programme is part of the national cooperation group FORSAMP together with other licence holders in Sweden (FCCA). Work to find other suitable forums, conferences and workshops is ongoing.

Clab considers the action resolved.

3.5. Regulator's assessment of the overall ageing management programme and conclusions

SSM agrees with the licensee that the actions that are considered to be resolved within the area concerning the overall ageing management programme have been resolved and the remaining actions will be handled by the supervisory programme and the PSR process to ensure they will be completed.

4. Electrical cables

4.1. FKA

4.1.1. AMP for ageing management of electrical cables

Planned action
A separate AMP for cables and cable system is under process of development and needs to be finalized and implemented.
Deadline: 2020-06-30

Current progress
To target the ageing degradation of electrical cables in a systematic manner, Forsmark performed a survey of the combined sum of existing activities managing electrical cables. The survey performed a comparison of external operational experience of best practice, both national and international. The survey also included an assessed the different methods which electrical cables can be condition monitored by, needed personnel qualifications and required specimen selections and intervals.
As a result of the reported survey on electrical cables, a strategy was formed to address the different identified areas for improvement. Examples of such areas for improvement consisted of the need to form a cable group entity for further development of ageing management programmes, collecting and sharing of knowledge and operational experience.
Since the strategy for electrical cables was formed, Forsmark has developed and implemented an ageing management programme (AMP) for electrical cables. The programme was developed using available information om international best practice, experience described in the IAEA IGALL AMPs, EPRI issued documentation and in cooperation with Ringhals NPP.
The documented AMP for electrical cables summons planned actions encompassing e.g. plans and procedures for one-time inspections, definition of scope for recurring walkdowns, training of personnel and routines for collecting of samples.

Forsmark considers this action resolved.

4.1.2. Appropriate techniques are used to detect degradation of inaccessible cables

Planned action
Forsmark is planning to analyze and test the condition of 6kV and 10kV cables within the NPP by using available methods, such as Tan Delta and Partial Discharge.
Deadline: 2023-12-31

Current progress
Condition monitoring tests, combined with visual inspections, are done at Forsmark Unit 1 & 2 for 6 kV Cables with a good result - No indications of significant ageing was found.
For Forsmark Unit 3, conditions monitoring tests combined with visual inspections of 10 kV cables has started and will be finished during 2024. The examination performed shows no signs of significant ageing so far.

Condition monitoring tests combined with walkdowns and visual inspections of HV cables are implemented as part of the ageing management program (AMP) for electrical cables.

Forsmark considers this action in progress.

4.2. OKG (No actions)

4.3. RAB

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

Planned action
Investigate the possibility for making cable deposits.
Deadline: 2019-12-31

Current progress
Cable deposits are to be installed in Ringhals 3 during the outage 2021.

Ringhals consider this action resolved.

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

Planned action
To analysis the validity of the activation energies used for cables.
Deadline: 2019-12-31

Current progress
An analysis of the validity of the activation energies for all components is finished. All activation energies for cables were found valid.

Ringhals consider this action resolved.

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

Planned action
Test 6 kV cables inside containment with the VLF Tan/Delta methodology.
Deadline: 2020-12-31

Current progress
The first VLF Tan/Delta tests on 6kV cables where done in 2020 in conjunction with switchgear jobs. No immediate problems where found but the test results will serve as a baseline for future tests.
The rest of the 6kV cables in Ringhals 3 and 4 will be measured during the remaining switchgear jobs until 2025.
The values obtained will indicate the needed intervals for further tests, also opportunistic tests will be done in case these cables are to be disconnected.

Ringhals consider the VLF Tan/Delta tests implemented and this action is thereby resolved.

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

Planned action
Clarify SSC credited in the plant safety analysis for a severe accident in the environmental qualification programme.
Deadline: 2022-12-31

Current progress
The additional SSC:s which are credited for Severe Accident and planned to be included in the EQ programme are SSC:s belonging to the consequence mitigating systems (360-systems). These systems are designed to handle Severe Accidents and associated environmental conditions. Since they are not safety functions they were not included in the scope for the EQ-programme at start. However, since they are safety related and designed to mitigate Severe Accidents Ringhals plans to include them in the EQ programme. This work remains to be done. A plan for this work will be formed 2021Q3. It can be noted that during 2020 the independent core cooling system (OBH) were installed. This system is situated in a new building designed to keep normal environmental conditions inside even after an initiating event. The OBH is included in the EQ programme. The OBH further reduces the probability for the need to use the consequence mitigating systems.

There are no electrical equipment credited for Severe Accidents (H5) inside the containment or in PMR. However there are integrity requirements for Electrical penetrations. Test specimen are prepared and the final tests are to be done during 2024.

Ringhals consider this action resolved

4.4. Clab (No actions)

4.5. Regulator's assessment and conclusions on ageing management of electrical cables

SSM agrees with the licensee that the actions that are considered to be resolved within the area concerning cables have been resolved and the remaining actions will be handled by the supervisory programme to ensure they will be completed.

5. Concealed pipework

5.1. FKA

5.1.1. Exchange Information and Experiences

Planned action
Forsmark will investigate how further cooperation can be organized.
Deadline: 2020-06-30

Current progress
As part of the cooperation on ageing management between the Swedish licensee, the subject of concealed piping is continuously discussed upon opportunity and necessity. This is to further identify examples in the typical Swedish designs which could implicate needs of ageing management development for buried or underground safety related pipework.
In addition, the Swedish licensee has initiated a joint annual meeting session involving plant engineering and mechanical maintenance staff to specifically discuss any recent operational experience involving concealed pipework. So far one such meeting session has been held.
In addition to these forums mentioned above, the Swedish licensee continuous to draft and assess information from the national and international operating experience and event reports issued by NORDERF, IAEA-IRS, WANO and EC-JRC-Clearinghouse.

Forsmark considers the action resolved.

5.1.2. Scope of Concealed Pipework included in AMPs

Planned action
Implement enhanced NSAS walk-down procedures and routines to include non-safety SSC's.
Deadline: 2021-05-30

Current progress
To further establish a complete scope of Structures, Systems and Components (SSCs) for ageing management in accordance with IAEA SSG-48, the scope has to be evaluated for other non-safety SSCs whose failure may prevent in-scope SSCs from fulfilling their intended functions (NSAS). To complete the scope for ageing management, such evaluation generally requires plant walk-downs to fully identify any such SSCs and complete the list of potential NSAS.
For the purpose of including NSAS structures or components, a walk-down procedure has been developed, documented and implemented as an appendix to the ageing management scoping instruction. The scoping instruction, as well as the walk-down procedure includes the evaluation of any concealed pipework components. Consideration is made to buried pipework as well as pipework placed in underground ducting or trenches, as well as a broader view to include NSAS.
The recently designed, constructed and commissioned independent core cooling facilities has prompted a further inclusion of structures, systems and components in the scope of ageing management to comply with the scoping criteria of IAEA SSG-48. The design of external civil structures for these facilities also encompass the introduction of some

concealed pipework for cooling water supply to the reactor buildings. These concealed pipework are identified as in-scope for ageing management.

Forsmark considers the action resolved.

5.2. OKG

5.2.1. Exchange Information and Experiences

Planned action
Oskarshamn will investigate how further cooperation can be organised.
Deadline: 2021-12-31

Current progress
As part of the cooperation within ageing management between the Swedish licensee, the subject of concealed piping is continuously discussed upon opportunity and necessity.

This is to further identify examples in the typical Swedish BWR designs which could implicate the need of ageing management development for buried or underground safety related pipework.

In addition, two of the Swedish licensee, Ringhals and Forsmark, have initiated a joint annual meeting session involving plant engineering and mechanical maintenance staff to specifically discuss any recent operational experience involving concealed pipework. So far one such meeting session has been held and for the next meetings OKG will be invited.

The licensee have also started a common work to develop technical specifications regarding civil structures.

In addition to these forums mentioned above, the Swedish licensee continue drafting and assessing of information from the national and international operating experience and event reports issued by NORDERF, IAEA/Igall, Energiforsk and FORSAMP.

OKG is engaged in several joint groups related to ageing management such as ELFORSK, EPRI, IAEA IGALL etc. and consider this to cover concealed pipework as well.
OKG is also planning for inspections in the fire fighting water system for Unit 3 during 2023/2024. The reason for this is that the pipes will be available due to maintenance work at the water hydrants.

OKG considers the action to be resolved.

5.2.2. Scope of Concealed Pipework included in AMPs

Planned action
Improvement in definition of non safety affecting safety in the scope of ageing management (NSAS).
Deadline: 2023-12-31

Current progress

OKG has defined a new scope for ageing management as a part of the LTO project. The new method used for the scope is based on IAEA SSG 48, especially chapter 5.16 a-c which also includes NSAS (NonSafetyAffectingSafety).

OKG considers the action resolved.

5.3. RAB

5.3.1. Exchange information and experience

Planned action
Ringhals will investigate how further cooperation can be organized.
Deadline: 2019-12-31

Current progress
As part of the cooperation on ageing management between the Swedish licensee, the subject of concealed piping is continuously discussed upon opportunity and necessity. This is to further identify examples in the typical Swedish designs which could implicate needs of ageing management development for buried or underground safety related pipework.
In addition, the Swedish licensee have initiated an joint annual meeting session involving plant engineering and mechanical maintenance staff to specifically discuss any recent operational experience involving concealed pipework. So far one such meeting session has been held.
In addition to these forums mentioned above, the Swedish licensee continuously draft and assess information from the national and international operating experiences and event reports issued by NORDERF, IAEA-IRS, WANO and EC-JRC-Clearinghouse.

Ringhals considers this action resolved.

5.4. Clab (No actions)

5.5. Regulator's assessment and conclusions on ageing management of concealed pipework

SSM agrees with the licensee that the actions that are considered to be resolved within the area concerning concealed pipework have been resolved and the remaining actions will be handled by the supervisory programme as well as the regulatory review of the PSR in order to ensure they will be will be completed.

6. Reactor Pressure Vessel

6.1. FKA

6.1.1. Environmental effect of the coolant

Planned action
When the unit enters LTO in 2025, the re-evaluated analyses will be in-place.
Deadline: 2024-12-31

Current progress
Further work to complete the remaining set of TLAAs for Unit 3 is commenced and is due to be completed in 2023. The TLAAs will be included in the regulatory processing of the Unit 3 PSR for LTO.

Forsmark considers this action in progress according to plan.
(See part 2.1.2)

6.2. OKG

6.2.1. Surveillance Programme for LTO

Planned action
The surveillance programme will be updated to cover the prolonged operational time (60 years).
Deadline: 2024

Current progress
The Surveillance programme is under working progress, due to some findings regarding the neutron fluency calculations. It shows some discrepancy between the historical analysis and the new ones from the EVND dosimeters. An analysis for finding the cause of the discrepancy has just been initiated. Contact between the contractors has just been taken. The authority would like to see an updated programme, but did not set a timeframe for the work.

OKG considers this action in progress according to revised time plan.

6.2.2. Environmental Effect of the Coolant

Planned action
This topic will be handled in the LTO-project as part of the TLAAs.
Deadline: 2024

Current progress
OKG uses attention values in environmental fatigue assessments, TLAA 106 (Environmentally Assisted Fatigue). The attention values are taken from the research report 2021:10 "Establishment and use of attention values in environmental fatigue assessments" published by the Swedish Radiation Safety Authority. TLAA 106 is seen as

part of TLAA 101 (Low-Cycle Fatigue Usage). Work is ongoing to review the load basis used in the fatigue analyses.

OKG considers this action in progress according to revised time plan.

6.3. RAB (No actions)

6.4. Regulator's assessment and conclusions on ageing management of reactor pressure vessels

SSM agrees with the licensee that actions will be handled by the supervisory programme as well as the regulatory review of the PSR in order to ensure they are or will be completed.

7. Concrete Containment Structures and pre-stressed concrete pressure vessel

7.1. FKA

7.1.1. Plant walk-down

Planned action
Forsmark intends to further elaborate and expand these plant walk-downs to meet updated governing instruction.
Deadline: 2021-05-30

Current progress
In each ageing management review, an assessment of whether there is a need for a walk-down regarding scope or component status is being done.
If the need for a plant walk-down is deemed necessary, it will be planned and carried out accordingly.
In addition, regular inspections regarding containment structures have been improved with more defined acceptance criteria and documentation procedures to create a better basis for status management. These instructions and procedures have been implemented and thus verified by performing of inspection activities.

Forsmark considers the action resolved.

7.1.2. Cooperation

Planned action
A plant-specific list of degradation mechanisms will be harmonized against national and international experiences such as IGALL and GALL.
Deadline: 2020-12-31

Current progress

A new list with degradation mechanisms that are in line with IAEA NP-T-3.5 and IGALL has been developed for concrete structures. This list is already being used as a template in new and revised ageing management reviews for concrete structures to identify current degradation mechanisms and ageing effects. It has been used for several new ageing management reviews for concrete structures, for example concrete structures indoors and outdoors and will be used in a current revised review for the containment.
Since the USNRC is actively represented in the IAEA IGALL projects, any new or re-defined GALL NUREG-2192 ageing degradation mechanisms are continuously being implemented in the IGALL report updates.

Forsmark considers the action resolved.

7.1.3. Trending analysis

Planned action
Forsmark intends to further elaborate and expand instructions regarding trending and follow-up.
Deadline: 2022-06-01

Current progress
New instructions and routines for creating a long-term and robust way of working have been developed.
Better defined acceptance criteria and requirements for documentation and reporting have been incorporated into existing and new instructions for maintenance. This has improved the reporting from maintenance inspections, which creates a better basis for trend analysis.
Trend analysis tools for civil structures have been created and implemented by the maintenance department and are monitored and evaluated through the technical area group for civil structures and components.

Forsmark considers this action resolved

7.1.4. Assessment of inaccessible and/or limited access structures

Planned action
Forsmark intends to inventory and review the occurrence of inaccessible structures.
Deadline: 2020-12-31

Current progress
An inventory of inaccessible areas and structures has been carried out by maintenance and engineering. Areas that are difficult to inspect have been identified. Thereafter, any consequences of this have been evaluated. In addition, alternative inspection methods and recommendations have been developed which are now being incorporated into ordinary inspection programmes in the form of clearer instructions and partly new inspection methods. One example of these inspection methods is the use of fiber optic cameras.
A guidance document for inspections has been developed, which prescribes certain methods to be used for inspection and evaluation of condition for some difficult to access civil structures and components of the pre-stressed reactor containments. This inspection methods will be tested and evaluated in the upcoming development of the inspection activities within ageing management of reactor containments, as well as civil structures in general. The development will be monitored and evaluated by the newly formed technical area group for civil structures.

Forsmark considers the action resolved.

7.2. OKG

Regarding the grouted tendons at unit 3, a monitoring test was performed 2020 to evaluate the behaviour. The test is a follow-up from the test performed in 2017.

The behaviour of the tendons and the concrete structure of the containment was monitored with strain gauges.
The test from 2020 is not yet fully evaluated but the preliminary results indicate a similar behaviour as in 2017, i.e. the behaviour of the structure was as expected. A comparison is also made with a theoretical FEM-analysis.
Since there is a big R&D test currently in progress in the permanently closed Barsebäck unit 2 reactor, the OKG test will be compared to the results from Barsebäck, once they are available.
The testing in Barsebäck is performed as a project within the scope of Energiforsk. The test is an attempt to evaluate the factual tension of grouted cables. Several material tests are performed, for the moisture profile of the concrete as well as of and for the tension cables. The purpose of the material tests is to calibrate the models that have been used, including re-evaluation of Oskarshamn unit 3 data.

7.2.1. Plant Walk-Down

Planned action
Plant walk- down
Deadline: 2023-12-31

Current progress

In the LTO project, a new scope has been developed which is based on the safety functions related to Oskarshamn 3. Walkdown has been carried out based on the components that occur in the most important fire cell boundaries related to the reactor safety that is pointed out in the analysis. If during the implementation of the project it is deemed necessary to carry out several or supplementary walkdowns, this will be performed.

OKG considers the action resolved.

7.2.2. Development and Improvement

Planned action
Continuing the visual inspections, that shall be documented in the C3.5-report. In the C3.5 there is a great deal of information given, which can be used for trending.
The inspections will be ended approximately in the beginning of 2020, and with that almost every room at unit 3 will have been inspected. Naturally, there will be an amount of rooms left that must be handled in the future and which are stated in the C3.5-report. The information from the baseline will even be an input for updating the defect definitions for civil so the deadline is therefore set at 2021.
Deadline: 2021-12-31

Current progress
The building inspections are ongoing and are part of the Preventive Maintenance programme. The intention is to go through the facility carefully and optimize the Preventive Maintenance programme.

A review has been carried out and the inspections are now carried out continuously and carefully according to instructions. There are also optimizations to perform, such as additions and updates as well as reviewing the intervals continuously.
The importance of these inspections is included in the preSalto review by the IAEA in 2022.
OKG has inspected the facility during several years continuously and systematically and documented this, and we have also taken account of the corrections or additions that need to be made.

OKG considers the action resolved.

7.2.3. Trending Analysis

Planned action
The rating scale for inspections needs to be further developed.
Deadline: 2025

Current progress
During the visual inspections there is a table given in the report/protocol from the two previous inspections which shall be compared to the ongoing inspections.
The trending analysis needs to be further developed in order to help prevent the structure from degradation related to ageing. Trending is currently only performed regarding pre-stressing forces for un-grouted tendons. The work needs to be based on internal and international standards.

Within the LTO-project, the "defect catalogue" is being updated.
Updating of the rating scale with associated information on grading of defects is something that may be performed after the defect catalogue has been updated.
In the future, the issue may be worked on further but it will not be ready until 2023/2024.

OKG considers this action in progress according to revised time plan.

7.3. RAB

7.3.1. Trending analysis

Planned actions
Developed the rating scale for inspections further.
Deadline: 2020-12-31

Current progress
Ringhals has developed the rating scale that is used during inspections. The rating scale has five steps where 0 is no remarks and 4 is severe malfunction of the structure. Every step is also judged according to type of deviation/malfunction where A is degradation, B is risk of personal injury and C is risk of effecting safety functions. The rating scale is implemented and documented in the "Function description of aging management of civil structures". However to be able to trend the results more inspections needs to be done.
In general, degradation of concrete structures are slow. The status of the structures are analyzed and actions are described in the strategic maintenance plans.
For the structures most important to safety (containment building and cooling water system) and for systems with many error reports (doors and hatches) system health reports

are done. In these reports the structure gets a grade based on different criteria and this grade is trended.
During the last year Ringhals also has started to perform programme health analyses, see 2.3.1. To ensure that the inspections are carried out in a reliable manner it is important to ensure that the quality of the programme is good. In the programme health report an ageing management programme gets a grade based on a multiple criteria analysis.
A few programme health reports have been done within the area of civil structures but it is too early to look at trends.

Ringhals considers the action resolved.

7.4. Clab (No action)

7.5. Regulator's assessment and conclusions on ageing management of concrete containment structures and pre-stressed concrete pressure vessel at the Swedish NPP

SSM agrees with the licensee that the actions that are considered to be resolved within the area concerning concrete containment structures and pre-stressed concrete pressure vessels have been resolved and the remaining actions will be handled by the supervisory programme ensure they will be completed.

8. Overall Assessment

Swedish licensee have pursued slightly different paths to develop their respective overall AMP, all with the goal to ensure the availability of required safety functions throughout the service life of the plant. Since SSM introduced a requirement for having an overall programme for ageing management in late 2004, all licenses has since after worked to systematically incorporate all the programmes to ensure a complete overall AMP.

SSM considers that all licensee now have an overall AMP that fulfils SSM requirements and international expectations. The key elements used by the Swedish licensee to assess ageing are based on the nine attributes in NS-G-2.12, which are similar to the ten elements described in NUREG-1801 and the licensee are all currently working to be consistent with SSG-48 as well as other new international guides.

SSM found previously in the NAR that none of the Swedish licensee have been working with quality management of the overall AMP in a systematic manner. SSM concludes that work has progressed a great deal in this area. All licensee have now implemented quality management and the cooperation forum FORSAMP has been very successful. SSM find it to be important for the licensee to continue this cooperation as well as participating in international forums in order to continuously improve quality management.

The NPP licensee follow the IAEA SALTO-process systematically by considering the recommendations and suggestions and taking actions in order to close the gaps. Results from SSM´s supervisory programme are in line with the SALTO.

During the TPR workshop in 2018, one of the challenges identified was “Acceptance criteria for the degradation mechanisms”. SSM concluded from the review that this was also a challenge for Clab. Furthermore, SSM also concluded that Clab need to perform more frequent trending analysis in order to prevent the structure from degradation related to aging. SSM concludes that the actions taken by Clab will enhance the ageing management programme as well as its results and has recently included Clab in the supervisory programme to ensure that the ageing management programme is effective. SSM intends to continuously follow the progress of the licensee´s work with ageing management in the supervisory programme.

Overall, SSM concludes that the Swedish licensee´s work on the action plans has been good and that the remaining measures in the action plans do not have a significant impact on radiation safety. These will be handled by the licensee in relevant programmes and followed up by SSM within the framework of the supervision programme. SSM therefore considers that the TPR process for aging management is now finalized.

9. References

[1] Topical Peer Review 2017, *Ageing Management, Swedish National Assessment Report,* SSM Report 2017:36
[2] ENSREG 1st Topical Peer Review, *Ageing Management, Swedish National Action Plan,* SSM Report 2019:17
[3] SSM report, *Follow up of ENSREG 1st Topical Peer Review Swedish National Action Plan for Swedish Nuclear Facilities*, SSM2021-1142-2, 2021-06-24