Strål säkerhets myndigheten
Swedish Radiation Safety Authority

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2019:17

ENSREG 1st Topical Peer Review Ageing Management Swedish National Action Plan

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SSM perspective

Background

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), have decided that the topic for the first topical peer review is ageing management.

This report include the Swedish National Action Plan addresses the results from the self-assessments and responds to the country specific findings allocated to Sweden in order to reach the Topical Peer Review expected level of performance.

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Content

1. Introduction

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), have decided that the topic for the first topical peer review is ageing management.

The objective of the first Topical Peer Review was to examine how well Ageing Management Programmes in participating countries meet international requirements on ageing management (in particular WENRA Safety Reference Levels – (SRLs) and the IAEA Safety Standards). Moreover, the objectives of the Topical Peer Review 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.

The Swedish Radiation Safety Authority (SSM) by the provision of the act of nuclear activities (1984:3) can decide by injunction that licensees 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).
Reports from all licensees were provided to SSM in June 2017. All information was processed and compiled in the Swedish national report (SSM report 2017:36) and distributed to ENSREG in December 2017.

The second phase started in January 2018 when the National Assessment Reports were made available for questions and comments from stakeholders. As an indication of the commitment to the Peer Review and the importance of the selected topic, this phase resulted in more than 2300 questions and comments. Subsequently, in May 2018, ENSREG organized a one-week workshop to discuss the results of the self-assessments, the questions and comments on the National Assessment Reports, as well as the replies to the questions, with a goal to identify and discuss both generic and country-specific findings on Ageing Management Programmes.

In the third and final phase of the Topical Peer Review, a Topical Peer Review Report and country specific findings have been compiled to provide input for national action plans and ENSREG work.

The main conclusion of the peer review is that Ageing Management Programmes exist in all countries for Nuclear Power Plants. In all countries, regulation of the Ageing Management Programmes is in line with the IAEA Safety Standards and WENRA Safety Reference Levels on ageing management. The review did not identify any major deficiencies in European approaches to regulate and implement Ageing Management Programmes at Nuclear Power Plants.

SSM decided in April 2019 that licensees operating nuclear reactors should report relevant information regarding the results of the TPR in accordance with the template

(ENSREG 1st Topical Peer Review Template National Action Plan on Ageing Management).
Reports from all licensees were provided to SSM in June-August 2019. All information from the licensees is included in this Swedish National Action Plan together with SSM assessment and was distributed to ENSREG in September 2019.

The Swedish National Action Plan addresses the results from the self-assessments and responds to the country specific findings allocated to Sweden in order to reach the Topical Peer Review expected level of performance. Furthermore, the Swedish licensees have taken into account all generic findings from the peer review and studied their applicability to improve implementation of Ageing Management Programmes at each Nuclear Power Plant.

The identified actions in the Swedish National Action Plan will be followed up in the Supervisory Programme for Nuclear Power Plants.

2. Findings resulting from the Self-assessment

This section lists the findings from the self-assessments as expressed in the Swedish National Report [1], referred to below "SSM Report 2017:36".

In the subsections below, Sweden's position for each finding is presented through a summary of actions that are planned to address each finding.

2.1. Overall Ageing Management Programmes (OAMPs)

2.1.1. State finding n°1, AFI, Systematic Quality management of the overall Ageing Management Programme

(SSM Report 2017:36 Chapter 2.7.1) None of the Swedish licensees have been working with quality management of the overall Ageing Management Programme in a systematic manner.

2.1.2. Country position and action on finding n°1

2.1.2.1. Forsmark position and action

Ageing Management Programmes are implemented according to IAEA standards and will be reviewed and assessed by SALTO review services in 2021.

Administrative controls is implemented via the quality management system and the instructions of the line organisation to verify the validity of the AMR reports, which are to be updated whenever needed. The AMR reports are used to update the maintenance system actions, testing procedures and inspections. The documented results of implementing the findings from the AMR's verify the implementation of the comprehensive ageing management for all relevant SSC's.

Progress of ageing management related actions in the CAP system are monitored and evaluated in the AMP group, consisting of representatives from respective involved departments. Forsmark plan to implement key performance indicators for the number of failures attributed to ageing degradation as a quota of the total number of failures. A new maintenance IT tool is being launched in 2021 that will enable recording a dedicated indicator of failures due to ageing when concluding a repair or restoration. The plan is to introduce the defined indicator in 2020. Presently an indicator based on LER and production loss failures is used.

Other indicators monitored are WANO SP1, SP2 and SP5, Number of regulatory injunctions, Availability and Number of LER's. These are all indicators which are likely to increase in the event of insufficient ageing management.

An upcoming plan is to define more effective indicators related to Ageing Management and this is an ongoing work together with Ringhals and Oskarshamn in joint ageing man-

agement development forum FORSAMP. The forum intends to compare/standardize indicators in between the Swedish utilities and to discuss the development of new common indicators. Recent focus has been to establish common criteria/interpretations for tagging of CAP actions and fault reports.

The FORSAMP is a well-established discussion and development forum in between the Swedish license holders, inclusive of the Swedish Nuclear Fuel and Waste Management Company (SKB). The forums main objective is to jointly review and discuss the interpretation and implementation of proven international guidance to meet national prerequisites and regulatory expectations in the development of systematic management of ageing and long term operation.

Action: Implement key performance indicator for ageing related failures.

2.1.2.2. Oskarshamn position and action

The process and instructions that are related to the living Ageing Management are well documented in our management system. According to these instructions AMP:s should be updated if there is a reason for this.

At the moment Oskarshamn has one defined KPI to measure the efficiency of the Ageing Management Program.

The intention is to implement more KPI:s related to Ageing Management and this is also an ongoing work together with Forsmark and Ringhals in FORSAMP.
Besides this there is also an ongoing work in Oskarshamn related to Equipment Reliability where one task is to identify proper KPI:s to measure the performance of programs used.

Action: In the AM instruction, include an obligatory update every 5 year for all AMP:s (done 2019)

Action: Enlarge the number of KPI:s (done 2020)

2.1.2.3. Ringhals position and action

The ageing management program is implemented according to IAEA standard and is verified by a SALTO review.

Administrative controls to verify the progress is in use for example AM documents are to be updated continuously when needed but not less often than every fifth year, AM documents are not released until the maintenance system is updated. Progress of ageing management related actions in the CAP system are monitored and evaluated in the AMP group.

Ringhals plan to implement a main key performance indicator as the relationship between number of faults related to ageing in relation to the total number of recorded faults. A new maintenance IT tool is being launched in 2020 that will make it possible to tag this type of faults when the fault is documented after completion. The plan is to introduce the

indicator the same year. Work is in progress to prepare the organization for the use of this indicator to be ready when the tool is updated.

In the meantime an indicator based on LER and production loss failures will be used. Other indicators that are followed are WANO SP1, WANO SP2, WANO SP5, Number of Authority injunctions, Availability and Number of LER's all which are likely to increase in case of insufficient ageing management.

This year we will add the trend of AM-tagged actions in the cap system.

Action: Implement main key performance indicator.

2.1.2.4. SSM Assessment

A key indicator is planned to be implemented in order to assess the effectiveness of the licensees overall Ageing Management Programme. SSM believes that this action, when implemented, will both develop and enhance current quality management of the OAMP in a systematic manner. SSM intends to follow up these actions in the supervisory programme.

2.1.3. State finding n°2, AFI, Use of more specified criterion to define conditional acceptance criteria

(SSM Report 2017:36 Chapter 2.7.1) High-level criterion should be more specified for example by a process for calculating specific numerical values to define conditional acceptance criteria to ensure the SSCs intended function.

An important attribute in ageing management is the establishment of acceptance criteria against which the need of corrective actions is evaluated. Swedish licensees use the high-level criterion that the SSCs shall maintain their intended function at the design basis events and during operating life. SSM considers that this high-level criterion should be more specified, to explain for example a methodology for calculating specific numerical values to define conditional acceptance criteria to assure the SSCs intended function taking into account sufficient margins.

According to SSM the purpose with acceptance criteria is to allow corrective action for SSCs to be implemented before loss of the intended function(s) for the SSC in question.

2.1.4. Country position and action on finding n°2

2.1.4.1. Forsmark position and action

All SSC are addressed in component group or object specific AMR documents which have evaluated and described the referred AMP's with aspect to specific acceptance criterions. The specific actions within each AMP contain the numerical values to define individual condition acceptance criteria.

When implementing AM actions or other procedures, each individual need for customized acceptance criteria is taken into account and applied.

Bases for development and improvement of methods to establish numerical acceptance criteria are often derived from knowledge and standards issued by such as ASME, EPRI, NUGENIA, Energiforsk or OEM component specific information.

Methods and acceptance criteria are continuously developed and improved by using R&D, trending and failure analysis.

Following the finalization of the LTO project in 2019 according to specifications in guide NS-G-2.12 and in order to achieve a complete scope of AMR's according to the new guide SSG-48, Forsmark has an ongoing action plan for the completion of only a few AMR updates for LTO.

Future upcoming need of amendments and modifications concerning AMR's and AMP's is managed by the line organizations and their respective responsibilities.
Forsmark will continuously improve methods, acceptance criteria and trending as part of ongoing work and is continuously governed by the current line organizations management instructions and documentation.

Forsmark consider this not to be an issue.

2.1.4.2. Oskarshamn position and action

Oskarshamn has developed approx. 30 different AMP:s which consists of IAEA nine paragraphs(SSG 48, table 2).

In the LTO project all AMP:s will be reviewed including the acceptance criteria for each AMP. In case any acceptance criteria don't fulfil the requirement, this will be fixed.

Action: Improvement of AMP:s acceptance criteria if necessary(done 2019-2023)

2.1.4.3. Ringhals position and action

All SSC are addressed in component or object specific ageing analysis documents which give specific acceptance criterions and descriptions of how these have been developed. Specific numerical values to define conditional acceptance criteria has been calculated where it is possible. The calculation methods is dependent on which ageing mechanism that is applicable and acceptance criterions are developed, conditioned that there should be sufficient margins and possibility for corrective action before a critical state occur.

Bases for development and improvement of e.g. methods to calculate numerical acceptance criteria are often produced in international cooperation such as for example within EPRI, NUGENIA, Energiforsk or OEM component/material specific groups.
For example acceptance criteria for concrete structures are based on ACI (American Concrete Institute) 349 and Swedish standard SS137010.

Methods and acceptance criteria are continuously developed and improved by using R&D, trending of faults and failure analysis.

Ringhals will continue to improve methods, acceptance criteria and trending as normal ongoing work. Ringhals thereby consider this not to be an issue.

2.1.4.4. SSM Assessment

SSM concludes that the licensees need to develop, in a systematic manner and on a national level, the process in working with acceptance criteria. SSM encourages the licensees for further cooperation and development in this area. SSM intends to follow up this issue in SSMs supervisory programme.

2.1.5. State finding n°3, Good Practice, Use of different timeframes

(SSM Report 2017:36 Chapter 2.7.1)
SSM considers that systematic assessment of preventive and remedial actions is a very important feature in ageing management that need to be documented and continuously evaluated. Forsmark also requires that for all systems a periodic system health report shall be compiled. This report is formed by interdisciplinary team members and identifies any need to improve preventive actions and needs for system or component upgrades. The time frames for the system health reports varies from short (0-3 years) to intermediate (upcoming 3-10 years) and finally plant end of life (60 years). SSM finds that systematic work with three different time frames demonstrates a mature organisation with regard to ageing management and is an example of a good practice.

2.1.6. Country position and action on finding n°3

2.1.6.1. Forsmark position and action

To further strengthen management of assets, Forsmark has implemented scorecards containing 17 defined indicators for system health reporting. The main objective is to measure plant status from various points of view in accordance with the pre-defined indicators of which one is labelled “long term planning”. This specific indicator includes Ageing Management Programs, plant strategies and long term plans per analysed plant system, thus forming a graded process feedback for the timely Managing of Ageing. In addition to this, indicator no.7 for System Performance and Trending will be integrated with reporting of identified degradation in performance with regards to ageing effects. All identified actions resulting from the forming of scorecards are evaluated in Forsmark risk assessment template to identify any possible impact due to defined criteria within the upcoming ten years.

The development of scorecards and the evaluative platform has been conducted in cooperation with Ringhals and Oskarshamn. Similar scorecards are implemented in all three utilities.

Forsmark considers this Good Practice implemented

2.1.6.2. Oskarshamn position and action

Oskarshamn has implemented scorecard containing 17 fixed indicators within System Health Reporting which will help Oskarshamn to obtain objective measurement of plant status. One of these indicators, “Indicator 12 – Ageing”, measures ageing with focus on important objects for the systems functions.

The system health reports updates annually but in specific cases the updates can be postponed or made in advance, depending on the system´s health or new experiences/incidents. The focus is to identify any need to improve preventive actions and needs for system or component upgrades.

Each identified action, verifies against MTP (Mid Term Plan), LTP (Long Term Plan) and LiTP (Life Time Plan). If the identified action is missing, the outcome is an observation that the management needs to consider and decide whether it’s needed or not. The observation turns into a recommendation if it´s approved. The observation is registered into the CAP system where an owner is named.

Oskarshamn consider this Good Practice implemented

2.1.6.3. Ringhals position and action

In order to strengthen asset management Ringhals has developed previous way of work that was same as Forsmark. International best practise within engineering is used and Ringhals has developed a scorecard containing 17 fixed indicators within System Health Reporting which will help Ringhals to obtain objective monitoring of plant status. One of these indicators measure “long term planning” which include Ageing Management Programmes, plant strategies and long term plans per system. Timeframe considered is from now to End of Life, EOL. Ringhals, Forsmark and Oskarshamn now uses similar scorecards.

Ringhals considers this Good Practice implemented.

2.1.6.4. SSM Assessment

SSM considers the licensees to have a systematic approach in assessing preventive and remedial actions. The system health reports are continuously evaluated in current health onto end of life. SSM considers the Good Practice implemented by all licensees.

2.1.7. State finding n°4, AFI, Fully implemented overall Ageing Management Programme

(SSM Report 2017:36 Chapter 2.7.3) Oskarshamn - Injunction. - SSM now considers that Forsmark and Ringhals have overall Ageing Management Programmes that fulfil SSM requirements and international expectations. The third licensee Oskarshamn has developed an overall Ageing Management Programme that still needs to be implemented in the organisation. SSM has by a decision (by injunction) issued as a condition for operation, that Oskarshamn for reactor Oskarshamn 3 shall have an implemented overall programme for ageing management before the end of January 2018 [2].

2.1.8. Country position and action on finding n°4

2.1.8.1. Oskarshamn position and action

In the end of January 2018, Oskarshamn got an approval from the regulator that the requirements are fulfilled(SSM2017-4265-17).

The ageing management in Oskarshamn is based on IAEA guides and are also reviewed by IAEA in SALTO missions.

Oskarshamn consider this Good Practice implemented.

2.1.8.2. SSM Assessment

The AFI applies to Oskarshamn who at the time of the TPR evaluation had not fully implemented the OAMP and therefore had an injunction from SSM to resolve remaining work that needed to be done. Oskarshamn have since shown SSM that the actions taken have made an impact on the OAMP and hence SSM now considers this AFI to be closed.

2.1.9. State finding n°5, AFI, Review and update of the overall Ageing Management Programme

(SSM Report 2017:36 Chapter 2.7.3) Review and update of the overall Ageing Management Programme for Swedish licensees is conducted in a similar manner as for updates in other programmes.

Findings from internal audits or external inspections by SSM, WANO or IAEA SALTO/OSART reviews normally result in tasks, documented in designated databases. Involvement of external organisations for review and updates of the overall Ageing Management Programme is according to SSM important to uphold its validity in the light of experience gained as well as of developments in science and technology. One important part for licensees to justify continued operation is to show that identified TLAAs meet the criteria established. The TLAAs should consider the entire remaining period of time for which the continued operation is planned. Additionally, it is SSMs view that results from international reviews of the overall Ageing Management Programme should be regarded as one basic information given in PSR documentation handed in by the licensees to justify that the programme is updated.

2.1.10. Country position and action on finding n°5

2.1.10.1. Forsmark position and action

Forsmark had a Pre-SALTO review in 2016 and one in 2019 and a full scope SALTO is planned for 2021. Frequent WANO reviews are also used as an important tool to improve various parts of working methods, management and quality.

All identified TLAA's have been considered and have been processed for the entire remaining period of the planned operation of 60 years for Forsmark Unit 1 & 2 as a part of the process for Periodic Safety review (PSR).

However, the Regulatory Body (RB) review of the PSR documentation for Forsmark Unit 1 & 2 has found some parts of the performed TLAA's as inadequate and in need of further re-work and therefore not approved. Furthermore, there were also TLAA's that was considered managed by AMR and AMP's which the RB did not approve as sufficiently managed, thus also concluding that the current methodology used for identification of TLAA is inadequate.

TLAA's identified by the RB as needing further development for LTO:
- Fatigue of containment linear plate and penetrations.
- Low-cycle fatigue, including environmental factors.
- Irradiation embrittlement of RPV for unit 1.
- Thermal ageing.
- Manufacturing defects.
- Irradiation induced stress corrosion cracking.
- Containment pre-stress tendons.

TLAA's currently managed by AMR and AMP's and identified by the RB as needing further development or clarification:
- Fatigue of cranes
- Environmental Qualification of electrical and I&C components.

The RB has via injunction requested an action plan to be presented for the planned amendment of the TLAA's in question.

The remaining TLAA's for Forsmark Unit 3 has a later plan due to Unit 3 entering LTO period in 2025.

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.

Action: Complete the work with the remaining relevant TLAA's for Forsmark Unit 3 to be valid for 60 years of operation.

2.1.10.2. Oskarshamn position and action

All findings (AFI) from WANO and IAEA-SALTO are recorded in Oskarshamn:s CAP tool CAP-SAFE which is integrated with the process for living ageing management.

Time Limited Ageing Analysis (TLAA) are used as a part to ensure some SSC:s functions in Oskarshamn. There is a continuously overview of these analysis where new knowledge and possible alteration in the construction and operation is considered.

The current status of the different TLAA:s are described in the PSR. In the power upgrade and life time extension project, PULS, TLAAs was performed for 60 years of operation. In an ongoing LTO-project a review and update of the TLAAs is performed, the work is planned to be finished in 2021.

Oskarshamn consider this area for improvement implemented.

2.1.10.3. Ringhals position and action

Ringhals have had a SALTO review in 2018 and a SALTO Follow-up is planned for March 2020. Frequent WANO reviews are also used as an important tool to improve different parts of Ringhals way of working.

The Ageing Management Program and the SALTO review are described in the PSR documentation that were submitted to SSM April 2019.

All TLAA's were updated and verified for operation beyond 40 years and included in the PSR. Two of these TLAA's are not yet fully validated for 60 years of operation, thermal ageing of Ringhals Unit 3 pressurizer shell weld material are verified for totally 45 years of operation and low cycle fatigue of Ringhals Unit 3 and 4 Spray- and Surge-piping with associated welds are verified for totally 50 years of operation.
There are ongoing prioritised projects to extend these two TLAA's for 60 years of operation.

Action: Complete the projects with the two remaining TLAA's to be valid for 60 years of operation.

2.1.10.4. SSM Assessment

The licensees have not yet completed all TLAA needed to verify safe operation when entering LTO. All licensees have developed actions, as described above, for the remaining TLAA in order to complete the analysis in due time. SSM considers the described actions to be adequate.

SSM does not agree with v that this AFI is implemented since the TLAAs were excluded from the latest PSR in 2017 by Oskarshamn. SSM has decided that Oskarshamn shall submit the TLAAs before the end of 2021.

2.2. Electrical cables

2.2.1. State finding n°1, AFI, Deal with ageing issues

(SSM Report 2017:36 Chapter 3.3)
The aim of the Ageing Management Programme is to deal with ageing's issues, which means to be proactive and not waiting until the cables are degraded and must be replaced through remedial actions.

2.2.2. Country position and action on finding n°1

2.2.2.1. Forsmark position and action

Forsmark combines the use of temperature monitoring and dosimeters, thermography camera, visual inspections and walk-downs in order to follow the ageing mechanism of electrical cables and their systems, both inside and outside the containment.
A separate AMP for cables and cable system is under process of development.

Action: Implement a separate AMP for cables and cable system.

2.2.2.2. Oskarshamn position and action

Analyses regarding ageing has been performed and that work will continue, based upon our knowledge about materials and surrounding environment and their ageing effects. Oskarshamn also tests cables at external test facilities, in order to determine the existing life time of cables and to verify that our analyses are correct. Visual inspections are also performed, with one task to react on degradation. These controls and their acceptance criteria are described in the AMPs for cables.

2.2.2.3. Ringhals position and action

Ringhals Strategic Maintenance Plan for cables deals with this, se NAR 3.1.1.
This is implemented via Ringhals Ageing Management Program.

2.2.2.4. SSM Assessment

SSM believes that the licensees perform measurements necessary to determine when replacement should take place.

2.2.3. State finding n°2, AFI, Consider hot spots

(SSM Report 2017:36 Chapter 3.3)
The use of qualified lifetime as a basis of maintenance might be an applicable method but the utilities have to consider if there are any hot spots and ensure that these hot spots will not impact the basis of the components qualification.

2.2.4. Country position and action on finding n°2

2.2.4.1. Forsmark position and action

Forsmark use thermography camera, temperature and humidity monitoring, dosimeters and walk-downs to identify possible hot spot that could have an impact upon cables and cable systems. The findings are evaluated and compared with the room environment data before they are implemented in Forsmarks maintenance plan.

2.2.4.2. Oskarshamn position and action

The rooms in the plant have been measured and analysed earlier, based on temperature, humidity and radiation. The work with verifying the earlier analyses and measurements are on-going. This work is done by measuring on selected positions, due to the possibility of detecting hot spots or increased values.

2.2.4.3. Ringhals position and action

Ringhals use walkdowns and thermography to find hot spots (areas – often localized – where temperatures and/or radiation dose rates are higher than expected). Those methods follow the recommendations in IAEA NP-T-3.6 ”ASSESSING AND MANAGING CABLE AGEING IN NUCLEAR POWER PLANTS”. This work is done frequently and according to maintenance plan.

Furthermore LIRA measurements are used to find changes which can be an effect of different degradation mechanism (high temperature, radiation, chemical influence, mechanical damages etc.).

Variation in the global environment (higher or lower than expected) not defined as hot spots are discussed in chapter 4.6.1.3.

2.2.4.4. SSM Assessment

SSM assesses that it is adequate that the licensees consider if there are any hot spots and have a method of ensuring that hot spots will not affect the basis of the components qualification.

2.2.5. State finding n°3, AFI, Cooperation between utilities

(SSM Report 2017:36 Chapter 3.3)
The cooperation between the Swedish utilities is very important to understand and learn more about degradations mechanisms. This will as well support utilities to carry out ageing analysis.

2.2.6. Country position and action on finding n°3

2.2.6.1. Forsmark position and action

Forsmark collaborates around cable and cable ageing issues with the Swedish NPPs and TVO in Finland. EKG (Electric Component Group) has a subsection for cable and cable system. They meet twice a year. Informal meeting and contacts occurs regularly between the NPP.

Internationally Forsmark is member of TeaM Cables - European Tools and Methodologies for an efficient ageing management of nuclear power plant Cables. Vattenfall is a

member of EPRI and Forsmark attends EPRIs yearly meeting Cable User Group for Nuclear Power Plants, Curtis & Wright EQ – Technical Meeting and IEEE & IEC cable research projects in order to follow the latest news in cable ageing.

2.2.6.2. Oskarshamn position and action

Oskarshamn will continue participating in EKG Kabelgruppen in order to share information about cables according audits, standards and regulatory requirements, tests/analyses/walkdowns, qualifications and experiences. All representatives in this group share information about cables, according to these topics. The representatives from each plant work with design, maintenance or quality issues.

2.2.6.3. Ringhals position and action

There is a cooperation between the Swedish Nuclear Power Plants and TVO in Finland within the framework of Electric Component Group. Cable ageing issues are dealt with in a subgroup with focus on cables and cable system. This cable group meets at least twice a year, but contacts between group members occur more often.
This is implemented in Ringhals Ageing Management Program.

2.2.6.4. SSM Assessment

SSM believe that the forums stated by the licensees are well suited as a platform to plan activities with regard to ageing management, for example to share experience and to learn more about e.g. degradation mechanisms and acceptance criteria. SSM welcomes the fact that the licensees e.g. are comparing their maintenance programmes in order to see if there are parts that can be adopted for all licensees. SSM notes that it does not appear that the licensees have any exchange in terms of ageing analysis, which SSM consider to be a task with improvement potential.

SSM would like to emphasize that the Ageing Management Programmes must be reviewed and updated in the light of gained experience and developments in science and technology in accordance with regulatory guide SSMFS 2008:1, Strålsäkerhetsmyndighetens föreskrifter och allmänna råd om säkerhet i kärntekniska anläggningar.

2.2.7. State finding n°4, AFI, Importance of modifying maintenance programme

(SSM Report 2017:36 Chapter 3.3)
The experience of the application of AMPs for electrical cables is that it is very important to modify the maintenance programme if needed, but also to perform constantly improvement regarding scope, methodology and frequency of existing AMP to ensure fulfilment of the objectives related to AMP.

2.2.8. Country position and action on finding n°4

2.2.8.1. Forsmark position and action

Forsmark continuously evaluate internal and external findings, experience and researches including ageing management. This follows the established process of our maintenance program.

2.2.8.2. Oskarshamn position and action

The AMPs are written to cover all cables in each cable class, without taken into account if their functions are classed as safety or none-safety. The AMPs are updated, if new experiences (both internal and external) are discovered. The preventive maintenance work is connected to the AMPs, so new experiences are also added to maintenance posts.

The methods for this type of work are evaluated and update due to new experiences, this will affect both the maintenance program and the AMPs. The AMP groups for instrumentation and electrical are responsible to keep the AMPs updated, so they contain the correct working methods and information.

2.2.8.3. Ringhals position and action

Experiences are evaluated continuously. The Strategical Maintenance Plan for cables is updated when new experiences or knowledge is present or at least every 5 years. The work follows the established process for evaluating internal and external experiences in the Maintenance Department.

All cables supporting a safety classified function are safety classified. The scope is stable and changes only when the safety class of the SSC that the cable support changes. These changes in safety class are done according to the Ringhals Quality Management System and result in changes in SAR SD 3.2.

All safety class cables (Class 1E) and also non-safety class cables if exposed to adverse environment are considered in Ringhals AMP for cables.

Methods for ageing management are evaluated when there are new internal or external experiences or when new knowledge are present via cooperation in research programs f.x. through Ringhals membership in EPRI. For more details see SSM 2017:36 TPR chapter 3.1.
This is implemented in Ringhals Ageing Management Program.

2.2.8.4. SSM Assessment

SSM considers that it is important that the Ageing Management Programmes must be reviewed and updated in the light of gained experience and developments in science and technology in accordance with regulatory guide SSMFS 2008:1, Strålsäkerhetsmyndighetens föreskrifter och allmänna råd om säkerhet i kärntekniska anläggningar

SSM acknowledges that the licensees evaluate internal and external knowledge concerning ageing management and if necessary updates the maintenance programme and SSM finds this sufficient.

2.2.9. State finding n°5, AFI, Forsmark injunction

(SSM Report 2017:36 Chapter 3.3)
According to SSMs decision Forsmark must:

- complete the analyses of components at the latest by November 2016 (performed and reported to SSM)
- inform and train operators and operations management about deficiencies concerning environmental qualification at the latest by March 2016 (performed and reported to SSM)
- annually (2016-2018) assess and report an overall assessment including performed measurement (for 2016 this was performed and reported to SSM)
- replace some components at the latest by 2018 or verify that they can withstand environmental conditions (for 2016 this was performed and reported to SSM)

SSMs work is still ongoing to ensure the fulfilment of SSM decisions by Forsmark.

2.2.10. Country position and action on finding n°5

2.2.10.1. Forsmark position and action

The injunction SSM2015-3079-22 was fulfilled in the end of 2018 and reported through the yearly report 2018 to SSM.

- The analyses are reported at 2016-11-30 to SSM through F-0038843.
- Information and training of operators and operation management was performed and finalized 2016-03-24. SSM has in an unannounced inspection 2016-04-20, verified that training and information was performed and finds the terms to be met, (SSM2016-2306).
- The overall assessment including performed measurement was reported to SSM at 2016-12-22 (F-0040804), 2017-12-28 (F-0069073) and 2018-09-26 (F-0088099).
- Replacement and verification of the components in injunction SSM2015-3079-22 was finalized and reported through the yearly report 2018 (F-0088099) to SSM.

2.2.10.2. SSM Assessment

SSM assesses that Forsmark has fulfilled their assignment.

2.2.11. State finding n°6, AFI, Oskarshamn injunction

(SSM Report 2017:36 Chapter 3.3)
SSM noted as well that Oskarshamn does not consider hot spots in AMP for electrical cables. Oskarshamn says that there are no cables which can be subject to higher temperature than 55°C or for radiation dose rate higher than 50 mGy/h.

SSM has by a decision (by injunction) issued an obligation for operation, that Oskarshamn for reactor Oskarshamn 3 shall have an implemented overall programme for ageing management before the end of January 2019 and also to consider hot spots within AMP.

2.2.12. Country position and action on finding n°6

2.2.12.1. Oskarshamn position and action

To verify the values within the environmental database, additional measurements are made for temperature and radiation. These sensors are installed, so they are able to detect increased values and verify the previous performed measurements. The AMPs are taken hot spots into account, during installation.

2.2.12.2. SSM Assessment

SSM assesses that Oskarshamn has fulfilled their assignment

2.3. Concealed pipework

2.3.1. State finding, AFI, Exchange information and experience

(SSM Report 2017:36 Chapter 4.3)
SSM concludes that the Swedish licensees Forsmark, Oskarshamn and Ringhals each have compiled an Ageing Management Programme that encompasses concealed pipework. The programmes are quite similar in scope while the results from the ageing assessment and the preventive actions differ slightly.

SSM believes it to be beneficial if the licensees would cooperate more on the matter, and perhaps discuss such topics as acceptance criteria and the reasons behind the differences in identified ageing mechanisms, as illustrated in NAR Table 10.

2.3.2. Country position and action

2.3.2.1. Forsmark position and action

Concealed pipework is part of the FORSAMP forum, however the cooperation in the field is not well developed. Due to specific Scandinavian climate adaption in plant design, the concept of concealed piping also needs to be further defined and established on a national level within the nuclear industry to further develop the scope of ageing management for LTO.

Forsmark aims to investigate how further cooperation can be organized.

Action: Investigate how further cooperation can be organized regarding concealed pipework.

2.3.2.2. Oskarshamn position and action

Oskarshamns position: Swedish utilities cooperates through several forums. THAG-BYGG (Common licensees working group regarding civil structure) with participants from Ringhals, Forsmark, Oskarshamn and SKB.

FORSAMP is a common forum with Ringhals, Forsmark, Oskarshamn and SKB, the purpose is to discuss ageing related issues when it's needed.

From the working group task assignments can be identified. For example there are one task assignment regarding comparing each licensees maintenance program and then after that to see if there are parts that can be adopted for all licensees.

Energiforsk is a R&D cooperation with Swedish and Finnish owner and SSM (the Swedish Radiation Safety Authority). Several topics have been investigated.

Regarding table 10, Oskarshamn have identified those ageing mechanism that can occur regarding cooling water channels performed in reinforced concrete. Some ageing mechanism considers to have a greater risk than others to occur, but there is, however, considered a theoretical possibility.

Oskarshamns position is that the topics regarding table 10 shall be handled in THAG-BYGG forum because its include the cooling water systems performed by reinforced concrete.

2.3.2.3. Ringhals position and action

Concealed pipework is part of the forum FORSAMP however the cooperation in the field is not well developed.
Ringhals will investigate how further cooperation can be organized.

2.3.2.4. SSM Assessment

SSM:s comment in the NAR "…beneficial if the licensees would cooperate more on the matter…" was made with respect to the already existing forums for cooperation that the licensees refer to above . SSM believe that these forums are well suited as a platform to plan activities with regard to ageing management, for example to share experience and to learn more about degradation mechanisms and acceptance criteria. SSM welcomes the fact that the licensees will investigate how further cooperation with respect to concealed pipework can be organized within these forums.

SSM notices that Oskarshamn has not provided a timeframe for the resolution of this AFI. SSM expect Oskarshamn to resolve the AFI within the same timeframe as put forward by Forsmark and Ringhals, or to provide SSM with a separate timeframe.

SSM would like to emphasize that the Ageing Management Programmes shall be reviewed and updated in the light of experience gained as well as developments in science and technology in accordance with regulatory guide SSMFS 2008:1, *Strålsäkerhetsmyndighetens föreskrifter och allmänna råd om säkerhet i kärntekniska anläggningar*.

2.4. Reactor pressure vessel

2.4.1. State finding n°1, Surveillance programme for LTO, AFI Forsmark

(SSM Report 2017:36 Chapter 5.3)
With respect to the plans for LTO of Forsmark 1-3, SSM considers that the surveillance programmes for those reactors need to be further developed to cover LTO until 60 years of operation.

2.4.2. Country position and action on finding n°1

2.4.2.1. Forsmark position and action

Forsmark surveillance program is updated to cover Long Term Operation (LTO). Forsmark surveillance program has fixed withdrawal schedule for the remaining capsules, it is presented in report FTM-2014-0716, that is notified and approved by the Swedish authority.

The schedule is as follows, Unit 1 schedule B capsule 2023, C capsule 2040. Unit 2 schedule B capsule 2018, B capsule re-constituted 2020 and withdrawn 2028 and C capsule 2031. Unit 3 schedule B 2025, C capsule 2035.

As a supplement to the surveillance program EX-Vessel Neutron Dosimetry (EVND) is installed in unit 3 2016, unit 2 2018 and EVND will be installed in unit 1 2020.

A development is to gather all Uddcomb manufactured Swedish BWR vessels in a developed Embrittlement Trend Curve (ETC) where every aspect from surveillance testing are documented and evaluated.

Program CARPE for material testing started 2016-2020 to gather material information on base- and welding material from Forsmark unit 1, unit 2, unit 3 and Oskarshamn unit 3. The material samples are neutron irradiated in situ in an accelerated position in unit 3.

2.4.2.2. SSM Assessment

SSM assesses based on the review that the updated surveillance program meets internationally accepted standards in the field and that the adaption of the program to the special conditions for Swedish RPVs has been performed in an acceptable manner. SSM will continue to follow-up on the on-going work with the development of the ETC as well as program CARPE.

2.4.3. State finding n°2, Surveillance programme for LTO, AFI Oskarshamn

(SSM Report 2017:36 Chapter 5.3)
With respect to the plans for LTO of Oskarshamn 3, SSM considers that the surveillance programme for this reactor needs to be further developed to cover LTO until 60 years of operation.

2.4.4. Country position and action on finding n°2

2.4.4.1. Oskarshamn position and action

The surveillance program will be updated to cover the prolonged operational time (60 years). This will be handled during 2019. Oskarshamn 3 will enter the LTO-period in 2025.

The situation with one remaining chain of test specimen is sufficient, according to our calculations. The most recent withdrawal and examinations of test specimens in 2017 give us knowledge of the behaviour of the vessel material up to 2035. The final withdrawal in approx. 2035 will then cover the rest of the lifetime, up to 60 years of operation. Oskarshamn follows the standard ASTM E2215-15. As a part of the updated program, external neutron dosimeters will be installed on the outside of the reactor pressure vessel in the outage of 2019. The dosimeters will be positioned in the same angle as the last remaining chain of test specimens, situated in the down comer. This will give a possibility to get an accurate neutron dose calculation for the test specimens. This is essential, since the chain of specimen lacks the special “neutron foil” that is usually analysed for this purpose. It will also give a possibility to evaluate the neutron doses at certain intervals during the next coming years, and by that adjust the surveillance program, if needed. The chain of specimen can also be moved to a position with higher neutron flux in order to justify an even longer operational time of the pressure vessel.

2.4.4.2. SSM Assessment

Oskarshamn has developed the surveillance programme for Oskarshamn 3 to cover LTO until 60 years of operation. The updated surveillance report has been received by SSM and will be reviewed during the autumn of 2019.

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

2.5.1. State finding n°1, AFI, Plant walk-down

(SSM Report 2017:36 Chapter 7.3.3) It is important to perform a plant walk-down as a way to help identify those systems which might, if they malfunction, affect the function of a safety classified system.

2.5.2. Country position and action on finding n°1

2.5.2.1. Forsmark position and action

Non-safety-rated SSCs that can affect safety-rated SSC (NSAS) have been identified and evaluated in scooping and screening according to then applicable governing instructions. Specific walk down to only look at NSAS for civil structures has not been done.

Plant walk-downs is however done at a large extent during inspections and checks that take place at predetermined intervals stored in the maintenance system. The system automatically requires walk-down performed according to documented procedures. Non safety affecting safety, NSAS, is part of the inspections carried out.

The approach is that a work order is automatically generated for the job, when the predetermined interval occurs. The results from the walk-downs are reported in the maintenance system and inspection records and damage reports from the inspections are documented in the document management system, Arken. The results from the inspection programs are analysed in order to assess the status of the structure and to identify any actions required. Current status and actions carried out is documented in specific system health reports, SHR, which is then used as basic references in the continued work with ageing analyses.

NSAS is also part of the project structure and are always evaluated before introducing changes in the plants.

Forsmark intends to further elaborate and expand these plant walk-downs to meet updated governing instruction. (See part 3.2.4 for action regarding extended procedure for NSAS.).

2.5.2.2. Oskarshamn position and action

Several walkdowns have been conducted through several project in the history.

This topic as well as the other disciplines regarding NSAS, will be handled in the LTO-project as a general issue in the scoping method and will be finished latest 2023.

2.5.2.3. Ringhals position and action

Non safety affecting safety, NSAS, evaluations has been done at a large extent during many years using analysis and walk downs. The LTO-project prior to the SALTO review verified the plants for NSAS.

NSAS is as a rule considered when changes in the plants are done and walk downs are done as part of inspections, plant modifications and for system health assessment.

Ringhals have no further actions planned for this AFI except the normal ongoing work.

2.5.2.4. SSM Assessment

SSM notice that Forsmark uses walk-downs for inspection which includes NSAS. But it is not clear if Forsmark uses dedicated walk-downs as a way to help identify NSAS in order to include them in their Ageing Management Programme. SSM found during an inspection *(SSM, Inspektionsrapport av Forsmarks underhållsverksamhet, 2019-03-11, SSM2018-3238-4*) that SHR is not developed for all SCCs. SSM sampled some SCCs during the same inspection which showed that some SHR were not updated. SSM asses that there are shortcomings in this work with SHR, and Forsmark needs to rectify it before SHR can be used as basic references in their continued work with ageing analysis. Forsmark had a pre-SALTO peer review mission performed in June 2019. The review team assessed that no dedicated walk-downs have been performed to verify that all NSAS SSCs are included in the scope of LTO. The review team also found that some NSAS SSCs had not been included in the scope of ageing management.

Based on Oskarshamn's response, SSM notes that Oskarshamn has not yet conducted walk-downs in all areas, but that the work is ongoing. SSM asses that there is currently a risk that some of the systems which might, if they malfunction, affect the function of a safety classified system i.e. NSAS are not currently included in their Ageing Management Programme. SSM would like to point out the importance of including these systems in the Ageing Management Programme as soon as possible. Oskarshamn had a Pre-SALTO peer review mission performed in November-December 2017. The review team assessed that no walk-downs were performed to identify and verify SSCs in scope (safety and non-safety).

SSM asses that Ringhals has implemented walk-downs to help identify NSAS. SSM welcomes the fact that Ringhals carries out walk-downs in order to help identify NSAS in connection to plant modifications. SSM further assumes that these NSAS are included in the Ageing Management Programme. Ringhals had a SALTO review done in February-March 2018 which showed that Ringhals has a wide application of walk-downs in the scoping process and the SALTO team assed it as a good performance.

SSM asses that all Swedish licensees implement walk-downs in various degree in order to help identify NSAS. SSM’s position is that plant walk-downs are important in order to identify those systems, structures and components which might, if they malfunction, affect the function of a safety classified system. It is also important to implement these NSAS in the plant´s Ageing Management Programme. SSM intends to follow up this issue in the supervisory programme.

2.5.3. State finding n°2, AFI, Cooperation

(SSM Report 2017:36 Chapter 7.3.3) A cooperation between the Swedish utilities is very important in order to understand and learn more about degradation mechanisms and acceptance criteria.

2.5.4. Country position and action on finding n°2

2.5.4.1. Forsmark position and action

Swedish utilities cooperates through several forums in the field. Degradation mechanisms and acceptance criteria is part of the task assignment in several of them.

- Together with other Nordic nuclear power companies and SSM, Forsmark participates in Energiforsk, primarily in research collaboration on concrete constructions.
- Forsmark is part of the TUD group, together with Oskarshamn, Ringhals, SSM and TVO (Teollisuuden Voima Oyj). The TUD system is an information system for the collection, processing and presentation of reliability data.
- The licensees' working group (THAG) addresses common issues in the area of construction engineering, both with regard to design and maintenance, such as when interpreting requirements and responding to regulations. This working group meets three times a year.
- Norderf is a Nordic operating experience organization led by KSU AB (Nuclear safety training) on behalf of the Swedish and Finnish nuclear owners. Members include Forsmark, Oskarshamn, Ringhals, TVO, SKB (Swedish Nuclear Fuel and Waste Management Company) and KSU. This organization screens and distributes events from the Swedish, Finnish and other nuclear power plants, facilities and authorities, including such sources as WANO, IAEA and NRC.
- In February 2019, Vattenfall also became a full member of EPRI, Electric Power Research Institute. EPRI is a utility research and development organization that was formed after an extensive power outage in the northeastern USA in 1965. The agreement means that Vattenfall, KSU, SVAFO, SKB, Ringhals and Forsmark will have access to specialist support in advanced technical issues and access to the very latest research from EPRI in the nuclear field. (SVAFO is owned by the power companies Ringhals AB, Forsmarks Kraftgrupp AB and Oskarshamn AB and has the task of decommissioning nuclear facilities and take care of nuclear waste from early Swedish nuclear research)
- There is also topic-specifik collaborations between the Swedish utilities, for example regarding coating (TBY).
- NOG (Nordic Owner Group) is a cooperation for security and environmental issues at the Nordic BWR plants. Participants are Forsmark, Oskarshamn, Ringhals och TVO. The task is to identify problems of a generic nature and to gather information that can be used to eliminate such problems.

During daily work with continuous improvement, a plant-specific list of degradation mechanisms will be harmonized against national and international experiences such as IGALL and GALL.

Action: A plant-specific list of degradation mechanisms will be harmonized against national and international experiences such as IGALL and GALL.

2.5.4.2. Oskarshamn position and action

Swedish utilities cooperates through several forums. THAG-BYGG (Common licensees working group regarding civil structure) with participants from Ringhals, Forsmark, Oskarshamn and SKB.

From the working group task assignments can be identified. For example there are one task assignment regarding comparing each licensees maintenance program and then after that to see if there are parts that can be adopted for all licensees.

There is also a cooperation regarding coating and surface treatment.

Energiforsk is a R&D cooperation with Swedish and Finnish stakeholders and SSM (the Swedish Radiation Safety Authority). Several topics have been investigated.

Regarding degradation mechanisms, the original list is made in the work of FORSAMP. That the degradation mechanisms differs in the report may be a result of that the licensees have interpreted the question differently.

The degradation mechanisms are based on international experiences such as IGALL and EPRI but and even Swedish national experiences.

Oskarshamn has been a member of IAEA/IGALL Working Group in phase 3 and 4 regarding Civil Structure which has been very useful.
IGALL (International Generic Ageing Lessons Learned) is an international forum/working group that is a part of IAEA. The participants in the forum are from all around of the world, both from regulators and licenses. The forum shares a lot of experiences related to Ageing and Long Time Operation.

FORSAMP is a Swedish national forum with Ringhals, Forsmark, Oskarshamn and SKB, the purpose is to discuss ageing related issues..

2.5.4.3. Ringhals position and action

Swedish utilities cooperate through several forums in the field. One example is THAG-BYGG (Licensees working group regarding civil structure). This working group meets three times a year to discuss current topics/issues/experiences. Participants from Ringhals /Forsmark/ Oskarshamn /SKB attends to the meetings.

From the working group task assignments are identified. For example there are one task regarding comparing the licensees maintenance programs in order to see if there are parts that can be adopted for all licensees.

There is also a cooperation regarding coating.

One other example of forum is Energiforsk in which Swedish and Finnish stakeholders and the authority cooperates regarding research and development.

Regarding degradation mechanisms, Ringhals has considered more degradation mechanisms than those mentioned in the NAR. That the degradation mechanisms differs in the report may be a result of that the licensees have interpreted the question differently. The degradation mechanisms are based on international experiences such as IGALL and GALL.

Ringhals have no further actions planned for this AFI except the normal ongoing work.

2.5.4.4. SSM Assessment

SSM believe that the forums stated by the licensees are well suited as a platform to plan activities with regard to ageing management, for example to share experience and to learn more about e.g. degradation mechanisms and acceptance criteria. SSM welcomes the fact that the licensees e.g. are comparing their maintenance programmes in order to see if there are parts that can be adopted for all licensees.

SSM would like to emphasize that the Ageing Management Programmes shall be reviewedand updated in the light of experience gained as well as developments in science and technology in accordance with regulatory guide SSMFS 2008:1, *Strålsäkerhetsmyndighetens föreskrifter och allmänna råd om säkerhet i kärntekniska anläggningar.*

2.5.5. State finding n°3, AFI, Development and improvement

(SSM Report 2017:36 Chapter 7.3.3) The licensees should handle the issues in the report 2017:36 which they conclude are missing or should be improved in order to develop and improve their Ageing Management Programme for concrete structures. SSM furthermore believes that it would be beneficial for the programmes if the licensees were to share their experiences identifying these improvements and in implementing their solutions amongst each other.

2.5.6. Country position and action on finding n°3

2.5.6.1. Forsmark position and action

Forsmark has developed and improved the program for ageing management overall, not just regarding concrete structures. Ageing analyses are reviewed and updated in normal ongoing work at least within a five year interval. Instructions regarding inspection of concrete structures has been reviewed and updated. Walk-down inspections are performed regularly.

Findings from the Pre SALTO-review, the LTO-project, and other internal/external experiences will be incorporated in the ageing management program for concrete structures.

Experiences are continuously shared in the several forums existing between the licensees.

2.5.6.2. Oskarshamn position and action

Maintenance instructions, AMPs and other ageing documents have and will be updated in the future when needed.

The status today is that the scope regarding ageing must be updated with those buildings that are non-safety classified if they contains systems covered by STF chapter 4 or if the buildings are built together with a classified building. During the walk-down/inventory which is done together with visual inspections that issue has been obvious. The scope re-wising will be done in the LTO-work.

Swedish utilities cooperates through several forums. THAG-BYGG (Common licensees working group regarding civil structure) with participants from Ringhals, Forsmark, Oskarshamn and SKB.

From the working group task assignments can be identified. For example there are one task assignment regarding comparing each licensees maintenance program and then after that to see if there are parts that can be adopted for all licensees.

Energiforsk is a R&D cooperation with Swedish and Finnish stakeholders and SSM (the Swedish Radiation Safety Authority). Several topics have been investigated.

The maintenance which is performed for civil structures is after the year of 2018 documented in a more detailed form in reports with a documentation code C3.5. This was also a remark from the Pre-SALTO review in 2017.

Regarding acceptance criteria the visual inspection has since the year of 2018 documented in detail in the C3.5-report, when defects have been detected, they are graded based on their assessed extent. Depending on this, a picture for future following up is taken or a fault report is written if action is to be carried out.

The Ageing program are now implemented and approved by SSM and the AMPs and other ageing documents are being updated when new facts are available.

In the C3.5-report which is mentioned above there is stated a lot of information, a rating scale is implemented, the rating of the degradation is linked to the actual building, room, commodity grouping, ageing effects. There is given more detailed information about the status in the report such a summary etc.

2.5.6.3. Ringhals position and action

Ringhals strategic maintenance plans regarding civil structures are now updated. The maintenance plans have included findings from the LTO-project, SALTO-review and other internal/external experiences. To continuously develop and update maintenance plans is normal ongoing work.

Several forums exists between the licensees where experiences are shared, se 2.5.4 and NAR 7.3.3.

Ringhals have no further actions planned for this AFI except the normal ongoing work.

2.5.6.4. SSM Assessment

SSM trust that the licensees handle or have plans for the deficiencies they identified themselves within the framework of the TPR work. However, like stated under section 2.5.4.4, SSM would like to emphasize the importance that the Ageing Management Programmes shall be reviewed and updated in the light of experience gained as well as developments in science and technology in accordance with regulatory guide SSMFS 2008:1, *Strålsäkerhetsmyndighetens föreskrifter och allmänna råd om säkerhet i kärntekniska anläggningar.*

2.5.7. State finding n°4, AFI, Trending analysis

The licensees need to perform more trending analysis on a regular basis in order to prevent the structure from degradation related to ageing.

2.5.8. Country position and action on finding n°4

2.5.8.1. Forsmark position and action

Instructions regarding inspections has been supplemented with a rating scale to make it easier to assess, evaluate and classify damage in buildings. Instructions which, among other things, describes how TLAA should be updated, and how trending / follow-up shall be performed, is currently being written. The instruction applies primarily to pre-stressing tendons and to the "containment partition slab gasket", but other areas will also be included in this instruction.

Action: Forsmark intends to further elaborate and expand these instructions.

2.5.8.2. Oskarshamn position and action

During the inspection, the protocol from previous inspection is included to be able to compare if there are any changes or following up stated. How to trend the results is based on the rating scale stated in the C3.5-report.

The maintenance which is performed for civil structures is after the year of 2018 documented in a more detailed form in reports with a documentation code C3.5. This was also a remark from the Pre-SALTO review in 2017.

Regarding trending we make a comparison with the inspections that was done before the one which is ongoing. A defect is rated after a scale and the scale states how it shall be documented, only a note, a photo and when a Fault report shall be written.

Regarding trending related to Fault report a summary is made every year for the systems and documented in a report.

Action: The rating scale for inspections needs to be further developed and will be finished latest 2023.

2.5.8.3. Ringhals position and action

Instructions regarding inspection of concrete structures have now been developed. A rating scale has been developed and more photos are included in the reports. Earlier, only findings were included in the inspection report, but now each room/position is included in the report. During the inspection, the protocol from previous inspection must be included to be able to compare if there are any changes. How to trend the results based on the rating scale needs to be further developed. To produce good quality trends, further inspections need to be performed with the method.

Trending is performed regarding the pre-stressing force in the tendons.

Action: The rating scale for inspections needs to be further developed.

2.5.8.4. SSM Assessment

SSM asses that trending analysis needs to be further developed for all the Swedish licensees 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.

3. Country specific findings resulting from the TPR

This section lists Sweden´s specific findings resulting from the Topical Peer Review
In the subsections below, Sweden´s position for each finding is presented through a summary of the actions that are planned in order to address each finding.

3.1. Overall Ageing Management Programmes (OAMPs)

3.1.1. Good Practice: External peer reviews services

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

3.1.2. Country position

3.1.2.1. Forsmark position

Forsmark has performed two Pre-SALTO reviews, one in 2016 and one in 2019. Full scope SALTO review is planned to be performed in 2021.

After performing the latest IAEA Pre-SALTO review in 2019, Forsmark has committed to produce a renewed action plan for further handling and follow-up of the total number of detailed input or amendments needed as a result of the review results. The action plan is part of the Forsmark Reactor Safety Program and monitors the progress of all plant programs.

The use of peer review services e.g. IAEA and WANO review services is part of the strategic enhancement of safety culture in Forsmark.

Forsmark considers this Good Practice implemented.

3.1.2.2. Oskarshamn position

Using SALTO peer review services provided by IAEA is a part of the LTO concept in Oskarshamn and handled by a separate sub project in the LTO project.

A preliminary plan is set as follows:
2019Q4-expert mission
2021Q1-pre SALTO
2023Q3-SALTO
2025Q1-Follow-up Salto

All findings from external peer reviews e.g SALTO, WANO are recorded in the CAP system with traceable “area-codes” for an easier follow up by responsible department in Oskarshamn.

Oskarshamn consider this Good Practice implemented.

3.1.2.3. Ringhals position

Ringhals has had a SALTO review in 2018 and a SALTO Follow-up is planned for March 2020.

Ringhals considers this Good Practice implemented.

3.1.2.4. SSM Assessment

All Swedish licensees are obliged by their management system to use external organisations such as WANO and IAEA in reviewing the plants programmes and organisation continuously. The results of the external reviews show in all cases that the Swedish licensees are perceived as professional, open, transparent, receptive to suggestions for improvement, and the management is committed to improving the plants status. Plant walkdowns performed by the review teams have shown that the Swedish plants are in good condition. SSM believes these results show that the Swedish plants have a good solid base for continued operations and by continuing to work proactively and in cooperation with internal and external organisations, the plants have the prerequisites for continued operation.

Since all the licensees are approaching LTO, specifically SALTO/Pre-SALTO missions are performed to help ensure adequate implementation of the overall Ageing Management Programme and LTO. SSM considers this a beneficial method for the licensees´ LTO.

SSM considers this good practice to be fully implemented in the Swedish plants but would like to stress the fact that the licensees need to prioritize and manage the recommendations and suggestions that arise from the reviews. SSM would also like to note that it is important for the licensees to ensure there is enough time to implement recommendations and suggestions that arise from Pre-SALTO and SALTO before entering LTO.

3.1.3. Good Performance - TPR expected level of performance: Data collection, record keeping and international cooperation

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

3.1.4. Country position

3.1.4.1. Forsmark position

R&D is performed within several areas in which there are appointed specialists responsible for projects in respective field of expertise. The goal of the R&D is to strive towards preparedness for future demands, to build competence, to develop methods and tools and to follow field research. Forsmark regularly participate in both joint projects between other Nuclear Operators and the Regulatory Authority and in other national and international groups such as for example EPRI, NUGENIA, Energiforsk and OEM specific groups.

Forsmark considers this Good Performance implemented.

3.1.4.2. Oskarshamn position

Oskarshamn are participating in the IAEA/IGALL project since 2011 and are also participating in other forums such as Energiforsk and EPRI.

Information from these forums, such as new testing methods, new techniques, lessons learned etc., are used to update and improve our AMP:s which results in an more effective OAMP.

Oskarshamn consider this Good Performance implemented

3.1.4.3. Ringhals position

R&D are performed within several areas in which there are appointed specialists who are responsible for projects in their field of expertise. The goal of the R&D is to strive towards preparedness for future demands, to build competence, to develop methods and tools and to follow research in the field. Ringhals participate in both joint projects between other Nuclear Operators and the Authority and in other international groups such as for example EPRI, NUGENIA, Energiforsk and OEM specific groups.

Knowledge obtained is for example used to identify new ageing mechanisms, how to detect them and to improve existing detection methods. Better methods makes it possible to detect ageing effects earlier and to follow changes that before have been undetectable.

Ringhals considers this Good Performance implemented.

3.1.4.4. SSM Assessment

SSM believes that collaboration between the licensees themselves and with international organisations ensures a proactive approach and strategy whilst working with ageing management. SSM considers this good performance to be implemented in a good manner.

3.1.5. AFI - TPR expected level of performance: Methodology for scoping the SSCs subject to ageing management

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

3.1.6. Country position and action

3.1.6.1. Forsmark position and action

The present scope setting and methodology for ageing management and LTO will be re-evaluated considering the definitions given in SSG-48. The present scope, based on definitions given in NS-G-2.12 and SR-57, will be assessed for any discrepancies and further managed in accordance with established routines for managing the scope of ageing management for long term operation.

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.

3.1.6.2. Oskarshamn position and action

Implementing SSG 48 is an ongoing work in Oskarshamn by the LTO project. Oskarshamns ongoing LTO project is based on the new IAEA guide SSG 48 while the internal requirements on ageing management is based on the old IAEA guide NS-G2.12. 2023 when the new scope, as latest, will be delivered by the project to the living ageing management, the new scope will replace the old scope.

Oskarshamn consider this ELP implemented.

3.1.6.3. Ringhals position and action

SSG-48 will be evaluated with regards to the methodology for scoping for the SSCs subject to ageing management. Any discrepancies compared to Ringhals original scoping based on SR-57 will be evaluated and managed in accordance with Ringhals routines for managing the scope.

Action: Update the scooping based on NS-G 2.12 and SR 57.

3.1.6.4. SSM Assessment

SSM believes the licensees are striving towards evaluating the Ageing Management Programmes according to the new IAEA SSG-48. SSM intend to follow the progress of the work in SSMs supervisory programme.

3.1.7. AFI - TPR expected level of performance Delayed NPP projects and extended shutdown

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

3.1.8. Country position and action

3.1.8.1. Forsmark position and action

For each commodity group, ageing is analyzed and documented by appointed experts responsible for the area. The analysis is renewed and updated continuously and includes utilizing feedback from the experience feedback system, feedback from work order system and expert knowledge from area specific working groups.
This work includes information on changes in operational and environmental conditions, if such change in conditions occurs.

The ageing management process for each area is working in collaboration with operational staff regarding any length of planned or un-planned shutdown and will address possible changes in degradation prerequisites, if needed.

Ageing of spare parts, components and materials which are stored for a long time before use are managed according to storage routines. Proper storage conditions are chosen according to component specific requirements and any degraded materials are changed before installation. New parts which are introduced via projects are scoped in and included in the AMR documents according to ageing management routines.

Forsmark has a planned action for managing ageing during extended shutdowns.
(See part 5.1.4.2.1)

3.1.8.2. Oskarshamn position and action

All possible ageing effects on all Systems, structures and components that are included in the ageing management, are based on analysis on commodity groups which includes environment data such as temperature, moisture, radiation etc.
In case of extended shutdown, parameters such environment and/or process parameters i.e flow or temperature could be changed. In the process for the living ageing management Oskarshamn included tasks for monitoring deviations in the environment. If any deviation should occur, this will be reported in our CAP-SAFE tool which is integrated with the living ageing management. So by using the CAP-SAFE tool in the living ageing management we have a better way to collect data that could affect the origin ageing analysis.

Oskarshamn consider this ELP implemented.

3.1.8.3. Ringhals position and action

For each commodity group ageing is analyzed and documented by a appointed expert who is responsible for the area. The analysis is renewed and updated continuously, inputs come from work with actions in the cap system and experiences drawn by the experts themselves or from area specific work-groups.
This includes information on changes in environmental conditions, changes in operations or when new knowledge is present.

The ageing management process is working independent of any length of shutdown and will address the possible changes in degradation.

Components and materials that are stored for a long time before use in projects are handled in accordance with normal storage routines. Proper storage conditions are chosen and aged material are changed before installation. New parts that are introduced via projects are scoped and incorporated in the documents for ageing analysis according to normal routines.

Ringhals have no further actions planned for the handling of long construction periods and extended shutdowns.

3.1.8.4. SSM Assessment

SSM does not consider that the licensees show, in an appropriate manner, that relevant ageing mechanisms are identified and appropriate measures are implemented to control any incipient ageing or other effects during long construction periods or extended shutdown. It is noted that one licensee has planned an action to manage ageing during extended shut downs and SSM intend to follow the progress of this action in SSMs supervisory programme. For the remaining two licensees, SSM intend to follow up this area in the supervisory programme. SSM considers this AFI to be continued an AFI for all licensees.

3.2. Concealed pipework

3.2.1. Good Performance - TPR expected level of performance: inspection of safety-related pipework penetrations

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

3.2.2. Country position

3.2.2.1. Forsmark position

Visual parts of containment penetrations are included in scheduled inspections. Leak-tightness of the penetrations is checked through inspection programs and individual penetration leak tightness tests and also global containment leak tests. Steel casted into concrete is generally situated in a mild environment, given that the concrete casting was initially performed in a correct manner. Safety-related pipework penetrations through concrete structures are included in the ageing management program.

Forsmark considers this Good Performance implemented.

3.2.2.2. Oskarshamn position

Safety-related pipework penetrations are included in the scope of ageing management and handled by several specific AMP:s.
Some of the AMP:s describe inspections that is a part of the ISI program.

3.2.2.3. Ringhals position

Visual parts of containment penetrations are included in the inspection. Leak-tightness of the penetrations are checked through the global containment air test. Steel casted in concrete is in a good environment as long as the casting of concrete initially were performed in a correct manner.

Pipes in penetrations with a known ageing mechanism (ODSCC) are verified with a qualified inspection method involving a robotic arm.

Ringhals considers this Good Performance implemented.

3.2.2.4. SSM Assessment

According to SSM's regulations SSMFS2008:13 chapter 3 section 1, all mechanical components (including pipework penetrations) shall be classified into inspection groups A to C in order to control the scope and orientation of ISI as per the following sections 5,7 and 8 of the same regulations. Mechanical components classified into inspection group A shall be inspected with qualified methods. If it can be shown that no active degradation mechanism is present, the component will either be classified into inspection group B or C – depending on the consequences of a failure. SSM agree with the licensees, that this Good Performance is implemented.

3.2.3. Good Performance - TPR expected level of performance scope of concealed pipework included in AMPs

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

3.2.4. Country position

3.2.4.1. Forsmark position

Ageing management at Forsmark includes all safety related SSC in accordance with the scope setting for the overall ageing management program, concealed piping included. Assessment to include non-safety SSCs whose failure may prevent SSCs important to safety from fulfilling their intended functions is an ongoing development target to further expand the scope. This is a planned action through developing enhanced NSAS walk-down procedures and routines, which also includes non-safety related piping.

Action: Implement enhanced NSAS walk-down procedures and routines to include non-safety SSC's.

3.2.4.2. Oskarshamn position

The cooling water channels and the safety related channels are in the scope for ageing management. When it comes to non safety related pipework whose failure may impact safety related SSC:s (NSAS), this is an ongoing general task to investigate for all SSC:s in the LTO project and will be finished latest 2023.

3.2.4.3. Ringhals position

Ageing management at Ringhals comprises, according to the overall ageing management program all safety related SSC, all Non Safety SSC that can affect safety SSC and all SSC that can be life-limiting for the plant or in the event of errors can lead to large production impacts.

Ringhals considers this Good Performance implemented.

3.2.4.4. SSM Assessment

SSM asses that Forsmark and Oskarshamn still has work needed to be done in order to identify and include non-safety-related pipework in their respective ageing managing programmes. It is not clear if non-safety-related pipework is included in their ageing managing programme today. Forsmark had a Pre-SALTO peer review mission performed in June 2019. The review team assessed that clear rules, methodology and walk-down plans, to identify non-safety structures and components (SCs) within the LTO scope had not been established. Oskarshamn had a Pre-SALTO peer review mission performed in November-December 2017 and the review team assessed that the identification of SSCs within the scope for LTO assessment is inadequate. SSM asses that there is currently a risk that some NSAS concealed pipework is not included in the plants ageing management programme. SSM would like to point out the importance of including these systems in the ageing management programme as soon as possible.

SSM assesses that Ringhals has implemented this good performance.

3.2.5. Good Performance - TPR expected level of performance: opportunistic inspections

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

3.2.6. Country position

3.2.6.1. Forsmark position

Opportunistic visual inspections of concealed pipework are performed when the pipework becomes accessible, by any reason. This is performed for e.g. cooling water tunnelling systems or bottom drain connection for fire water tanks, which are otherwise concealed piping components.

Forsmark considers this Good Performance implemented.

3.2.6.2. Oskarshamn position

That will and must be handled in every single case. If there are some damages everything should be handled. For example regarding the fire protection line, when the pipe were exchanged the penetration through the building wall were inspected, and some of the penetration must be replaced.

The replacement regarding the fire protection line penetrations will be handled in the ongoing maintenance measure.

Opportunistic visual inspections of concealed pipework are performed when the pipework becomes accessible, by any reason according the AMP for concealed pipe.

3.2.6.3. Ringhals position

Opportunistic visual inspections of concealed pipework with or without designated potential degradation mechanisms and effects are performed when the pipework are accessible for inspection for another reason.

Ringhals considers this Good Performance implemented.

3.2.6.4. SSM Assessment

SSM assesses that the Swedish licensees are undertaking opportunistic inspections of concealed pipework and that this Good Performance is implemented.

3.3. Reactor pressure vessel

3.3.1. Good Practice: Hydrogen water chemistry

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

3.3.2. Country position

3.3.2.1. Forsmark position

Forsmark implemented HWC between 1986 and 1991, evaluated its feasibility, and subsequently abandoned the program of HWC for its ASEA internal pump BWR's. The four reactors with internal pumps, Forsmark 1-3 and Oskarshamn 3, do not apply HWC. Test with HWC in reactors with internal pumps have shown that it is very difficult to establish mitigation environmental conditions at the bottom of the RPV.

3.3.2.2. Oskarshamn position

Hydrogen water chemistry which has been proved to mitigate initiation and developing of SCC-cracks is not an option for Oskarshamn 3. It is a BWR with internal main circulation pumps, and tests on reactors with this configuration have shown that it is almost impossible to create the mitigating environmental conditions in the bottom of the pressure vessel.

Oskarshamn has a high knowledge of HWC-operation, since this was applied for the reactor Oskarshamn 2 for many years. Oskarshamn 2 is taken out of operation since 2015.

3.3.2.3. Ringhals position

HWC was introduced at Ringhals Unit 1 mainly to protect sensitive objects in the external recirculation loops from Stress Corrosion Cracking.

Ringhals Unit 1 will be shut down at the end of 2020 so there are no further plans or actions regarding the HWC issue at Ringhals.

3.3.2.4. SSM Assessment

Sweden has a long history of developing hydrogen water chemistry programmes for the reactors where the method is proven efficient. Tests with HWC in reactors with internal pumps have shown that it is very difficult to establish mitigating environmental conditions at the bottom of the RPV. Hence, the four reactors with internal pumps, Forsmark 1-3 and Oskarshamn 3, do not apply HWC.

3.3.3. Good Practice: Implementation of a shield

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

3.3.4. Country position

3.3.4.1. Forsmark position

Finding not applicable on the Forsmark BWR-reactors.

3.3.4.2. Oskarshamn position

Oskarshamn 3 is a BWR, and by that shielding in the PWR-way is not an option. In the BWR-case, one efficient way to protect the RPV wall is to use highly burned fuel in the peripheral fuel positions. This will work as a shield for the large amount of neutrons produced in the high power inner regions of the core, and at the same time produce relatively few own neutrons since the reactivity of these fuel assemblies is low. The loading pattern is called “low leakage”, and has been used when designing the core for the entire lifetime of Oskarshamn 3.

3.3.4.3. Ringhals position

The shielding factor of each type of Shielding Fuel Assembly (SFA) configuration has been confirmed by evaluation of external vessel dosimetry.
It is a continuous process to optimize the configuration of the SFA and the core design to meet the LTO plans for each RPV.

There are no other actions planned regarding the shielding issue at Ringhals.

3.3.4.4. SSM Assessment

Shielding Fuel Assemblies have been successfully used at Ringhals to reduce neutron flux on the RPV wall. Improvements are made continuously in order to fulfil the LTO requirements. SSM has noted that the finding does not apply to Oskarshamn and Forsmark.

3.3.5. Good Performance - TPR expected level of performance: Volumetric inspection for nickel base alloy penetration

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

3.3.6. Country position

3.3.6.1. Forsmark position

Finding not applicable on the Forsmark BWR-reactors.

3.3.6.2. Oskarshamn position

PWSCC is connected to PWR-reactors, and by that not fully applicable for BWRs like Oskarshamn 3. However, IASCC/IGSCC is a similar failure mechanism for BWRs and handled by inspection of the nickel base alloy penetrations within certain (calculated) intervals. The inspection system used in these cases is a combination of qualified eddy current- and ultrasonic techniques. An indication observed on the surface of the weld (and HAZ) with eddy current can then be depth-measured with ultrasonic.

3.3.6.3. Ringhals position

Remaining Nickel base alloy objects susceptible to Primary Water Stress Corrosion Cracking requires careful follow-up and will continue to be monitored through periodic volumetric inspections.

Nickel base alloy objects susceptible to Primary Water Stress Corrosion Cracking will continue to be inspected according to previously established programs.

There are no further actions planned regarding this good performance at Ringhals.

3.3.6.4. SSM Assessment

In Sweden, periodic volumetric inspection is performed for nickel base alloy penetrations according to well-established ISI-programmes. In many cases where defects have been detected during ISI, the defects have been removed and the welds have been repaired. Where possible, the objects have been replaced.
SSM assesses that the currently on-going work on monitoring the remaining nickel base alloy penetrations which are susceptible to Primary Water Stress Corrosion Cracking through periodic volumetric inspections is a good way to detect cracking at an early stage.
SSM has noted that the finding does not apply to Oskarshamn and Forsmark.

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

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

3.3.8. Country position and action

3.3.8.1. Forsmark position and action

Introduction:
During manufacture of large forgings for nuclear components, inherent problems, such as hydrogen flaking, macro-segregation, or non-metallic inclusions, can occur that can lead to a potentially degraded part. These problems have been well known from the early days of large-sized forgings manufacture and lessons learned have been incorporated in modern practices to mitigate or avoid the various deleterious material issues. These materials concerns have existing controls that are applied during manufacturing to mitigate the potential degradation.

Manufacturing and inspection records:
As a consequence of the "Hydrogen Flakes" defects discovered in the reactor vessels in NPP Doel 3 and Tihange 2 (Belgium), Forsmark performed comprehensive reviews of the manufacturing and inspection records of the forged rings for the RPV. Inspection requirements and techniques employed during fabrication had the ability to detect indications such as those at Doel 3 and Tihange 2 if such flaws had existed in the Forsmark 3 RPV. Even non-metallic inclusions as those at RPV of Beznau 1 would have revealed possibly indications from manufacturing. No indications of any problems with hydrogen flakes could be found. As well were testing based on ultrasound conducted on Forsmark 3s archive material (530x260mm) from original production performed. The ultrasonic testing was performed with sensibility as today's requirements with a size ≤ 5 mm (flat bottom hole). Requirements at manufacturing: Size ≤ 8mm + 6 dB. Angle 0º, 2MHz DAC and angle 45º, 2MHz DAC V-notch. No findings were reported.
The assessments were that the material in the reactor vessels in Forsmark unit 1, 2 and 3 were free from these defects and no need for further investigations or examinations were identified. If new information indicates the possibility of hydrogen flakes or other inherent problems in forgings, Forsmark may revise its standpoint.

Minimize Materials Issues:
The cylindrical part of the RPV for Forsmark 3 is made from forged rings. Manufactured by Uddcomb, Sweden, and the forged rings were made by Japan Steel Works (JSW). JSW has been manufacturing forgings for nuclear plant components to US Nuclear Regulatory Commission standards since 1974 and around 130 Japan Steel Works reactor pressure vessels are in service around the world. Vacuum degassing was used to reduce hydrogen content in the steel when the ingot is poured and thus to reduce flaking. This is the process specified by ASTM/SA-508. Vacuum degassing processes refer to the exposure of molten steel to a low-pressure environment to remove gasses (chiefly hydrogen and oxygen) from the steel. In order to obtain higher degree of vacuum during casting, a steam ejector was introduced in 1970 at JSW. The minimal amount of hydrogen in the low-alloy steel forging material after vacuum degassing may not be sufficient to completely prevent hydrogen flaking. Therefore, a degassing heat treatment (or dehydrogenation treatment) have been performed to reduce the hydrogen content to an acceptable level, performed at UDDCOMB at a temperature of 620 ± 15 ºC for 40 hours. No de-hydrogenation heat treatment has been reported for the Doel 3 and Tihange 2 RPV shells. It is impractical to heat treat large forgings for the period necessary for hydrogen to diffuse out. Hydrogen flaking was certainly an issue known during the fabrication of the Doel 3 and Tihange 2 reactor vessels; several components destined for those vessels were rejected due to hydrogen flaking.

Lessons learned:

Belgian Federal Agency for Nuclear Control (FANC)

FANC Final Evaluation Report August 28, 2015 concludes that: The elastic-plastic analysis was performed according to ASME III primary stress re-evaluation. The calculations demonstrated that the collapse load is only slightly reduced in comparison with a model without flaws. The primary stress criteria are met – i.e. the calculated collapse pressure is more than 1.5 times the design pressure as required by code.

The fatigue crack growth analysis was performed according to Appendix A of ASME XI. It was shown that the flaw indications will not grow significantly by fatigue for the remaining time of operation. It was also shown that flaw indications at the beginning of lifetime could not have grown significantly by fatigue during 30 years of operation.

FANC conclusions confirm the structural integrity of Doel 3 and Tihange 2 under all design transients with ample margins.

In conclusion the FANC confirms that all the safety concerns that were at the origin of the short-term and mid-term requirements have been solved in a satisfactory manner.

NRC and EPRI summary from evaluations and conclusions for Quasi-Laminar Indications:

Final Report, December 2018 (EPRI MRP-367):

Low cycle fatigue during transients such as startup and cooldown cycles is the only potential flaw growth mechanism. The Doel 3 and Tihange 2 safety case showed that fatigue would not constitute a safety concern for the present indications. Both units were restarted in 2013.

Evaluation of the Reactor Vessel Beltline Shell Forgings of Operating:

The results from review of the inspection records provide high confidence that the phenome-non observed at Doel 3 / Tihange 2 is not present in the U.S. PWR fleet of RPV beltline ring forgings.

EPRI performed a bounding safety assessment for a vessel postulated to have a large number of Q-L indications in the beltline shell forgings. The bounding assessment included a probabilistic fracture mechanics (PFM) analysis of the U.S. PWR with highest mean reference temperature in a beltline ring forging at the end of an 80-year license and determined that the incremental risk would be a factor of 6 below the risk criteria set by NRC.

Therefore, it is unlikely that conditions similar to those observed at Doel 3 exist in U.S. PWRs. Even if substantial Q-L indications are postulated to exist in beltline ring forgings in U.S. PWRs, the potential for vessel failure is acceptably low.

Conclusion EPRI:

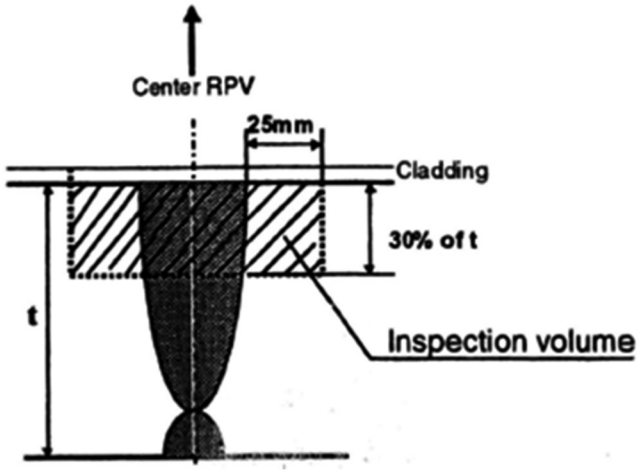
The discovery in 2012 and 2014 of thousands of Q-L indications in beltline ring forging in PWRs in Belgium and element macro-segregation in PWRs in France has caused early plant shutdowns, long plant outages, costly inspections, radiation exposure, extensive research programs, and plant operational restrictions to address RPV integrity issues related to Q-L indications and segregation. This research shows that it is unlikely that conditions similar to those observed at Doel 3 exist in U.S. PWRs. Even if substantial Q-L indications are postulated to exist in beltline ring forgings in U.S. PWRs, the potential for vessel failure is acceptably low.

NRC recommendations:

Technical Assessment September 8, 2015: Evaluate, communicate, and follow developments with no other required actions. Even if quasi-laminar indications similar to those

discovered at Doel 3 and Tihange 2 existed in U.S. plants, the indications are not expected to significantly affect reactor pressure vessel integrity under normal or accident conditions.

Inspection volume during RPV ISI:
In the Forsmark report F-0081990 "*Forsmark 1, 2 and 3: Prerequisites for qualification of an inspection system for the longitudinal and circumferential welds in the reactor pressure vessel (RPV).*" Is a section on the inspection volume, this section states that at least 20 mm unaffected base material is included in the ISI of the RPV.
"*The inspection volume on site shall include the weld, cladding and HAZ. The extent of the HAZ in the stainless steel cladding has been estimated to maximum 5 mm from the fusion lines. In order to accommodate possible variations and uncertainty in the location of the weld an inspection volume extending 25 mm either side of the fusion lines has been chosen.*"



Conclusion Forsmark:
All reviews and testing have shown:

- no defects from manufacturing
- high confidence that no hydrogen flaking or other inherent problems exist
- earlier inspections performed at manufacturing are on par with existing controls today
- potential remaining defects in the base material do not significantly affect reactor pressure vessel integrity under normal or accident conditions

In addition to the 10 year periodic in-service inspection of the beltline weld and adjacent base material, no further action is scheduled. If new information is made available, Forsmark will evaluate this and open to re-evaluate its standpoint.

3.3.8.2. Oskarshamn position and action

When the Doel- and Tihange findings were discovered, the Swedish authority SSM demanded the Swedish utilities having RPVs formed of forged rings to investigate the possibility of these manufacturing defects to occur in their RPV vessels. The RPVs to be investigated were the RPVs of Ringhals 2-4, Oskarshamn 3 and Forsmark 3.

In the Oskarshamn 3-case, a thorough study of the manufacturing history and related quality documents was performed. Special attention was put to heat treatments and noted deviations in any of the manufacturing stages. Also the quality control including non-destructive testing was investigated closely.

The result from the investigations show that RPV material fulfils all criterias demanded from the reactor vendor, ASEA ATOM, as well as the standard ASME 1974 section II, SA-508. All inspections performed with ultrasonic technique connected to any hydrogen flake or similar problems have all passed without deviations.

Due to the findings in Doel and Tihange, a special procedure was used during the outage in 2014 as an additional activity. A complementary ultrasonic inspection was performed on the RPV. During the campaign an equipment scanned 20 strokes from the bottom of the RPV to the upper ring, thereby including the belt line. The positions of the strokes were randomized over the periphery.
The inspection was performed from the outside of the RPV, and the equipment was calibrated to the same sensibility as the manufacturing inspection. The acceptance criteria was the same as the one used at the manufacturing inspection, indications corresponding to a so called Flat Bottom Hole (FBH) ≥ Ø 8mm was not accepted. The reason for using the same sensibility as the original manufacturing UT-inspection was to see if any anomalies < 8 mm, accepted at the manufacturing, had grown. As a complement to this scanning, 7 areas (300 X 400 mm each) were tested with a manual ultrasonic equipment with the same sensibility as the scanning device. No findings were reported.

No additional UT-inspection or material analysis of archive material has been performed due to the findings in Doel and Tihange. This because the archive material was included in the original manufacturing UT-inspection and that the material is from the same charge as the forgings in the vessel.

Oskarshamn concludes from these different investigations (checking of manufacturing protocols and performing of ultrasonic inspection) that there are no signs of manufacturing defects, neither as the ones reported in Doel and Beznau or any other types.

History

Forging
The RPV was ordered by the reactor vendor, ASEA ATOM, from UDDCOMB - a Swedish RPV manufacturer. UDDCOMB then made an order for the four forged rings, together with the bottom dome and lid, from Japan Steelworks. The material to be used was SA 508 CL 3.
In the manufacturing documentation there are no specific datas from the casting process, therefore there are no proof of vacuum degassing. However the standard used, ASME BPVC II SA-508/SA508M, stipulates vacuum degassing and there is no deviation from the standard regarding degassing noted. The vacuum degassing is very favourable in relation to hydrogen expulsion from the steel.

Chemical analyses
Chemical analyses were performed both on the ingoing charges and as special analyses of specified materials. In all cases except one the analyses meet the criterias. The deviation

occurred in ring segment no 4, and consists of a slightly low alumina content. This deviation is judged by Oskarshamn as not related to any higher risk of hydrogen flakes or any other, so far known, defect type related to manufacturing.

Mechanical testing
The mechanical properties were tested on the rings in shipping conditions. Tensile-, impact- and Pellini tests were performed with normal results for this type of steel.

Non-destructive testing during fabrication
Ultrasonic examinations have been performed after hardening and annealing of the manufactured details. All areas have been examined from both in- and outside with a technique that has shown its capability to detect a so called flat bottom hole ≥8 mm in diameter. No indications are noted.

Heat treatment
The rings of the RPV have all been hardened in 6-13 hours at 900 ºC and then cooled in water. After this they have been annealed in 5-7 hours in 650 ºC.

The final heat treatment of the RPV was performed at UDDCOMB at a temperature of 620 ± 15 ºC for 40 hours. At this temperature the hydrogen removal possibility show a maximum value, thereby acting as a good tool for lowering the hydrogen amount in the material.

In-service-inspection
The welds (and HAZ) between the rings of the RPV have been inspected with qualified ultrasonic equipment at least three times during the time of operation of Oskarshamn 3. All reported indications have been analysed and found to be acceptable. During the last in-service-inspection in 2014, an additional 50 mm of base material has been included on each side of the welds (and HAZ).

3.3.8.3. Ringhals position and action

In-service Inspection
The In-service Inspection (ISI) of the Reactor Pressure Vessel (RPV) is mandatory according to the Swedish regulation and follows the principles, methods and procedures that have been notified to the authority. For the Core Zone, the ISI includes weld joints and its heat-affected zones. The RPV ISI is implemented at a 10-year interval. The inspection system shall be qualified and certified by the Swedish Qualification Centre (SQC).

Scope of ISI
All circumferential PWR RPV shell welds are inspected. The scope is to detect, characterize and size longitudinal defects. For the W4 weld (Belt-Line Weld) the scope is to detect, characterize and size longitudinal and transversal defects.

Current inspection volume W4 weld:

- Weld width 50 mm +25 mm on each side of weld
- Depth 56 mm from inner cladded surface

Historic inspection volumes W4 weld:

- First 10 year ISI, full volume, weld width 50 mm +100 mm on each side of weld
- Second 10 year ISI, weld width 50 mm +100 mm on each side of weld, depth 56 mm from inner cladded surface
- Third 10 year ISI, weld width 50 mm +25 mm on each side of weld, depth 56 mm from inner cladded surface

ISI Technique
Ultrasonic Technique (UT) is used for inspection of all circumferential welds.

Type	*Angle in SS (°)*	*Angle* in CS (°)*	*Frequency (MHz)*	*Bandwidth*	*Probe Shoe Profile*	*Focal Depth (mm)*	*Crystal Size (mm)*	*Housing (mm)*	*Working Range Depth (Refer to Scan surface) (mm)*
70 TRL	70	75	2.25	≥70%	Flat	10	2(15 x25)	≤40 x40	0 to 26mm
0 TRL	0	0	2	≥70%	Flat	10	2(½ Ø12)	≤40 x40	0 to 56mm
45 TRL	45	46.7	4	≥70%	Flat	10	2(7 x10)	≤40 x40	0 to 20mm
45 TRL	45	46.7	4	≥70%	Flat	30	2(15 x25)	≤40 x40)	15 to 56mm

In addition the inner cladded surface of W4 weld (Belt-Line Weld) is inspected by Eddy Current Technique (ET).

Name	**Single Coil**
Type	X-wound without ferrite core
Mode	Driver – pickup
Ferrite Coil	No
Instrument configuration	Driver - pickup
Active field (-6dB) Ø	2.5 mm ± 0.5 mm
Signal to noise ratio	> 30 dB
Frequency range	100 -800 kHz
Spring loaded	Yes
Housing	≤ 40 x 40 mm

Result
None of the 10-year ISI performed detected any reportable indications of safety significance.

Additional inspections
The following gives a brief description of additional inspections of the Core Zone carried out at Ringhals 2, 3 and 4 as a direct consequence of the Operating Experience (OE) from the Belgian units Doel 3 and Tihange 2 2012.

Analysis of manufacturing documentation
Early on, it was clear that the defects detected in Belgium originated from the manufacturing process used for the RPV shell forgings, the defect type is also known as Hydrogen Flakes.
Rotterdam Shipyard delivered the reactor pressure vessel for Doel 3, Tihange 2 and Ringhals 2.
A review of available manufacturing documentation was carried out at Ringhals. There were no reported deviations which indicated that there would have been problems during the manufacturing process of the forging components. Furthermore, available experience

indicated that some information was difficult to trace or not fully disclosed, which indicated that there were reasons to question the manufacturing documentation. Furthermore, there were reasons to question whether the manufacturing control and testing techniques used was sensitive enough to detect the type of defect in question.
Overall, Ringhals considered that there was insufficient evidence that the defects detected in Doel and Tihange would not be present in Ringhals RPV forged components. It was decided to immediately modify and qualify the existing RPV inspection system to also enable detection and characterization of the so-called Hydrogen Flakes, a laminar defect type with its main direction parallel to the in- and outside of the vessel wall. A 10-year ISI of the vessel was performed at Ringhals 2 fall 2012 including an additional and qualified inspection of the vessel forgings to verify if Hydrogen Flake defects existed or not. Corresponding additional inspections for Hydrogen Flakes were performed at Ringhals 3 2016 and Ringhals 4 2014.
Inspection systems used for additional Hydrogen Flakes inspections at Ringhals 2, 3 and 4 were fully qualified and certified by the SQC. Associated inspection programs and final reports have been reviewed and approved by the Accredited Inspection Body (AIB).

Scope of additional inspection
Purpose of examination:

- To inspect all four ring forgings above the bottom dome and spherical ring including the flange forging for one quarter section between 270° and 0°
- A 100% volumetric examination up to 215 mm into the reactor vessel wall material
- Ability to detect Hydrogen Flakes in the inspection volume , with following detection target sizes or larger:
    - Defect size: ≥ Ø 10 mm. The lamination distribution in X and Y direction to be measured
    - Defect tilt: ≤ 10°
- To distinguish between two adjacent defects if they are separated with ≥ 5 mm
- To position and size defects properly (tolerance: size ± 5 mm, depth ± 5 mm, positioning vertical ±18 mm, horizontally ± 25 mm)

Technique used for additional inspection
The probe set-up contains one immersion phased array probe for detection and evaluation and 5 conventional immersion probes for additional characterization of defects, if any.

Phased Array probe (PA-Probe)
One immersion 2,25MHz 32x4 elements PA- probe is mounted on the manipulator of the vessel wall at a stand-off distance of 60 mm.

Principle:	2-D linear Phased Array style transducer
Wave form:	Longitudinal
Direction:	X or Y direction, the probe can be rotated

Property	Value
Centre frequency (-6dB)	2 ¼ MHz ± 10%
Active area: Number of channels Surface Elementary pitch in primary axis X Elementary pitch secondary axis Y Inter element spacing (pitch)	 32 x 4 elements 54,4x32 1.7 mm 8 mm 0.1 mm
Mechanical focusing	none (flat active area)
Acoustic matching	water
Inter-element cross coupling	< -30 dB
Parasitic echoes	< -60dB / interface echoes
Sensitivity homogenenity	± 3dB
Electrical matching	none
Probe house	65x45x35
Cable	30 mtrs, Multicoax

45°T-probes and 0°L

Four conventional immersion probes are mounted in the holder so that 45° shear wave beams are created with beam directions +Y, -Y, +X and -X. In the middle a 0°L is positioned for measuring the stand-off distance and can also be used for confirmation of detected indications with the phased array probe. The design is such that all beams are having a stand-off distance of 170 mm in water. A fifth conventional probe in the middle is for measuring the stand-off distance.

The 45° shear wave beams can be used to obtain additional information during evaluation of a detected indication.

Probes- RV Laminar indications

Name	Probe data	Angle	Freq. (MHz)	Housing (XxYxZ) (mm)	Stand-off Distance (H2O)	Purpose
1-45+Y	0°L2,25-H2O (ø25)C	45°T	2,25MHz	ø29x 32mm	170mm	Characterisation
2-45-Y	0°L2,25-H2O (ø25)C	45°T	2,25MHz	ø29x 32mm	170mm	Characterisation
3-45+X	0°L2,25-H2O (ø25)C	45°T	2,25MHz	ø29x 32mm	170mm	Characterisation
4-45-X	0°L2,25-H2O (ø25)C	45°T	2,25MHz	ø29x 32mm	170mm	Characterisation
5-0L	0°L2,25-H2O (ø25)C	0°L	2,25MHz	ø29x 32mm	170mm	Detection
5-0dist						Measuring distance of probe head

Result

No indications above detection target were detected according to procedure.

Conclusion
The conclusion is that there are no laminar defects of the type Hydrogen Flakes in the RPV ring forgings at Ringhals 2, 3 and 4.
Based on completed inspections, analyses of manufacturing documentation, available international OE and guidelines, there is currently no reason to take further actions nor to question the quality of the RPV ring forgings.

Future inspection plans
The Swedish regulation stipulates that programs for ISI shall be updated annually and reviewed by the AIB. At the annual update, the program shall be adapted to the latest OE and new knowledge must be taken into account. The way Ringhals acted based on the OE from Doel and Tihange 2012 is a good example of how an ISI program can be adapted with short notice.

To the best of our knowledge, there is no new OE or knowledge that requires a correction of the ISI program for the reactor pressure vessel core region, however this may change in the future. Ringhals continuously seeks out international OE and actively participates in international material forums to ensure that the latest knowledge and guidelines in the industry are taken in to account.

Ringhals Unit 2 will be shut down for decommissioning at the end of 2019 and Ringhals Unit 1 will be shut down for decommissioning at the end of 2020. No further RPV ISI or additional RPV inspections are scheduled for Ringhals Unit 1 and 2.

The plan is to operate Ringhals Unit 3 and 4 until 2041 and 2043 respectively. The fourth 10-year RPV ISI will take place 2020 at both Ringhals Unit 3 and 4, the ISI will not include additional inspections for laminar defects.
There are no further plans for additional inspections of the Core Zone.

3.3.8.4. SSM Assessment

When the manufacturing defects in the reactor vessels in Doel and Tihange were discovered, SSM demanded that the Swedish licensees having reactor pressure vessels that are manufactured of forged rings, thoroughly investigate the possibility of manufacturing defects occurrence. The reactor pressure vessels to be specifically investigated were those of Ringhals 2-4, Oskarshamn 3 and Forsmark 3.

All three licensees performed comprehensive reviews of the manufacturing and inspection records of the forged rings for their respective reactor pressure vessels. The reviews emphasized on important operations during manufacturing such as forging, heat treatments and non-destructive testing.

All three licensees are actively following international operation experience and guidelines. During the annual update of the ISI programmes, new international knowledge is taken into account. For example, in the case of hydrogen flakes findings, consideration was taken to knowledge and conclusions from the Belgian Federal Agency for Nuclear Control (FANC), United States Nuclear Regulatory Commission (USNRC) and Electric Power Research Institute (EPRI).

At Forsmark it is included in the ISI programme of the reactor pressure vessel that at least 20 mm unaffected base material shall be inspected when inspecting the longitudinal and circumferential welds of the reactor pressure vessel.

Oskarshamn performed, during the outage in 2014, an extra inspection campaign where the equipment scanned 20 strokes from the bottom of the RPV to the upper ring, thereby including the belt line. In addition, during the last in service inspection in 2014, an additional 50 mm of base material was included on each side of the welds and HAZ.

At Ringhals 2, the planned in service inspection of the vessel during the autumn of 2012 was increased in scope by including an additional and qualified inspection of the vessel forgings to verify if hydrogen flake defects existed or not. Corresponding additional inspections for hydrogen flake defects were performed at Ringhals 3 in 2016 and Ringhals 4 in 2014. The inspection systems used for additional inspections at Ringhals 2, 3 and 4 were fully qualified and certified by the Swedish Qualification Centre. Associated inspection programmes and final reports have been reviewed and approved by the Accredited Inspection Body according to the Swedish regulations.

All NDE performed by the three licensees, with the purpose of detecting any defects in the base material of the beltline region, have passed without deviations.

Based on performed NDE, comprehensive reviews of the manufacturing and inspection documentation, analysis of available international operational experience and guidelines, SSM assesses that the Swedish licensees have shown that it is unlikely that conditions similar to those observed in the reactor vessels in Doel and Tihange exist in Sweden. The Swedish licensees will continue to follow any developments and operational experience that may lead to revised requirements in the ISI programme. Thus, SSM considers this Good Performance to be implemented.

3.3.9. Good Performance - TPR expected level of performance: Environmental effect of the coolant

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

3.3.10. Country position

3.3.10.1. Forsmark position

Forsmark 1 and 2: Existing fatigue analyses have been re-evaluated to ensure adequate margins of the fatigue design for an extended operating time of 60 years. The re-evaluation takes into account the updated design curve that has been implemented in the latest editions of the ASME Code and the fact that recent years' studies, as presented in NUREG/CR-6909 and ASME CC N-792, indicate that reactor water environment has a greater limiting effect on the service life than what was considered in original analyses.

Forsmark 3: When the unit enters LTO in 2025, the same re-evaluated analyses will be in-place.

3.3.10.2. Oskarshamn position

This topic will be handled in the LTO-project as part of the TLAAs. The work is planned to be finished in 2021.

3.3.10.3. Ringhals position

Existing fatigue analyses have been re-evaluated to ensure adequate margins of the fatigue design for an extended operating time of 60 years. The re-evaluation takes into account the updated design curve that has been implemented in the latest editions of the ASME Code and the fact that recent years' studies, as presented in NUREG/CR-6909 and ASME CC N-792, indicate that reactor water environment has a greater limiting effect on the service life than what was considered in original analyses.

Ringhals considers this Good Performance implemented

3.3.10.4. SSM Assessment

The Swedish licensees have started to re-evaluate the fatigue analyses with regard to the environmental effects of the coolant. SSM has received the analysis from Ringhals 3 and Ringhals 4 but have yet to review them. Forsmark 3 and Oskarshamn 3 are the two units where evaluation work is still in progress.

3.4. Concrete containment structure and pre-stressed concrete pressure vessels

3.4.1. Good Performance - TPR expected level of performance: monitoring of pre-stressing force

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

3.4.2. Country position and action

3.4.2.1. Forsmark position and action

Pre-stressing forces of un-grouted tendons are being controlled by periodic testing to ensure the safety function of the containment. The measurement of pre-stressing force is done by a lift-off test with a jack. The interval between tests and the selection of tendons tested are mainly done in accordance with USNRC Reg. Guide 1.35. Samples of wire from some tendons are also being cut out and analysed.

The maintenance system is configured to automatically send notification to the maintenance department when tendons are scheduled for testing. Instructions regarding inspection, testing and replacement of tendons are stored in Arken. Results from measurements of the pre-stressing forces are also kept in the same system.

A few tendons are equipped with a load cell between the bearing plate and anchor head, which makes it possible to determine pre-stress forces in these tendons without performing the lift-off test.

Forsmark considers this Good Performance implemented.

3.4.2.2. Oskarshamn position and action

In the year of 2017 a deformation test were performed of the containment of Oskarshamn 3. The tendons are grouted so therefore strain gauges were placed at the outside of the containment at the concrete surface.
The test is bases on Regulator guide 1.90 and the specific Oskarshamn -TLAA for the tendons. The result from the test is that the behaviour of the containment and the tendons is following what is expected from the analysis.

It is recommended to perform a following up of the deformation tests, but no decision is taken yet.

3.4.2.3. Ringhals position and action

Pre-stressing forces of un-grouted tendons are controlled by periodic testing to ensure the safety function of the containment. The measurement of pre-stressing force is done by a lift-off test with a jack. The interval between tests and the selection of tendons tested are mainly done in accordance with USNRC Reg. Guide 1.35 and ASME Boiler and pressure vessel code section XI, subsection IWL. Samples of wire from some tendons are also being cut out and analysed.

The maintenance IT tool is configured to automatically send notification to the maintenance department when tendons are scheduled for testing. Instructions regarding inspection, testing and replacement of tendons are stored in Darwin. Results from measurements of the pre-stressing forces are also kept in the same system. Results from all performed measurements are also summarized in a strategic maintenance document for tendons.

Ringhals have no further actions planned.

3.4.2.4. SSM Assessment

Forsmark and Ringhals are monitoring their pre-stressing forces with lift-off tests according to Reg. Guide 1.35 and ASME Boiler and pressure vessel code section XI, subsection IWL which SSM assesses to be validated methods for their purpose.

The tendons at Oskarshamn 3 are grouted and no sensors were installed during the construction period 1979-1982. SSM regards it to be positive that Oskarshamn has performed deformation test of the containment with strain gauges placed at the containment concrete surface. SSM asses it to be important to follow up with new deformation tests. SSM believes that deformation tests with associated analyses can provide valuable information about the condition of the grouted tendons.

4. Generic findings related to Electrical Cables

In the subsections below, Sweden's position for each finding related to electrical cables is detailed and a summary presented of the actions that are planned to address it.

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

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

4.1.1. Country implementation

4.1.1.1. Forsmark implementation

Forsmark is monitoring and follows the actual environment by combining the use of temperature monitoring and dosimeters, thermography camera, visual inspections and walkdowns. Decommissioned, used samples and deposit cables and are extracted on a regular base from the plant for analysis and testing. Both non-destructive and destructive test methods are used to confirm and verify the residual lifetime of the cable and also its environment. Forsmark has a cable deposit in the containment of Forsmark unit 3 and is considering other types of cable deposit at site.

4.1.1.2. Oskarshamn implementation

Oskarshamn have a cable deposit with a selection of cable types, to perform tests on. Oskarshamn also send used and changed cables for testing, the last tests were earlier this year.

The tests we have performed on natural aged and thermal aged cables, with external laboratory, are EAB (Elongation At Break), density measurements and thermogravimetric analysis together with some electrical tests such as insulation resistance. For example for the EAB measurement we use the initial value from then the cable was new and compare with the value of the aged cable. The acceptance criteria for EAB are defined to 50%.

We also use Arrhenius equation to calculate what remaining lifetime in actual environment is, based upon used test parameters.

4.1.1.3. Ringhals implementation

(NAR 3.1.3)
Non-destructive testing of cables important to nuclear safety is performed regularly. The cables in the most harsh environment are taken to represent all other cables of the same type in milder environment. In the case that non-destructive methods are not usable Ringhals plans to carry out tests with destructive methods. For those tests we will use decommissioned cables aged in real environment or cable sample from cable deposit.

4.1.1.4. SSM Assessment

SSM acknowledges that the licensees perform tests and analysis on cables aged within the plants harsh environment in order to assess cable condition and determine residual lifetime and finds this sufficient.

4.1.2. Country planned action if relevant

4.1.2.1. Forsmark planned action

A separate AMP for cables and cable system is under process of development. (See part 2.2.2)

4.1.2.2. Ringhals planned action

Non-destructive tests are implemented in Ringhals Ageing Management Program.
The possibility for making cable deposits are currently being investigated.

4.1.2.3. SSM Assessment

SSM finds the licensees intensions to develop cable deposits as a positive development.

4.2. TPR expected level of performance: documentation of the cable Ageing Management Programme

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

4.2.1. Country implementation

4.2.1.1. Forsmark implementation

Forsmark has implemented the Ageing Management for Nuclear Power Plants, IAEA Safety Guide No.NS-G-2.12, in the Maintenance Plan. Forsmark's database for cables contains necessary information of the installed cables. The document management system (Arken) handles all kind of cable data, type-tests, qualification reports and other necessary information linked to the cables.

Data from the actual environment is collected and are stored in the databases. Also visual inspections and walk-downs are performed on regular bases to verify this data and stored in databases. Forsmark also follows international experiences in the Ageing Management field.

4.2.1.2. Oskarshamn implementation

The AMPs are finished since the TPR. Their structure is the same as described in IAEA INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Guide NS-G-2.12, Vienna: IAEA, 2008. These AMPs have our cable list as reference, and in this list information regarding cable type, material etc. are found.

Each cable in the cable list is connected to an article within our design software. These articles are connected to documents, such as qualification report, test reports etc.

4.2.1.3. Ringhals implementation

The Strategic Maintenance Plan for cables describes the Ringhals Ageing Management Program. The cable database contains all necessary information about the installed cables in Ringhals.

All Ringhals Strategic Maintenance Plan´s follow the structure of IAEA Safety Guide No. NS-G-2.12. These plans are stored in Ringhals document management system (Darwin).

The Strategic Maintenance Plan for cables describes the ageing analysis made and which cables it is done for. It includes references to cable listing, databases, reports and other documents important for traceability. This document also describes the chosen maintenance strategy.

4.2.1.4. SSM Assessment

SSM assesses that all licensees manage necessary information in a structured way. Oskarshamn and Ringhals have implemented an AMP for cables, while Forsmark still has ongoing work in developing an AMP for cables. SSM also assesses that Oskarshamn and Ringhals intend to follow IAEA NS-G-2.12. SSM intends to follow up this in the supervisory programme.

4.2.2. Country planned action if relevant

4.2.2.1. Forsmark planned action

A separate AMP for cables and cable system is under process of development. (See part 2.2.2*)*

4.2.2.2. Ringhals planned action

This is implemented in Ringhals Ageing Management Program.

4.2.2.3. SSM Assessment

SSM assesses that it is important for Forsmark to implement an AMP for cables with a structure which is consistent with suitable standards.

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

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

4.3.1.1. Forsmark implementation

Data and tests are collected thru thermography camera, temperature monitoring, dosimeters, isolation resistance, walk-down and findings are documented at Forsmark.
The results are an input to the maintenance plan and to the AMP for cables.

4.3.1.2. Oskarshamn implementation

Visual inspections are set up as maintenance task in our maintenance test system ODU, all findings are documented. Oskarshamn also perform for example isolation resistance measurements, the results from these tests are also documented.

4.3.1.3. Ringhals implementation

Test results are collected and documented according to Ringhals instruction ”R1-R4 Presentation of Preventive Maintenance and EQ-maintenance within cable ageing”.

The test results are inputs to the strategic maintenance plan.

4.3.1.4. SSM Assessment

SSM assesses that the licensees have methods to collect cable ageing and performance data to support the AMP for cables.

4.3.2. Country planned action if relevant

4.3.2.1. Forsmark planned action

A separate AMP for cables and cable system is under process of development. (See part 2.2.2)

4.3.2.2. Ringhals planned action

This is implemented in Ringhals Ageing Management Program.

4.3.2.3. SSM Assessment

SSM assesses that it is important for Forsmark to implement AMP for cables to ensure compliance and necessary knowledge for continued operation.

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

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

4.4.1.1. Forsmark implementation

Identified mechanisms and stressors are listed in cable AMR documents for the Ageing Management Program. This list is based on a common list of ageing mechanisms from FORS-AMP forum, in cooperation between Swedish licensees.

Forsmark also follows international guides and experiences. New findings are reviewed and implemented in relevant programs.

4.4.1.2. Oskarshamn implementation

The AMPs are updated due to new experiences, both internal and external, so they should cover all the relevant ageing mechanisms.

The work with identify and evaluate ageing mechanisms were done in our project for implementation of ageing management, during the steps of Scooping&screening and AMR. The coordination group for ageing management is responsible for address new discoveries and experiences to the AMP groups, for implementation in the AMPS.

4.4.1.3. Ringhals implementation

Degradation mechanisms and stressors are listed in the Strategic Maintenance Plan for cables. This list is based on a common gross list of ageing mechanism, which is a result of cooperation between Swedish licensees within the framework of FORS-AMP forum.
The FORS-AMP forum meet twice a year. In the agenda includes new experiences, R&D issues within ageing management and developing of ageing management process.

The Strategic Maintenance Plan is updated continuously with new experiences (internal and external) or other changes.

Strategic Maintenance Plans are updated at least every 5 years but updates are made when new input exists.

4.4.1.4. SSM Assessment

SSM assesses that the licensees follow up degradation mechanisms and stressors both internally and externally in order to detect possible downgrades.

SSM believe that the forum FORS-AMP stated by the licensees is well suited as a platform to plan activities with regard to ageing management, for example to share experience and to learn more about e.g. degradation mechanisms and stressors. SSM welcomes the fact that the licensees e.g. are comparing their maintenance programmes in order to see if there are parts that can be adopted for all licensees.

4.4.2. Country planned action if relevant

4.4.2.1. Forsmark planned action

A separate AMP for cables and cable system is under process of development. (See part 2.2.2)

4.4.2.2. Ringhals planned action

This is implemented in Ringhals Ageing Management Program.

4.4.2.3. SSM Assessment

SSM assesses that it is important for Forsmark to implement AMP for cables to ensure compliance and necessary knowledge for continued operation.

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

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

4.5.1.1. Forsmark implementation

Forsmark is monitoring and follows the environment for the cable systems to ensure that the cable system has acceptable environment. Forsmark does not have any problem with the NPP cables due to the good environment of the cable systems for the high voltage cables.

Visual inspections and walk-downs are performed on regular bases to verify these conditions.

4.5.1.2. Oskarshamn implementation

Oskarshamn has not that type of problem, within the scope of the TPR.

The cables with crosslinked polyethylene as insulation/jacket are not used in that type of environment, there water treeing is an issue. Oskarshamn has had some issues with water treeing, on cables with crosslinked polyethylene installed during the seventies on facilities outside of the scope. These facilities don´t have any safety related functions, so the used activities are change or repair the cable.

4.5.1.3. Ringhals implementation

VLF Tan/Delta tests have been done on XLPE insulated 6kV cables to detect water treeing and other cable issues. Further tests will be done according to the existing preventive maintenance program.

Drain systems for ground culverts where XLPE cables are located are controlled regularly for water.

Ringhals have had no historical problems with water treeing.

Tests with the Tan/Delta method were done in year 2000, 2010 and 2013 on 6kV cables for emergency diesel generators located in ground culverts.

In 2013 there were a blocked drain in one of the cable trenches and a test where needed to verify the cables operability. This incident is described in detail in SSM 2017:36 TPR 2017 chapter 3.1.4. The test methods Tan/Delta and VLF are described in SSM 2017:36 TPR 2017 chapter 3.1.3.

4.5.1.4. SSM Assessment

SSM assesses that the Swedish licensees have no problems with water treeing, and that this is followed up continuously by visual inspections, walk-downs and tests.

4.5.2. Country planned action if relevant

4.5.2.1. Forsmark planned action

A separate AMP for cables and cable system is under progress of development. (See part 2.2.2)

Forsmark is planning to analyse and test the condition of our 6kV and 10kV cables within the NPP by using available methods, such as Tan Delta and Partial Discharge. (See part 4.8.2)

4.5.2.2. Ringhals planned action

This is implemented in Ringhals Ageing Management Program.

4.5.2.3. SSM Assessment

SSM assesses that the Swedish licensees approach is to continuously do follow-ups to minimise the risk of water treeing in cables with polymeric insulation.

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

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

4.6.1.1. Forsmark implementation

Forsmark frequently evaluate our operational environment based on changes according to data collected with installed temperature monitoring & dosimeters and also upon international guides and experiences.

Changes in environment is evaluated on a regular basis and compared with the room environment data. Based upon changes and new data evaluation of the residual lifetime of the cable and its environment is done to ensure uncertainties.

4.6.1.2. Oskarshamn implementation

Before environmental qualification is started, a complete requirement specification is written that specify which environmental effects the tests should cover. This is performed on a general basis, so that Oskarshamn can use the cable types in different environments.

To define the requirements, the data in the environmental database and the performed measurements are used.

Then Oskarshamn receives new experiences, the first action is to see if this affects our company. If it affects a qualified cable, the data within in the qualification is reviewed to see if newly received experience affects the performed qualification. If it does, a technical issue is raised and after that further investigation/analyzes/tests/decisions are made.

Oskarshamn has an on going work to verify that the environmental data in our room database is correct, therefore Oskarshamn has installed several sensors to measure temperature and radiation. If the new measured values are different than the values in the room database for a room, an investigation regarding how the changed value affects the components/cables installed in that room is started. That type of investigation can have different outcomes, for example shielding for radiation, change of components/cables etc.

By working with external laboratories and participating in the cable group, we get new experiences that lead to reviewing our made qualifications. For example it can be that an activation energy used for a polymer is wrong, and it results in a new calculation for remaining lifetime for accelerated aged cable.

4.6.1.3. Ringhals implementation

Cables within the EQ-program are tested regularly to measure the condition. Another way to decrease the uncertainties in EQ is to test cables aged in real environment (dismantled or cable deposit) and compare the test results with the result from the accelerated ageing.

In the qualification process is the validity of the activation energy and the method used to determine it assessed. Ringhals collect information to choose a value for the activation energy for the specific material, where no such data is available 0,8 eV will be used in the calculations of qualified life.

The Swedish authority has noticed that the activation energy with accelerated ageing for some cables was higher than 0.8 eV. Why this higher energy level was used wasn´t documented properly. Ringhals have started a work to analyze the method used to determine the activation energy.

To ensure that uncertainties in the test profile are enveloped Ringhals use conservative margins.

How variations in the environment is evaluated differs between the BWR (Ringhals Unit 1) and the PWR´s (Unit 2, 3, 4).

The temperature and radiation level is measured in selected rooms at Unit 1 every year and if necessary the Room Environment Database is updated.

Global room temperature values at normal conditions are used for Unit 2, 3 and 4 and these values are set so conservative that normally no further evaluation is necessary.

However plant modifications may demand new or revised analyses regarding the environment, the Room Environment Database is revised with the result of the analyses.

4.6.1.4. SSM Assessment

SSM assesses that the Swedish licensees evaluate if weaknesses exist in the initial qualification by controlling the environment in the facilities and collecting information from both internal and external sources that can affect the status of the qualification.

4.6.2. Country planned action if relevant

4.6.2.1. Forsmark planned action

Forsmark has an implemented EQ programme.

4.6.2.2. Ringhals planned action

Periodic control of EQ cables is implemented in Ringhals Ageing Management Program.

The possibility for making cable deposits are currently being investigated.

An Analysis of the validity of the activation energies is started.

4.6.2.3. SSM Assessment

SSM assesses that each of the Swedish licensee has an EQ programme and they collaborate through forums regarding EQ qualification. SSM also assesses that the ambition of creating cable deposits is valuable and intends to follow up on this issue in the supervisory programme.

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

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

4.7.1.1. Forsmark implementation

Cables in Forsmark are tested according to their requirement based operating environment in the EQ programme. An evaluation of the stressors in their operating environment and their functions under Design Basis Event and throughout their expected lifetime are implemented in the EQ programme.

The EQ program assures that SSC credited in the plant safety analyses will be capable of performing their safety functions after long-term exposure to normal environmental conditions followed by exposure to expected environmental conditions during and after a DBE or a Severe Accident.

4.7.1.2. Oskarshamn implementation

According to Oskarshamn s environmental qualification program cables are tested based on environmental database/measurements. Environmental database are updated with newly performed measurements. The cables are aged both thermal and radiological due to their installation environment and their expected life time. After the ageing the cables are tested to ensure their function during DBA and post DBA, for as long time as their function is required according to the STF.

Equipment that have requirement to function during and after a DBE is covered by Oskarshamn s environmental qualification program. In TBE 102:1 (Technical requirement for electric equipment) different environmental accident profiles are specified depending on if the equipment is installed in containment or outside of containment. Oskarshamn tests and environmental qualifies their equipment according to these profiles, which covers DBA, post-DBA and DEC according to IEC/IEEE 60780-323:2016.

4.7.1.3. Ringhals implementation

According to Ringhals EQ program cables are tested based on data from a room environment database. Cables are exposed for accelerated ageing and tested to determine their capabilities to fulfil their safety functions under DBA and post DBA conditions. The required time for the test is based on the requirement of the safety function.

Equipment that handle CCF events in safety system (SSMFS 2008:17 §10) is within the scoop of the EQ program and so even equipment for cooling in long time after DBE (SSMFS 2008:17 §8).

The environmental qualification program assures that SSC credited in the plant safety analyses will be able to perform their safety functions after long-term exposure to normal environmental conditions followed by exposure to environmental conditions as a consequence of a DBE or a Severe Accident.

4.7.1.4. SSM Assessment

SSM assesses that the Swedish licensees test SSCs according to their requirements based on operating environment and their safety functions for DBA, post-DBA and DEC.

4.7.2. Country planned action if relevant

4.7.2.1. Forsmark planned action

Forsmark has an implemented EQ programme which includes such as Design Basis Accident and Common Cause Failure.

4.7.2.2. Ringhals planned action

Tests for DBA and CCF are implemented in Ringhals EQ program.

Planned action is that include and/or clarify SSC credited in the plant safety analyses for a Severe Accident in the environmental qualification program.

4.7.2.3. SSM Assessment

SSM assesses that there is potential for improvement and intends to follow up on this issue in the supervisory programme.

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

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

4.8.1. Country implementation

4.8.1.1. Forsmark implementation

Forsmark tests the inaccessible cables with Insulation resistance and for NIS cables Forsmark also use the TDR methods to identify changes or degradation.

4.8.1.2. Oskarshamn implementation

By measuring the cables installation environments and evaluate experiences both internal and external of similar cable types, some problems can be predicted. Some cables are continuously monitored by a closed current circuit, this will only alert that something is wrong but the plant has four safety trains so there is time to perform an exchange without jeopardizing the plant safety.

Closed current circuit for signal cables is just one example of fault detection, others methods are for example then a 4-20 mA transmitter gives 0 mA back. This states either a problem with the transmitter or the cable.

Other controls performed on cables are visual inspections, insulation resistance measurement. Oskarshamn has very little of completely inaccessible cables, so visual inspections can be made at least on the two ends on a cable. While performing maintenance on an object, the maintenance personnel perform a visual inspection on the cable according to their instruction.

4.8.1.3. Ringhals implementation

NIS cables are tested with insulation resistance and TDR methods. Other inaccessible cables are tested by insultation resistance, LIRA and/or Tan/Delta measurement, depending on the cable type.

Ringhals is planning to test 6 kV cables inside containment by VLF Tan/Delta methodology.

4.8.1.4. SSM Assessment

SSM assesses that the Swedish licensees continuously consider and evaluate which methods are necessary and most effective to detect degradation.

4.8.2. Country planned action if relevant

4.8.2.1. Forsmark planned action

Forsmark is evaluating existing measuring techniques for further use.
Forsmark is planning to analyse and test the condition of our 6kV and 10kV cables within the NPP by using available methods, such as Tan Delta and Partial Discharge.

Action: Analyze and test the condition of the 6kV cables within the NPP by using available methods, such as Tan Delta and Partial Discharge at Forsmark Unit 1 & 2.

Action: Analyze and test the condition of the 10kV cables within the NPP by using available methods, such as Tan Delta and Partial Discharge at Forsmark Unit 3.

4.8.2.2. Ringhals planned action

This controls are implemented in Ringhals Ageing Management Program except the VLF Tan/Delta tests inside the containment that are planned to be done in 2020.

4.8.2.3. SSM Assessment

SSM assesses that there is potential for improvement and intends to follow up on this issue in supervisory programme.

5. All other generic findings

This section is dedicated to the generic findings made by the Topical Peer Review.

5.1. Overall Ageing Management Programmes (OAMPs)

5.1.1. Good practice: External peer review services

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

5.1.1.1. Good Practice - Allocation by the TPR

5.1.1.2. Country position

5.1.1.2.1. Forsmark position

Work started in 2007 to understand and implement the IAEA Ageing Management Process in Forsmark, following issuing of upgraded regulatory requirements regarding ageing management.

A Pre-SALTO review mission where performed in 2016 and one later in 2019, confirming that ageing management process was implemented and supported the evaluations and results of the LTO project activities. Detailed findings resulting from the latest Pre-SALTO mission are currently being processed to be resolved by further work, further enhancing the quality of the managing of ageing.

A full scope SALTO review will be conducted in Forsmark in 2021 to ensure positive progress in the field of ageing management and readiness for safe long-term operation.

Forsmark has participated as observer and reviewer in several SALTO missions and SALTO follow-up missions at various sites and thus collected experiences and formed a network within the business around ageing management and long term operation. This network is an important part of resolving issues and develop the scope and approach for the detailed parts of the overall ageing management program.

The IGALL project managed by IAEA serves as joint development of standardised AMPs for the nuclear business and also serves to strengthen the international network.

Forsmark will continuously observe national and international peer plant SALTO, OSART and IGALL activities to gain and share experiences in AM and LTO.

5.1.1.2.2. Oskarshamn position

Oskarshamn decided in an early phase of the LTO project to use IAEA SALTO services as a tool to make sure that Unit 3 will be ready for Long Term Operation which will be entered 2025 and that this work is in line with the latest IAEA guides. This resulted in the first Pre-SALTO December of 2017 and the result from this is used by the ongoing LTO project to tune the methods used for i.e scoping, AMR, and TLAA etc.

To make sure that the updated methods are in line with the IAEA guides Oskarshamn have a preliminary plan for future IAEA peer reviews:

2019Q4-expert mission
2021Q1-pre SALTO
2023Q3-SALTO
2025Q1-Follow-up Salto

Oskarshamn consider this Good Practice implemented.

5.1.1.2.3. Ringhals position

Work started in 2007 to understand and implement the IAEA Ageing Management Process in Ringhals.

A Pre SALTO where performed in 2014 when an ageing management organization and a LTO project where in place.

In February 2016 Ringhals hosted a Pre SALTO Follow Up that gave important input for the following work.

The SALTO review that took place at Ringhals in March 2018 found good progress in the field of ageing management and preparedness for safe long-term operation. A limited amount of findings are now being solved and Ringhals will host a SALTO Follow-up in March 2020.

The work in preparing for a SALTO resulted in an increased company focus and made it easier to organize the AM work in a structured way and to improve the documentation.

The preparations have also helped to spread knowledge of ageing management to the whole organization. Without the SALTO focus it would likely have been harder to get the work prioritized.

5.1.1.3. SSM Assessment

See section 3.1.2.4

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

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

5.1.2.1. Good Performance - Allocation by the TPR

5.1.2.2. Country position

5.1.2.2.1. Forsmark position

R&D is performed within several areas in which there are appointed specialists who are responsible for projects in their respective field of expertise. The goal of the R&D is to continuously strive towards preparedness for future demands, to build knowledge and competence, to develop methods and tools and to follow research in the field. Forsmark participate in both joint projects between other nuclear operators and the Swedish regulatory authority and in other international groups such as for example EPRI, NUGENIA, Energiforsk and OEM component and material specific groups.

Forsmark has participated and supports e.g. POLYLIFE EPDM elastomer research, non-destructive testing of PVC cables and research of various detailed corrosion problems. Forsmark has participated and concluded results from some 44 different projects within R&D area “materials and chemistry” the last 5 years.

Project results and gained knowledge are implemented to benefit the activities or future plans or predictions. The joint venture research projects financed by the national licensees are proven grounds for fruitful improvements, especially regarding Swedish BWR plants and its unique design details and prerequisites in operating and maintaining.

5.1.2.2.2. Oskarshamn position

Oskarshamn are participating in the IAEA/IGALL project since 2011 and are also participating in other forums such as Energiforsk and EPRI.

Information from these forums are, among other things, used to update our AMP:s when it comes to new experiences, new detecting techniques, new monitoring techniques, new testing techniques etc.

Some of the AMP:s used by Oskarshamn are developed from the AMP:s in IGALL so for Oskarshamn it is important to participate in IGALL.

5.1.2.2.3. Ringhals position

R&D are performed within several areas in which there are appointed specialists who are responsible for projects in their field of expertise. The goal of the R&D is to strive towards preparedness for future demands, to build competence, to develop methods and tools and to follow research in the field. Ringhals participate in both joint projects between other Nuclear Operators and the Authority and in other international groups such as for example EPRI, NUGENIA, Energiforsk and OEM component and material specific groups.

Knowledge obtained is for example used to identify new ageing mechanisms, how to detect them and to improve existing detection methods. Better methods make it possible to detect ageing effects earlier and to follow changes that before have been undetectable. Important work is done in material research for example in ageing mechanisms in metal and plastic. This knowledge is used to identify possible undetected problems and to be prepared for future actions.

Development of Geoscanning to detect black corrosion in wet concrete structures has been used with good result at Ringhals. This method was developed at Energiforsk programs for NPP and is a good example of how R&D could be used.

5.1.2.3. SSM Assessment

See section 3.1.4.4

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

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

5.1.3.1. AFI - Allocation by the TPR

5.1.3.2. Country position and action

5.1.3.2.1. Forsmark position and action

The methodology for scoping described in SSG-48 will be implemented in the currently used methodology for scoping for SSCs subject to ageing management. Any discrepancies found compared to Forsmark present scoping of SSCs based on SR-57 will be evaluated and managed in accordance with current routines for managing the scope. As a part of a living program, the scope of ageing management will be continuously evaluated and updated, either due to findings regarding present plant SCCs or due to component or system upgrades, thus securing a living program for re-assessing the managing of ageing over time.

Action: Re-evaluate the present scope based on IAEA SSG-48. (See part 3.1.6.1)

5.1.3.2.2. Oskarshamn position and action

Oskarshamn:s ongoing LTO project is based on the new IAEA guide SSG 48 while the internal requirements on ageing management is based on the old IAEA guide NS-G2.12. The day when the new scope will be delivered by the project to the living ageing management, the new IAEA guide SSG 48 will be adopted in to the internal requirements regarding ageing management.

5.1.3.2.3. Ringhals position and action

SSG-48 will be evaluated with regards to the methodology for scoping for the SSCs subject to ageing management. Any discrepancies compared to Ringhals original scoping based on SR-57 will be evaluated and managed in accordance with Ringhals routines for managing the scope.

Action: Update the scooping based on NS-G 2.12 and SR 57.

5.1.3.3. SSM Assessment

See section 3.1.6.4

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

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

5.1.4.1. AFI - Allocation by the TPR

5.1.4.2. Country position and action

5.1.4.2.1. Forsmark position and action

For each commodity group, ageing is analyzed and documented by appointed area responsible experts. The analysis is renewed and updated continuously and includes utilizing feedback from the experience feedback system, feedback from work order system and expert knowledge from area specific working groups.

This work includes information on changes in operational and environmental conditions, if such changes in conditions occur.

The ageing management process for each area is working in collaboration with operational staff regarding any length of planned or un-planned shutdown and will address possible changes in degradation prerequisites, if needed.

One specific experience of the need for specific consideration regarding extended shutdown condition was from the exchange of low pressure turbines, which was a prolonged outage. The cooling water system for the main generator stator windings had increased oxygen exposure during this time. This formed a mild corrosion problem which had not previously been observed regarding shorter outage durations.

Ageing of spare parts, components and materials which are stored for a long time before use are managed according to storage routines. Proper storage conditions are chosen according to component specific requirements and any degraded materials are changed before installation. New parts which are introduced via projects are scoped in and included in the AMR documents according to ageing management routines.

Routines for addressing the issue of prolonged shutdowns are currently missing in the instruction for outage management.

Action: Implement the aspect of ageing management due to prolonged shutdowns in the instruction for outage management.

5.1.4.2.2. Oskarshamn position and action

In case of extended shutdown, parameters such environment and/or process parameters i.e flow could be changed. All these parameters are continuously handled in the process for living ageing management at Oskarshamn and handled by the CAP tool CAP-SAFE.

5.1.4.2.3. Ringhals position and action

For each commodity group the ageing is analyzed and documented in an Ageing Analysis by an appointed expert who is responsible for the area. The analysis is renewed and updated continuously, inputs come from work with actions in the CAP system and experiences drawn by the experts themselves or from area specific working groups.
This includes information on change in environmental conditions, change in operations or when new knowledge is present.

The ageing management process is working independent of any length of shutdown and will address the possible changes in degradation.

Components and materials that are stored for a long time before use in projects are handled in accordance with normal storage routines. Proper storage conditions are chosen and aged material are changed before installation. New parts that are introduced via projects are scoped and incorporated in the documents for ageing analysis according to normal routines.

Ringhals have no further actions planned for the handling of long construction periods and extended shutdowns.

5.1.4.3. SSM Assessment

Se section 3.1.8.4

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

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

5.1.5.1. Not concerned - Allocation by the TPR

5.2. Concealed pipework

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

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

5.2.1.1. Allocation by the TPR

None

5.2.1.2. Country position

5.2.1.2.1. Forsmark position and action

Soil and building settlements are not an issue since the constructions are built at solid rock. No safety relevant buried pipes exist in the current design.

The cooling water tunnels excavated in bedrock or reinforced concrete tunnels designed within bedrock are continuously inspected for ageing related degradation.

The scheduled building walk-downs conducted routinely and systematically are existing means to reveal harmful changes in environment or plant building structural condition.

Forsmark has no actions planned for this Good Practice.

5.2.1.2.2. Oskarshamn position and action

Settlements in any significant extent is not anything that has been observed. The reasons are that plant is constructed on solid rocks, the buildings are founded on the granit. Concealed pipes are founded on a bed of crushed rock.

5.2.1.2.3. Ringhals position and action

Soil and building settlements are not an issue since the constructions are built at solid rock.

Ringhals have no actions planned for this Good Practice.

5.2.1.3. SSM Assessment

SSM agrees with the licensees that this Good Practice is not applicable for the Swedish plants, see section 5.4.1.3 .

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

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

5.2.2.1. Allocation by the TPR

None

5.2.2.2. Country position

5.2.2.2.1. Forsmark position and action

New or unproven pipe materials are not normally used but in case that would be needed, these materials would be properly evaluated and incorporated in the Technical Standard for Forsmark and the other Swedish nuclear operators.

Forsmark consider this Good Practice implemented.

5.2.2.2.2. Oskarshamn position and action

We use proven materials according to those given in the technical regulations, TBM, which is a common technical document for the Swedish stakeholders. So we have no plans for doing this.

5.2.2.2.3. Ringhals position and action

New pipe materials are not normally used but in case that would be needed the materials would be properly evaluated and incorporated in the Technical Standard for Ringhals.

Ringhals consider this Good Practice implemented.

5.2.2.3. SSM Assessment

According to SSMFS 2008:1 Chapter 3 Section 2 and 4, construction principles and materials shall be proven to be suitable for use in the intended application – it is not allowed to install a new or novel material and after a period of operation inspect to see that the properties are as expected. SSM assesses that, in this particular case, the Swedish licensees adhere to the higher safety standards as stipulated in the SSMFS regulations than to those that this Good Practice suggests.

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

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

5.2.3.1. Allocation by the TPR

5.2.3.2. Country position and action

5.2.3.2.1. Forsmark position and action

Visual parts of containment penetrations are included in scheduled inspections. Leak-tightness of the penetrations is checked through walk-down inspection programs and individual penetration leak tightness tests and also global containment leak tests.

Forsmark has specifically made a visual inspection of the inside of the containment penetrations, via the leak detection drains using endoscope cameras.

Steel casted into concrete is generally situated in a mild environment, given that the concrete casting was initially performed in a correct manner.

Forsmark considers this Good Performance implemented.

5.2.3.2.2. Oskarshamn position and action

There is visual inspection of the penetration of the containment, this is handled in the ISI-programme. Civil maintenance is checking the concrete around the penetrations. Since the penetrations are grouted as well as the reinforcement there will be delamination of the surrounded concrete if we have some ongoing corrosion.

The Containment Air Leakage test will even monitor if there is some penetration that is not leak-tight.

For those penetrations outside the containment they are visual inspected by the civil maintenance department, both safety and non-safety related.

5.2.3.2.3. Ringhals position and action

Visual parts of containment penetrations are included in the inspection. Leak-tightness of the penetrations are checked through the global containment air test. Steel casted in concrete is in a good environment as long as the casting of concrete initially were performed in a correct manner.

Pipes in penetrations with a known ageing mechanism (ODSCC) are verified with a qualified inspection method (MPP-031) involving a robotic arm.

The penetrations has a dual pipe design with the outer pipe cast in the concrete and with the water carrying pipe inside. There is a small volume between the pipes and due to limited access a special manipulator arm was developed to place the transducer. The method utilizes a combination of Eddy Current (detecting) and Ultra Sound (characterization) techniques.

Ringhals considers this Good Performance implemented.

5.2.3.3. SSM Assessment

See section 3.2.2.4.

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

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

5.2.4.1. Allocation by the TPR

5.2.4.2. Country position and action

5.2.4.2.1. Forsmark position and action

Ageing management at Forsmark includes all safety related SSC in accordance with the scope setting for the overall ageing management program, concealed piping included. Assessment to include non-safety SSCs whose failure may prevent SSCs important to safety from fulfilling their intended functions is an ongoing development target to further expand the scope.

When scoping for components within systems or plant facilities, it is relevant to make detailed walk-downs to reveal any spatial interaction or other risk factors. This includes also concealed piping, safety and non-safety related. It is a factor to be implemented in the developing of ageing management scoping procedure that continuously scheduled walk-downs also focus on interactions such as NSAS to further enhance the scope extent and quality.

Forsmark has a planned action scheduled to enhance plant walk-down procedures and routines to achieve a well-documented structure for NSAS to support ageing management for LTO. (See part 3.2.4).

5.2.4.2.2. Oskarshamn position and action

The cooling water channels, the safety related channels are in the scope. Those channels with non-safety class will be inspected with the same criteria as those that are safety-related. That will be clarified in the LTO-Scope.

For pipe-penetrations for the containment those are handled with visual inspection of the ISI-programme.

For those penetrations outside the containment they are visual inspected by the civil maintenance department, both safety and non-safety related.

The continuous inspection of the fire protection ring line will start next year, camera inspection will be performed inside the pipes.

5.2.4.2.3. Ringhals position and action

Ageing management at Ringhals comprises, according to the overall ageing management program all safety related SSC, all Non Safety SSC that can affect safety SSC and all SSC that can be life-limiting for the plant or in the event of errors can lead to large production impacts.

Which components / system positions that are scoped are specified by a selection process. The purpose of this process is to systematically perform and document the selected components that are included in the ageing process. This process also includes compiling input data that is necessary for to do the ageing analysis.

Grouping of components in commodity groups is also an important part of ageing analysis.

Ringhals considers this Good Performance implemented.

5.2.4.3. SSM Assessment

See section 3.2.4.4.

5.2.5. TPR expected level of performance: opportunistic inspections

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

5.2.5.1. Allocation by the TPR

5.2.5.2. Country position and action

5.2.5.2.1. Forsmark position and action

Opportunistic visual inspections of concealed pipework are performed when the pipework becomes accessible, by any reason. This is performed for e.g. cooling water tunnelling systems or bottom drain connection for fire water tanks, which are otherwise concealed piping components.

Remote cameras are used as visual technology to inspect the inside of pipes and along stretches of piping systems, otherwise inaccessible for inspection.

Pipes are routinely opportunistically inspected when available, even if there are no known and documented particular risks of degradations mechanisms. Such examples are pipes connected to valves, pumps and heat exchangers where upon maintenance, pipe inspections are routinely made.

Forsmark considers this Good Performance implemented.

5.2.5.2.2. Oskarshamn position and action

That will and must be handled in every single case. If there are some damages everything shall be handled. For example regarding the fire protection line, when the pipe were exchanged the penetration through the building wall were inspected, and some of the penetration must be replaced.

5.2.5.2.3. Ringhals position and action

Opportunistic visual inspections of concealed pipework with or without designated potential degradation mechanisms and effects are performed when the pipework are accessible for inspection for another reason. Opportunistic visual inspections of concealed pipework with identified potential degradation mechanisms and effects are performed when the pipework are accessible for inspection in connection with inspection of other mechanical components such as pumps, valves, heat exchangers etc. Fiberoptic equipped cameras are used to inspect a bit into the tube in each direction.

The system positions of the pipework are used for reporting any deviations on pipeworks.

Ringhals considers this Good Performance implemented.

5.2.5.3. SSM Assessment

See section 3.2.6.4.

5.3. Reactor pressure vessel

5.3.1. Good practice: Hydrogen water chemistry

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

5.3.1.1. Good Practice - Allocation by the TPR

5.3.1.2. Country position

5.3.1.2.1. Forsmark position

See section 3.3.2.

Forsmark considers this Good Practice evaluated. (Not beneficial for Forsmark BWR design).

5.3.1.2.2. Oskarshamn position

See section 3.3.2.

5.3.1.2.3. Ringhals position

HWC was introduced at Ringhals Unit 1 mainly to protect sensitive objects in the external recirculation loops from Stress Corrosion Cracking. The effect of HWC inside the RPV can still be discussed.

Ringhals Unit 1 will be shut down at the end of 2020 so there are no further plans or actions regarding the HWC issue at Ringhals.

5.3.1.3. SSM Assessment

See section 3.3.2

5.3.2. Good practice: Implementation of a shield

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

5.3.2.1. Good Practice - Allocation by the TPR

5.3.2.2. Country position

5.3.2.2.1. Forsmark position

See section 3.3.4

Good practice not applicable on the Forsmark BWR reactors.

5.3.2.2.2. Oskarshamn position

See section 3.3.4

5.3.2.2.3. Ringhals position

The shielding factor of each type of Shielding Fuel Assembly (SFA) configuration has been confirmed by evaluation of external vessel dosimetry.

There have been some minor issues with the mechanical design of the SFA. Ringhals has experienced some cracked springs in the top nozzle due to the fact that the SFA is somewhat stiffer than a normal fuel assembly. This has been corrected by reducing the spring stiffness.

Using SFA may add restrictions to the core design.
It is a continuous process to optimize the configuration of the SFA and the core design to meet the LTO plans each RPV.

There are no further actions planned regarding the shielding issue at Ringhals.

5.3.2.3. SSM Assessment

See section 3.3.4

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

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

5.3.3.1. Good Performance - Allocation by the TPR

5.3.3.2. Country position and action

5.3.3.2.1. Forsmark position and action

See section 3.3.6

Good Performance not applicable on the Forsmark BWR reactors.

5.3.3.2.2. Oskarshamn position and action

See section 3.3.6

5.3.3.2.3. Ringhals position and action

See section 3.3.6

5.3.3.3. SSM Assessment

See section 3.3.6

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

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

5.3.4.1. AFI - Allocation by the TPR

5.3.4.2. Country position and action

5.3.4.2.1. Forsmark position and action

See section 3.3.8

5.3.4.2.2. Oskarshamn position and action

See section 3.3.8

5.3.4.2.3. Ringhals position and action

See section 3.3.8

5.3.4.3. SSM Assessment

See section 3.3.8

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

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

5.3.5.1. Good Performance - Allocation by the TPR

5.3.5.2. Country position and action

5.3.5.2.1. Forsmark position and action

See section 3.3.10

5.3.5.2.2. Oskarshamn position and action

See section 3.3.10

5.3.5.2.3. Ringhals position and action

See section 3.3.10

5.3.5.3. SSM Assessment

See section 3.3.10

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

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

5.3.6.1. Not concerned - Allocation by the TPR

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

5.4.1. Good practice: monitoring of concrete structures

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

5.4.1.1. Allocation by the TPR

None

5.4.1.2. Country position

5.4.1.2.1. Forsmark position and action

No sensors where installed in the original design. The integrity of the containment is checked through the containment leakage tests and through monitoring of pre-stressing forces in the tendons.

Visual inspections are primarily used to monitor concrete structures. If necessary, these are supplemented by a number of different methods. Primarily, non-destructive testing such as sonic echo testing which is defined on the basis of how the sound waves propagate in the structure.

Destructive testing in which core samples are taken from the material for laboratory analysis is used for adhesion testing of the coating.

5.4.1.2.2. Oskarshamn position and action

No sensors were originally installed either in the containment or in the other buildings.

We have no plans for installing any sensors at the moment.

The concrete are visual inspected on regular basis, the structure is blasted on solid rock (granite) and we don’t see any behaviour of settlements that’s ongoing.

5.4.1.2.3. Ringhals position and action

No sensors where installed in the original design. The integrity of the containment is checked through the containment air tests and through monitoring of pre-stressing forces in the tendons.

Visual inspections are primarily used to monitor concrete structures. If necessary, these are supplemented by a number of different methods. Primarily, non-destructive testing such as sonic echo testing which is defined on the basis of how the sound waves propagate in the structure.

Ringhals have no further actions planned.

5.4.1.3. SSM Assessment

No sensors are installed in the concrete containment at the Swedish plants. Since the Swedish plants are built on solid rock there is no need due to settlements, to monitor the plants with strain gauges. SSM asses that strain gauges can be used on the concrete containment surface during containment air tests which has been done at Oskarshamn 3, see section 3.4.2.4.

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

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

5.4.2.1. Allocation by the TPR

None

5.4.2.2. Country position

5.4.2.2.1. Forsmark position and action

Inaccessible structures and structures with limited access are included in the maintenance plans. Inspections are planned based on the surrounding accessible areas.

If the part never is accessible, an assessment is made as to whether the part is subjected to degradation mechanisms that will impair its function over a certain period of time.

Action: Forsmark intends to inventory and review the occurrence of inaccessible structures.

5.4.2.2.2. Oskarshamn position and action

When visual tests are performed there is stated in the C3.5 documentation if a room is not accessible. If no signs of degradation or defects is visual at the other side of the structural parts with limited access a statement is made. It is stated that that the room/structural parts with limited access fulfils its integrity.

If we suspect that there will be ongoing degradation in a room or spaces with limited access, inspections cameras can be used. If necessary even a hole can be drilled to look into. But this is decision that will be taken in every single actual case.

5.4.2.2.3. Ringhals position and action

Inaccessible structures are included in the strategic maintenance plans. If the part never is accessible an assessment is done. Inspections are also planned based on the surrounding accessible areas.

Ringhals have no further actions planned.

5.4.2.3. SSM Assessment

SSM notice that the Swedish licensees take into account the assessment of inaccessible structures by, among other things, taking into account the condition of nearby structures. However, structural modifications during the life of a NPP may provide opportunities to access formerly inaccessible parts of the structure. Licensees should consider the effect of these modifications on the structures and maintenance regime, but also the opportunities that some of these modifications provide an opportunity to inspect inaccessible areas.

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

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

5.4.3.1. Allocation by the TPR

Good Performance

5.4.3.2. Country position and action

5.4.3.2.1. Forsmark position and action

Pre-stressing forces are monitored based on Reg. Guide 1.35 as described in chapter 3.4.2.

5.4.3.2.2. Oskarshamn position and action

Deformation tests were originally performed in 1984 and following up measurements was performed in 2017.

The tests are evaluated and the behaviour of the tendons and the concrete containment is what was expected and analysed.

It is recommended to do a following up measurements but no decision is taken yet.

5.4.3.2.3. Ringhals position and action

Pre-stressing forces are monitored. The inspection are based on Reg. Guide 1.35 and ASME Boiler and pressure vessel code section XI, subsection IWL.

Ringhals considers this Good Performance implemented.

5.4.3.3. SSM Assessment

See section 3.4.2.4.

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

6.1. Board recommendation

The Board recommends that countries explore the regulation and implementation of Ageing Management Programmes of other risk significant nuclear installations while developing and implementing National Action Plans to ensure they exist and are effective.

6.2. Country position and action (fuel cycle facilities, installations under decommissioning, waste facilities, etc.)

The SSM regulations (SSMFS) concerning Safety in Nuclear Facilities, SSMFS 2008:1, are applicable, in a graded way, to all licensed nuclear facilities. The regulations aim to specify measures needed to prevent and mitigate radiological accidents, prevent the illegal handling of nuclear material and nuclear waste, and to conduct efficient supervision.

The regulations deal with:

- Application of multiple barriers and defence-in-depth
- Handling of detected deficiencies in barriers and the defence-in-depth
- Organization, management and control of significant safety activities
- Actions and resources for maintaining and developing safety
- Physical protection and emergency preparedness
- Basic design principles
- Assessment, review and reporting of safety
- Operation of facilities
- On-site management of nuclear materials and waste
- Reporting to SSM of deficiencies, incidents and accidents
- Documentation and archiving of safety documentation
- Final closure and decommissioning

The requirement on ageing management states that a programme for management of ageing degradation and damage shall be in place. The programme shall be documented, reviewed and updated in the light of experience gained in science and technology as well as developments. General advice to this requirement further specifies that the programme for the management of ageing degradation and damage should comprise the identification, monitoring, handling and documentation of all the ageing mechanisms that can affect structures, systems and components as well as other devices that are of importance for safety. Additional guidance on maintenance and the management of ageing degradation can be found in the IAEA:s safety standards.

SSM supervises the ageing management of each licensee with a graded approach, and with the help of a supervisory program. The supervision program controls the scope and frequency of each licensee.

A thorough review on the licensees Ageing Management Programme is carried out for all other nuclear installations in connection with the Periodic Safety Review that takes place every ten years.

References

[1]. Topical Peer Review 2017, Ageing Management, Swedish National Assessment Report, SSM Report 2017:36
[2]. SSM, Beslut OKG Aktiebolag Åldershantering reaktor O3, SSM2017-384-16

Abbreviations

AMP	Ageing Management Programme
AMR	Ageing Management Review
APS	Working Committee for Production Safety Ringhals
Avärs	Corrective Action Program Ringhals
BG Group	R&D group structural verification
BiCycle	Data trending system
CASS	Cast austenitic stainless steel
CG	Commodity Groups
CSPE	Chlorosulfonated polyethylene
CSS	Core Shroud Support
DAP	Design Assurance Process
DBTT	Ductile to Brittle Transition Temperature
DT	Destructive Testing
DMW	Dissimilar Metal Weld
EAB	Elongation At Break
EKG	Kabelgruppen EKG, Kabelgruppen, forum with participants from Swedish and Finnish utilities
Energiforsk	Swedish Energy Research Center
ENIQ	European Network for Inspection Qualification
ET	Eddy current Testing
FENIX	maintenance system Forsmark
FOCUS	CAP-system at Forsmark
FORSAMP	Joint forum for ageing issues involving Forsmark, Oskarshamn, Ringhals and SKB
Forsmark	Forsmarks Kraftgrupp AB
Forsmark 1	Forsmark unit 1
Forsmark 2	Forsmark unit 2
Forsmark 3	Forsmark unit 3
GALL	Generic Ageing Lessons Learned
HOLMUG	Halden On-Line monitoring User Group
HR	Human Resource
HRP	The Halden Reactor Project
HTG	Pressure-Temperature Limit
HWC	Hydrogen Water Chemistry
IGALL IAEA	Generic Ageing Lessons Learned
IGSCC	Intergranular Stress Corrosion Cracking
IOÖ	Certificate of Compliance
IR	Insulation Resistance
ISI	In-Service-Inspections
KBM	Quality Regulations for Mechanical Equipment
KTH	Royal Institute of Technology
LAS	Low Alloy Steel
LCF	Low Cycle Fatigue
LERs	Licensee Event Report
LIRA	Line Resonance Analysis

LTO	Long Term Operations
MG	Group R&D group material
MIC	Microbiologically Induced Corrosion
MRP	Materials Reliability Programme
NAR	National Assessment Report
NDT	Non Destructive Testing
NIS	Neutron Flux Instrumentation Cables
NMAC	Nuclear Maintenance Application Centre
NOG	Nordic Owners Group
NORDERF	A Nordic organisation for experience feedback
NSAS	Non-Safety Affecting Safety
NWC	Normal Water Chemistry
ODSCC	Outside Diameter Stress Corrosion Cracking??
ODU	Oskarshamn maintenance system
OIT	Oxidation Induction Time
Oskarshamn	OKG AB
Oskarshamn 1	Oskarshamn unit 1
Oskarshamn 2	Oskarshamn unit 2
Oskarshamn 3	Oskarshamn unit 3
PD	Partial Discharge
PEX	Cross-Linked Polyethylene
PMBD	Preventive Maintenance Basis Database
Polymer LE (PEEK)	Polyether ether ketone
PSA	Probabilistic Safety Analyses
PSR	Periodic Safety Review
PTS	Pressurised Thermal Shock
PWSCC	Primary Water Stress Corrosion Cracking
QB	Qualification Body
R&D	Research and Development
Ringhals	Ringhals AB
Ringhals 1	Ringhals unit 1
Ringhals 2	Ringhals unit 2
Ringhals 3	Ringhals unit 3
Ringhals 4	Ringhals unit 4
RPV	Reactor Pressure Vessels
SAFE	CAP-system at Oskarshamn
SAR	Safety Analysis Report
SC	Structures and Components
SCC	Stress Corrosion Cracking
SGMP	Steam Generator Management Programme
SKB	Swedish Nuclear Fuel and Waste Management Co
SKI	Swedish Regulator Swedish Nuclear Power Inspectorate (until 2008)
SKIFS	Swedish Nuclear Power Inspectorate Regulations (until 2008)
SPOC	Single Point of Contact
SQL	Structured Query Language
SRCM	Streamlined Reliability-Centered Maintenance
SSC	Systems, Structures and Components
SSI	Swedish Radiation Protection Authority
SSM	Swedish Radiation Safety Authority

SSMFS	Swedish Radiation Safety Authority Regulations
STF	Technical Specifications
SUP	Strategic Maintenance Plan
TBM	Technical Requirements for Mechanical Equipment
TBY	Technical Requirements Surfaces protection
TDR	Time Domain Reflectometry
TGSCC	Transgranular Stress Corrosion Cracking
TLAA	Time Limited Ageing Analyses
TTR	Time to Repair
TUD	Component Unavailability Data
UCC	Under cladding cracks
UT	Ultrasonic Testing
VLF	Very Low Frequency
XLPE	Cross-Linked Polyethylene

7. Table: Summary of the planned actions

This table should contain the planned actions for each reactor in a country, the associated deadlines and the monitoring process by the national regulator. The table should contain sufficient detail to facilitate the follow-up process

Installation	Thematics	Finding	Planned action	Deadline	Regulatory´s approach to monitoring
Forsmark	OAMP	No key performance indicator	Implement key performance indicator	2020-12-31	SSM intends to follow up these actions in our supervisory programme.
Forsmark 3	OAMP	TLAA not fully updated	Complete the work with the remaining TLAA's of Forsmark Unit 3 to be valid for 60 years of operation.	2024-12-31	SSM intends to follow up these actions within the scope of the PSR.
Forsmark 1 & 2	OAMP	TLAA not fully updated	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.	2019-10-31	SSM intends to follow up these actions within the scope of the PSR.
Forsmark	OAMP	Methodology for scoping the SSCs subject to ageing management	Fully implement SSG-48 and evaluate the original SR-57 based scoping accord-	2020-12-31	SSM intends to follow up these actions in our supervisory programme.

			ingly. Any discrepancies will be managed in accordance with ongoing routines for managing the scope of AM and LTO in Forsmark.		
Forsmark	OAMP	Delayed NPP projects and extended shutdown	Implement the aspect of ageing management due to prolonged shutdowns in the instruction for outage management.	2020-03-31	SSM intends to follow up these actions in our supervisory programme.
Forsmark	Concealed pipework	Exchange information and experience	Forsmark will investigate how further cooperation can be organized.	2020-06-30	SSM intends to follow up these actions in our supervisory programme.
Forsmark	Concealed pipework	Scope of concealed pipework included in AMPs	Implement enhanced NSAS walk-down procedures and routines to include non-safety SSC's.	2021-05-30	SSM intends to follow up this action in our supervisory programme
Forsmark	Electrical Cables	AMP for ageing management of electrical cables	A separate AMP for cables and cable system is under process of development and needs to be finalised and implemented.	2020-06-30	SSM intends to follow up this action in our supervisory programme

Forsmark 1 & 2 & 3	Electrical Cables	Appropriate techniques are used to detect degradation of inaccessible cables	Forsmark is planning to analyse and test the condition of our 6kV and 10kV cables within the NPP by using available methods, such as Tan Delta and Partial Discharge.	2020-12-31	SSM intends to follow up this action in our supervisory programme
Forsmark	Concrete containment structure and prestressed concrete pressure vessel	Plant walk-down	Forsmark intends to further elaborate and expand these plant walk-downs to meet updated governing instruction. (See part 3.2.4 for action regarding extended procedure for NSAS.).	2021-05-30	SSM intends to follow up this action in our supervisory pro-gram.
Forsmark	Concrete containment structure and prestressed concrete pressure vessel	Cooperation	A plant-specific list of degradation mechanisms will be harmonized against national and international experiences such as IGALL and GALL.	2020-12-31	SSM intends to follow up this action in our supervisory programme.
Forsmark	Concrete containment structure and prestressed concrete pressure vessel	Trending analysis	Forsmark intends to further elaborate and expand instructions regarding trending and follow-up.	2020-12-31	SSM intends to follow up these actions in our supervisory programme.

Forsmark	Concrete containment structure and pre-stressed concrete pressure vessel	Assessment of inaccessible and/or limited access structures	Forsmark intends to inventory and review the occurrence of inaccessible structures.	2020-12-31	SSM intends to follow up this action in our supervisory programme.
Forsmark 3	Reactor pressure vessel	Environmental effect of the coolant	When the unit enters LTO in 2025, the re-evaluated analyses will be in-place.	2024-12-31	SSM intends to follow up this action in our supervisory programme.
Oskarshamn 3	OAMP	Systematic Quality Management of the overall Ageing Management Programme	In the AM instruction, include an obligatory update every 5 year for all AMP:s	2019-12-31	SSM intends to follow up these actions in our supervisory programme.
Oskarshamn 3	OAMP	Systematic Quality Management of the overall Ageing Management Programme	Enlarge the number of KPI:s	2020-12-31	SSM intends to follow up these actions in our supervisory programme.
Oskarshamn 3	OAMP	Use of more specified criterion to define conditional acceptance criteria.	Improvement of AMP:s acceptance criteria if necessary	2023-12-31	SSM intends to follow up these actions in our supervisory programme.
Oskarshamn 3	OAMP	Review and update of the overall Ageing Management Programme	Review and update of TLAA	2021-12-31	SSM intends to follow up these actions within the scope of the PSR.
Oskarshamn 3	Concealed pipework	Exchange information and experience			SSM notices that Oskarshamn has not provided a timeframe for the resolution of this AFI. SSM expect Oskarshamn to resolve

					the AFI within the same timeframe as put forward by Forsmark or Ringhals, or to provide SSM with a separate timeframe. SSM intends to follow up these actions in our supervisory programme.
Oskarshamn 3	Concealed pipework	Scope of concealed pipework included in AMPs	Improvement in definition of non safety affecting safety in the scope of ageing management (NSAS)	2023-12-31	SSM find that this planned activity is not in full agreement with the statement by Oskarshamn in section 3.2.3. SSM expect that all NSAS concealed pipework will be identified and included in the AMPs not later than 2023 - SSM intends to follow up this action in our supervisory programme.
Oskarshamn 3	Concrete containment / Concrete structures	Plant walk-down		Latest 2023	SSM intends to follow up this action in our supervisory programme.
Oskarshamn 3	Concrete containment / Concrete structures	Development and improvement	Continuing visual inspections which shall be documented in the C3.5-report. In the C3.5 there is given a lot information which can be used for trending. The inspections	2021-12-31	SSM intends to follow up these actions in our supervisory programme.

			will be ended approximately in the beginning of 2020, and with that almost every room at unit 3 will be inspected. Of course there will be an amount of room left that must be handled in the future 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 therefore the deadline is 2021.		
Oskarshamn 3	Concrete containment / Concrete structures	Trending analysis	The rating scale for inspections needs to be further developed	Latest 2023	SSM intends to follow up this action in our supervisory programme.
Oskarshamn 3	Reactor pressure vessel	Surveillance programme for LTO	The surveillance programme will be updated to cover the prolonged operational time (60 years)	2019-12-31	SSM has received the updated programme and will review during the autumn of 2019

Oskarshamn 3	Reactor pressure vessel	Environmental effect of the coolant	This topic will be handled in the LTO-project as part of the TLAAs.	2021-12-31	SSM intends to this action in our supervisory programme.
Ringhals	OAMP	Systematic Quality Management of the overall Ageing Management Programme	Implement key performance indicator	2020-12-31	SSM intends to follow up these actions in our supervisory programme.
Ringhals 3, 4	OAMP	Review and update of overall Ageing Management Programme	All TLAA´s are updated and presented in the PSR for R3 and R4. The PSR was submitted to SSM April 2019	2020-12-31	SSM intends to follow up these actions within the scope of the PSR.
Ringhals 3, 4	OAMP	Methodology for scoping the SSCs subject to ageing management	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.	2019-12-31	SSM intends to follow up these actions in our supervisory programme.
Ringhals	Concealed pipework	Exchange information and experience	Ringhals will investigate how further co-operation can be organized.	2019-12-31	SSM intends to follow up this action in our supervisory programme

Ringhals 3, 4	Electrical Cables	Good practice: characterize the state of the degradation of cables aged at the plant	Investigated the possibility for making cable deposits.	2019-12-31	SSM intends to follow up this action in our supervisory programme
Ringhals 3, 4	Electrical Cables	TPR expected level of performance: consideration of uncertainties in the initial EQ	To Analysis the validity of the activation energies used for cables	2019-12-31	SSM intends to follow up this action in our supervisory programme
Ringhals	Electrical Cables	TPR expected level of performance: techniques to detect the degradation of inaccessible cables	Test 6 kV cables inside containment with the VLF Tan/Delta methodology.	2020-12-31	SSM intends to follow up this action in our supervisory programme
Ringhals 3, 4	Electrical Cables	TPR expected level of performance: determining cables performance under highest stressors	Clarify SSC credited in the plant safety analysis for a severe accident in the environmental qualification programme.	2020-12-31	SSM intends to follow up this action in our supervisory programme
Ringhals	Concrete containment structure and prestressed concrete pressure vessel	Trending analysis	Developed the rating scale for inspections further.	2020-12-31	SSM intends to follow up this action in our supervisory programme.

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The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 300 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

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