Review of Current ONR Guidance on Management of Ageing and Degradation of SSCs: Summary Report

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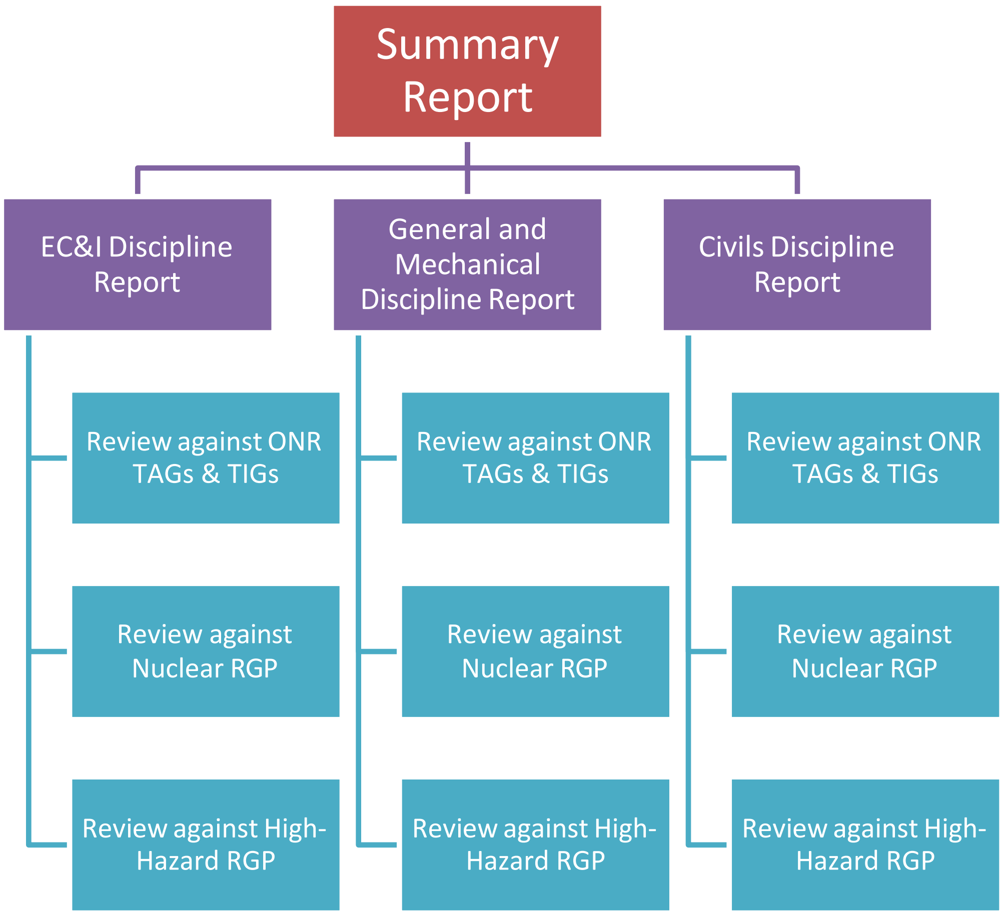
Executive Summary

A comprehensive understanding of potential ageing and degradation effects on nuclear facility Structures, Systems and Components (SSC) is important to maintaining nuclear safety. There are many codes, standards and Relevant Good Practice (RGP) guides used across high-hazard industries, including nuclear, which discuss SSC ageing and degradation management practices.

The ONR determined that a review of Safety Assessment Principles (SAPs) EAD.1 to EAD.5 on ageing and degradation should be performed against established relevant nuclear and other high-hazard industry RGP documentation, which should confirm their on-going fitness-for-purpose and/or identify any potential improvements to these principles. The review was extended to consider the relevance of the identified RGP to Principle ENC.2 (Examination through life) specifically in the context of ageing and degradation.

The reviews undertaken were recorded in three discipline reports, which focused on Mechanical SSCs and generic ageing and degradation information (Reference 2), Civil Engineering (Reference 3) and EC&I (Reference 4). The links between these documents and this Summary Report are shown below:



A total of 98 documents were identified across the different sources of RGP identified above. Given some documents were excluded for various reasons (e.g. due to being superseded) and the scope overlapped the discipline reports, a total of 115 reviews were undertaken across the three documents. The reviews undertaken identified a number of common themes that were identified across all documents and a series of considerations that were unique to the discipline report or had applicability across all reports.

In general, the themes and considerations identified in the review of ageing and degradation RGP aligns to the existing Principles EAD.1 to EAD.5 on ageing and degradation. However, some differences were identified and in order to align the ageing and degradation related Principles with current RGP it is recommended that:

- Two new principles be added to the SAPs relating to an Ageing Management Programme and identification of ageing and degradation mechanisms.
- Amendments to the existing paragraphs that support the Ageing & degradation principles be considered.
- Additional information and considerations identified from the review of RGP be captured as part of an ageing and degradation TAG.

Contents

1. Introduction

1.1 Background

Nuclear facilities, like other industrial plants, are subject to a range of ageing and degradation mechanisms (potentially impacting on capability, efficiency and/or safety). Ageing effects become increasingly prevalent and challenging as nuclear facilities reach their final stages of operation. Understanding these types of challenges is important to nuclear safety in order to ensure suitable and sufficient monitoring and management of ageing and degradation effects are in place.

A comprehensive understanding of potential ageing and degradation effects on nuclear facility Structures, Systems and Components (SSCs) is important to maintaining nuclear safety. There are many codes, standards and Relevant Good Practice (RGP) guides used across high-hazard industries, including nuclear, as well as significant research investments. Prominent examples of codes, standards and cross-industry RGP in relation to the management of ageing plant are identified in Appendix 1.

It was considered important to review current Office for Nuclear Regulation (ONR) guidance against established codes and knowledge, and against other high hazard industries RGP, to identify where lessons could be learned and applied to the nuclear industry. The basis of this was to review current ONR guidance in the form of a specific number of Safety Assessment Principles (SAPs) (Reference 1) against established cross-industry codes, regulations, codes of practice and RGP.

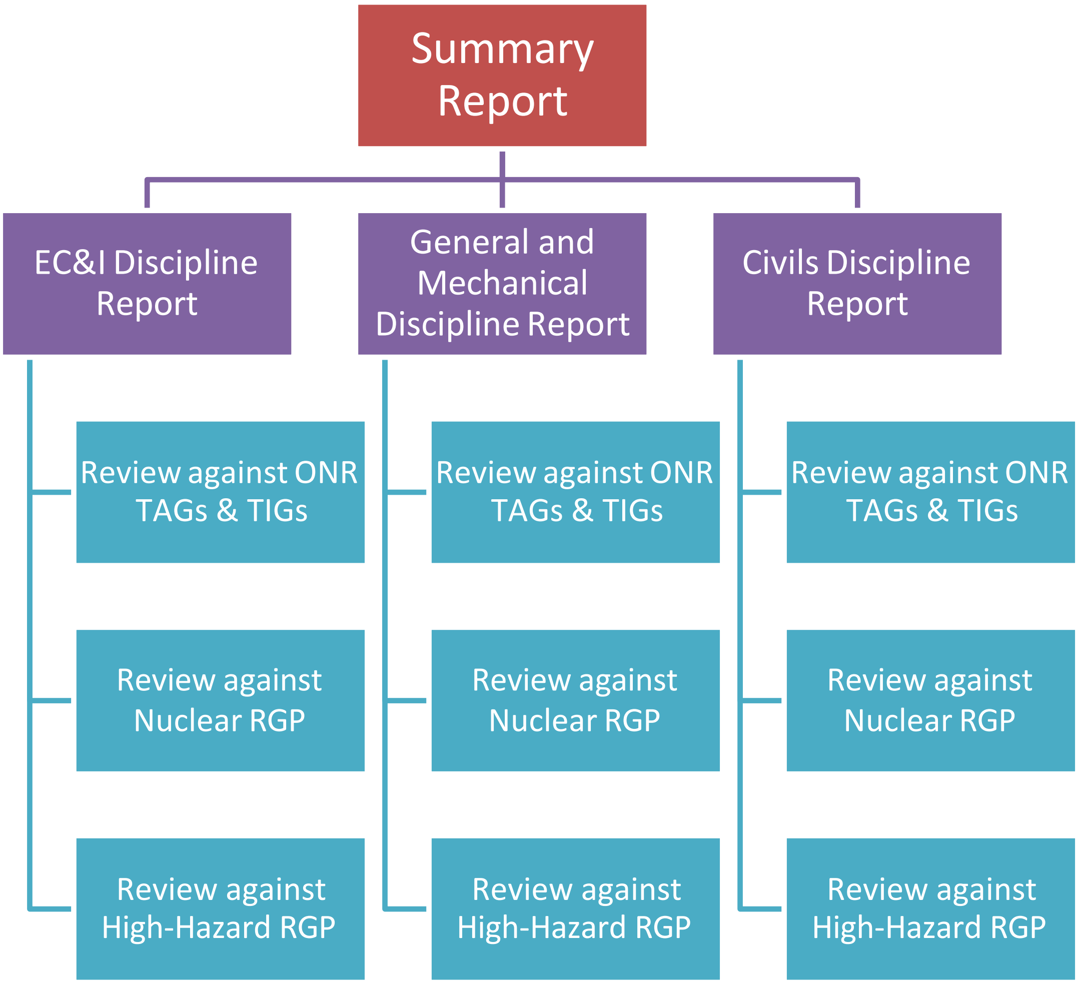
1.2 Purpose

This document is a 'Summary Report' that presents a summary of the review of current ONR guidance on management of ageing and degradation of SSCs as set out in the extant ONR SAPs (Reference 1). This summary report draws together the output from three separate discipline based reports, which covered Mechanical (Reference 2), Civils (Reference 3) and EC&I (Reference 4). In addition, across the range of RGP a significant number of general or programmatical guidance was identified that would apply equally to all three discipline reports. To avoid excessive repetition these generic documents have been reviewed as part of the Mechanical report (Reference 2). The reviews consider whether the extant ageing and degradation related Principles adequately cover the key themes and considerations currently identified in the following sources of RGP:

- ONR Technical Assessment Guides (TAGs) and other ONR guidance documents;
- Other nuclear industry RGP;
- Non-nuclear, high-hazard industry RGP.

The key themes and considerations identified within each of the discipline review reports have been summarised within this overarching Summary Report, which will includes a consolidated suite of in-scope SAP recommendations. Figure 1 below provides an overview of the interactions between this document and the three disciple specific reports.

Figure 1: Relationship between the Project Documents



The following definitions of 'themes' and 'considerations' are provided for clarity:

- **Theme** – a high level description covering a particular topic associated with ageing and degradation, e.g. Safe Working Life, Lifetime Margins, Ageing and Degradation Mechanisms. The titles of Principles EAD.1 to EAD.5 and ENC.2 have been used as a starting point, with additional themes identified where the identified RGP is not encompassed by the extant Principles.
- **Consideration** – Information to guide inspectors when assessing a safety submission, similar in detail and format to that provided in the ONR TAGs, e.g. for the theme of 'Ageing and Degradation Mechanisms'; consider if all applicable ageing and degradation mechanisms are clearly identified and understood.

1.3 Scope

The scope of the review presented in this document covers the following management of ageing and degradation related ONR SAPs, along with their supporting notes:

- Principle EAD.1 (Safe working life)
- Principle EAD.2 (Lifetime margins)
- Principle EAD.3 (Periodic measurement of material properties)
- Principle EAD.4 (Periodic measurement of parameters)
- Principle EAD.5 (Obsolescence)

For ease of reference, the text of each of the above Principles is replicated in Appendix 2.

The scope of this review includes:

- A summary of the output from the reviews of RGP, identified in Appendix 1 against the extant ageing and degradation Principles in each of the Discipline Reports (Reference 2 to 4).
- Consideration of recommendations that could be implemented within the SAPs, i.e. that are sufficiently generic as to be applicable to any UK nuclear licensed site (and are not just Nuclear Power Plant (NPP) related).
- In addition to Principles EAD.1 to EAD.5, the review also considers the relevance of the identified RGP to Principle ENC.2 (Examination through life)[1] specifically in the context of ageing and degradation.

The following are out of the scope of the review presented within this document:

- A review of ONR SAPs other than those listed above;
- Reactor core and graphite components.

The scope of this task did not specifically include the identification of SSC ageing and degradation mechanisms. However, a table of typical ageing and degradation mechanisms for various SSCs has been included as an Appendix in each of the Discipline Reports for information (Appendix 6 in References 2 to 4).

1.4 Document Structure

This document is structured as follows:

- Section 1: Introduction, including purpose and scope of this assessment
- Section 2: An overview of the methodology of this assessment and some additional background for the task.

[1] It should be noted that this principle relates to non-metallic components and is reflected in other parts of the SAPs relating to other disciplines. For instance, SAP EMC.27 for Metal Components or SAP ECE.20 within the Civil Engineering principles.

- Section 3: A summary of the review of the SAPs against key nuclear industry RGP (review tables are included at Appendix 3).
- Section 4: A summary of the key themes and considerations identified in each of the Discipline Reports (Summary tables are included in Appendix 4).
- Section 5: A summary of the potential future considerations relating to ageing and Degradation from the Discipline Reports.
- Section 6: Conclusions and Recommendations resulting from the reviews undertaken.
- Appendix 1: Listing of all reference documentation and identification of the discipline report that reviews the RGP.
- Appendix 2: Listing of the in-scope ageing and degradation related SAPs
- Appendix 3: Review of ONR SAPs against key elements of nuclear RGP.
- Appendix 4: Summary of identified themes and the source RGP documents that identify additional considerations
- Appendix 5: Table of Abbreviations

2. Methodology

2.1 Review Methodology

In order to establish whether the current ONR guidance on the management of ageing and degradation of SSCs adequately covered the key themes and considerations currently identified in RGP documentation, the following methodology was used:

1. Online searches for published RGP by Subject Matter Experts (SMEs) were performed and supplemented by information from Mechanical / EC&I / Civil Engineering discipline Heads of Professions (HoPs) within the Wood Nuclear Business Unit.
2. The initial list of RGP was then reviewed by the relevant SMEs and HoPs during the development of the scope of work for this task. This also included discussions with SMEs and HoPs from the wider Wood to ensure that the identified sources of other high-hazard industries RGP were relevant and complete.
3. The list of RGP was then agreed with the ONR at the project kick-off meeting, which included the relevant SMEs and discipline HoPs.
4. During the development of the Mechanical (including generic aspects), EC&I and Civil Engineering discipline reports, the SME report authors identified further relevant RGP (in addition to that within the agreed scope of work), which was then added into the overall list of RGP for review.
5. For production of the discipline reports the SME authors undertook reviews of both the nuclear industry RGP and the other high-hazard industry RGP, with respect to the ageing and degradation related Principles within the scope of the task, to identify key themes and considerations. Where the RGP reviewed included additional relevant information that could complement the existing ageing and degradation related Principles, then this was identified within the appendix review tables of the relevant discipline report.
6. Consolidation of the key themes and considerations identified above was then included within Sections 3 to 5 of the discipline reports.
7. The relevant ONR SAPs were then reviewed to ensure that the consolidated key themes and considerations identified in Sections 3 to 5 of the discipline reports were adequately covered.
8. Recommendations for updates to the SAPs, with respect to the scope of each discipline review were then made.
9. As part of discipline report production, the list of both the nuclear industry RGP and the other high-hazard industry RGP was reviewed by the relevant SMEs and discipline HoPs prior to issue of the documents.
10. The final step presented in this document was to review and consolidate the findings and recommendations from each of the interim reports.

A list of all relevant RGP that has been considered as part of the overall review is listed in Appendix 1 which summarises the documents reviewed across the three reports and identifies which interim report considers the RGP. It should be noted that in some cases the RGP has been reviewed in multiple discipline reports due to the nature of the content.

Within the Nuclear Industry, understanding and managing ageing and degradation has become more important with an increasing role in ensuring nuclear safety over the years. The work undertaken in this area has ranged from the development of strategies and programmes to manage ageing and degradation through to detailed Research & Development (R&D) to better understand the effects of ageing or specific degradation mechanisms. As a result, the breadth and depth of potential RGP is relatively large and could lead to significant effort to review. However, given the nature of the SAPs and the level of detail they incorporate, the emphasis of searches undertaken tended to focus more on the programmatical aspects of ageing and degradation. While some of the identified RGP relating to the Mechanical, EC&I and Civil SSCs may be of interest it is judged that this information is too detailed for the scope of this task. Some items that fall into this category are included in the discipline reports for further reading.

2.2 Additional Background

To establish a common understanding of the terminology used in this report, it is considered appropriate to define several commonly used terms. The definitions for some of the terms vary and, in some cases, terms are interchangeable with others depending on the source. The terms, abbreviations and definitions are outlined in the table below:

Term / Abbreviation	Definition
Ageing Management	IAEA SSG-48 (Reference 5) identifies that Ageing Management covers all activities that aim to prevent or control ageing effects, within acceptable limits, throughout the entire lifetime of the nuclear power plant (i.e. design; fabrication or construction; commissioning; operation, including Long Term Operation (LTO); and decommissioning, including long term shutdown).
Asset Management	The integration of ageing management and economic planning to optimise the operation, maintenance, and service life of SSCs; maintain an acceptable level of performance and safety; and maximise return on investment over the service life of the plant.
Beyond Design Life (BDL)	A period of an SSCs lifetime that exceeds the original design life of the item. Please see Figure 2.
Design Life	The Design Life, as identified in Reference 1, is the period of time during which a facility or component is expected to perform according to the technical specifications to which it was produced.
International Generic Ageing Lessons Learned (IGALL)	The objective of the IGALL publication (Reference 6) is to provide a technical basis and practical guidance on managing ageing of mechanical, electrical and instrumentation and control (I&C) components and civil structures of nuclear power plants important to safety.
Lifecycle	Reference 1 identifies that Lifecycle is defined as all the stages in the life of a facility from conception through to delicensing. This includes design, build, commissioning, operation, maintenance, closure, decommissioning, disposal of waste and the return of a site to a safe state.
Long Term Operation (LTO)	IAEA SSG-48 (Reference 5) identifies that LTO of a nuclear power plant is operation beyond an established time frame defined by the licence term, the original plant design, relevant standards or national regulations.

Term / Abbreviation	Definition
Periodic Safety Review (PSR)	IAEA NP-T-3.24 (Reference 7) identifies that a PSR is a comprehensive safety review of all important aspects of safety, carried out at regular intervals, typically every 10 years. It also notes that a PSR may be used in support of the decision making process for licence renewal or LTO, or for the restart of a nuclear power plant, following a prolonged shutdown or lay-up period.
Plant Life Extension (PLEX)	Plant Life Extension, similar in meaning to LTO; however, LTO is now more commonly used than PLEX.
Plant Life Management (PLiM)	IAEA NP-T-3.24 (Reference 7) identified that Plant Life Management is defined as the integration of ageing and economic planning to optimise NPP investments in favour of safety, commercial profitability and competitiveness, while providing a reliable supply of electrical power.
Structures, Systems and Components (SSCs)	Reference 1 identifies that an SSC is an item important to safety within the facility design which provides a safety function. It is a general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety. IAEA SSG-48 (Reference 6) identifies that the following SSCs should be included in the scope of ageing management: a) SSCs important to safety that are necessary to fulfil the fundamental safety functions. b) Other SSCs whose failure may prevent SSCs important to safety from fulfilling their intended functions. c) Other SSCs that are credited in the safety analyses (deterministic and probabilistic) as performing the function of coping with certain types of event, consistent with national regulatory requirements.
Stated or Claimed Life	The period for which an SSC has been demonstrated, through testing, analysis or experience, to be capable of functioning within acceptance criteria during specified operating conditions while retaining the ability to perform its safety functions in a design basis event.
Time-Limited Ageing Analyses (TLAA)	IAEA SSG-48 (Reference 5) identifies that TLAA should demonstrate that the analysed ageing effects will not adversely affect the capability of a structure or component to perform its intended function(s) throughout an assumed period of operation

Table 1: List of Definitions

Further information on common terminology can be found in Reference 1, the IAEA Safety Glossary (Reference 8) or the Glossary of Nuclear Power Plant Ageing from the Organisation for Economic Cooperation and Development (OECD), Nuclear Energy Agency (Reference 9).

To provide support to ensuring a common understanding between this task and similar tasks currently being undertaken for the ONR, Figure 2 has been prepared to illustrate the relationship between different processes that will contribute to the management of ageing and degradation, plus support Beyond Design Life expectations. The simplified figure presents key stages over the operating lifetime of an SSC, identifying aspects to be considered through operation and in to decommissioning. This figure could include the design, manufacture, installation and commissioning as these steps will also contribute to the lifetime expectations of the SSC, the degradation mechanisms, any tolerable (minor) defects and the ease of Maintenance and Inspection. The figure presents an SSC that operates over a considerable life (some 70+ years) when extended operation and decommissioning is factored in. However, this figure could be applied to SSCs with shorter lifetimes; for instance, an SSC installed initially for a 5-year period either on a temporary basis or due or closeness to the claimed end of life. In this instance there may be limited interaction between the Safety Case and a PSR.

It is recognised that the level of degradation recorded against an SSC will vary depending on the nature and complexity of the SSC. Therefore, the performance and subsequent life of the SSC may be determined by individual parameters or a collection of mechanisms that contribute to the overall performance of the SSC. In addition, for complex SSCs modification or replacement of accessible components may alter the rate of degradation. The simplified figure assumes a relatively constant level of degradation for the SSC over the life of the item. As the rate of degradation will vary depending on the SSC and its function it is important to understand the different elements that can influence the variables within the figure, this may include (but not limited to):

- What the degradation mechanisms are for the SSC.
- How the degradation is affected by time, considering (but not limited to):
  - The materials used;
  - The environment it will operate in;
  - The impact changes to operation may have;
  - Factors that could increase or decrease the rate of degradation;
  - Recognising any non-conformities that may have occurred during manufacture.
- The material properties or parameters that can be used to monitor the rate of degradation.
- The assessment or analysis tools or techniques that demonstrate current and future performance. This may also include:
  - Assumptions used as input values in original design analyses, for instance relating to material properties.
  - Use of original certified values from build records compared to assumed values.
  - Assumptions or conservatism that are within the tools and codes use to extrapolate future performance.
- Any Research & Development (R&D) programmes that can provide additional information to support any of the points above.

To provide further clarification in Figure 2 a number of the variables associated with the SSC and interactions with the Safety Case identify supporting notes; these are presented below the figure.

Figure 2: Simplified Figure to Support Beyond Design Life and Ageing & Degradation Definitions & Discussion

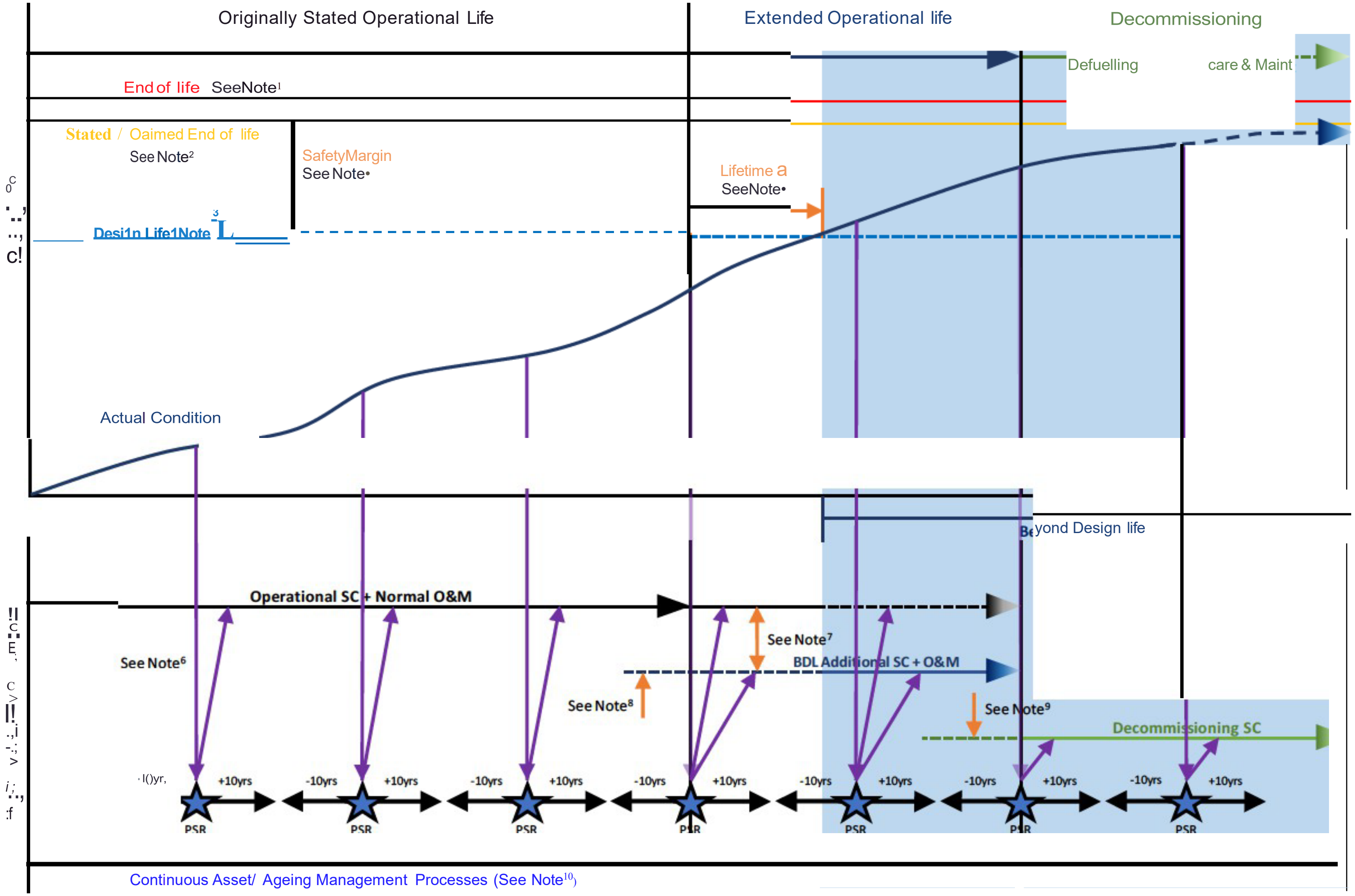


Figure 1 Notes

Note 1: The point at which an SSC fails, beyond which no corrective actions are possible, in many instances will be unknown. The point at which an SSC will fail is subject to significant uncertainty that must be taken into account in any BDL decision making process. Defined as **End of Life** this is based on several different criteria specific to the SSC and will relate to the identified ageing & degradation mechanisms. This will be based on specific material properties and parameters.

Note 2: The **Stated** or **Claimed End of Life** is the point at which an SSC is claimed or stated within the Safety Case (SC) as no longer fit for service. This value may reflect uncertainties introduced during the manufacture process that resulted in non-conformities being raised. As with End of Life, this may be based on different criteria specific to the individual SSC and the identified ageing & degradation mechanisms. However, as there may be some conservatism in the supporting analysis or assessments, the stated value could differ from the point at which the actual End of Life occurs.

Note 3: The **Design Life** - The life specified in the original design the SSC should operate safely for. The design life may have had an influence on the materials used, manufacturing process and Examination, Inspection, Maintenance and Testing (EIMT) over the life of the SSC.

Note 4: The **Safety Margin** - The margin between the original design life and stated or claimed end of life. The knowledge on what this margin is will vary due to several factors such as the nature and Class of the SSC and the age of design and manufacture. For instance, the Safety Margin should be greater & better defined for safety significant SSCs, while less significant items may have less of a gap between the two points. The Safety Margin may also be influenced by the degree of redundancy in the total system for delivery of a Safety Function. Building in additional redundancy at the design stage will reduce the reliance (and potential safety significance) of an individual SSC, so that (for instance) a replacement strategy could be used to mitigate the impact of ageing.

Note 5: The **Lifetime Δ** - The gap between the actual condition at the end of the originally stated operational life and when the SSC reaches the end of the design life will vary due to various factors. For instance, how effective the asset / ageing management has been, actual environment compared to the design intent, actual utilisation compared with the original design intent, the development of ageing mechanisms not considered during design, and potential changes to the operation. This difference will also be linked to how well the Operations & Maintenance (O&M) have been carried out over the life of the SSC compared to the original design intent. It will represent the difference between the validity period of the SC and the plant life expectations of the duty holder based on changes to the O&M during the operational life of the SSC.

Note 6: A PSR includes a comprehensive assessment of the facility's condition, operating experience, SC, safety management arrangements, and culture, looking forward at least the next ten years and normally to the end of life. The review is carried out at appropriate intervals through the different lifecycle phases of the facility, usually every ten years starting at the commencement of active commissioning. The PSR process will review how the actual condition of the SSC is managed, identify if there were significant plant performance issues over the previous 10 years, and provide statements of confidence for operation over the next 10 years. This will be achieved by review of various EIMT results or dedicated inspections for the PSR that are specific to the SSC. The output of the PSR process, across all aspects of the review (including changes relating to the condition of the SSC) will need to be reflected in the applicable SC. At the transition from the Operational SC to the additional BDL SC, and from this combination into the Decommissioning SC, the output from the PSR should be incorporated in to the extant SC. It should be noted that the BDL SC is the 'Operational SC' that incorporates BDL elements and may not significantly differ to the Operational SC if existing analyses are still valid; however, the process to determine that additional substantiation is not required should still be recorded.

Note 7: The additional effort required to support / substantiate BDL will vary depending on the nature and Class of the SSC. Associated Ageing Management Plans will also vary in detail according to the nature and Class of the SSC. The process for BDL should take input from the PSR process, the Asset / Ageing Management processes and existing O&M regimes. It is noted that the level of effort required to substantiate BDL will depend on various factors including the relevance of original safety justification, Time-Limited Ageing Analyses (TLAAs), validity of original assumptions and relevance of extant O&M to BDL operation. The gap between the extant O&M and the BDL O&M may relate to changes in the operating conditions or environment, increases in dose, or other unforeseen challenges that may alter the way EIMT is carried out. The Δ between the two will inform the level of effort required to demonstrate operation BDL is ALARP.

Note 8: The work to prepare BDL submissions will be required to commence during the originally stated operating life. This may relate to the complexity of the SSC; alternatively, it may be due arbitrary dates associated with anticipated operational life within the extant SC. The originally stated lifetime limits (defined by fatigue life, cycle limits, calendar limits etc.) are often imposed due to limited knowledge, or an inability to predict material properties with high confidence for long periods of operation. Other factors that influence early BDL assessment / investigation of SSCs may include a lack of evidence on the actual condition of the SSCs, and this may require extended outages to provide confidence. PSR also provides a mechanism to identify life limited SSCs well ahead of the need to extend into the BDL region.

Note 9: The Decommissioning SC must be reviewed and updated to reflect changes that arise due to extended operation and the information included in the BDL SC. This may be due to changes in the level of radioactive waste or SSCs having a greater dose then expected.

Note 10: Asset & Ageing Management Processes run continuously throughout the whole life of the SSC. The specific strategies employed for SSCs should evolve and change to reflect the age of the SSC, level of degradation, obsolescence, loss of knowledge (Suitably Qualified & Experience Persons (SQEPs) or Original Equipment Manufacturers (OEMs)), changes in operational demands, or changes in safety function. In addition, advances in tools & techniques to minimise the effects of ageing and degradation or more accurately measure the actual condition and ensure continued reliability should be reviewed on a routine basis (e.g. as part of PSR).

As previously noted, Figure 1 is a simplified overview to identify different elements to be considered as part of the BDL expectations.

3. Review of SAPs against Key Nuclear Industry RGP

The concepts and principles of ageing management and Long Term Operation (LTO) have evolved over time since the initial concerns around these issues were first raised in the mid to late 1990's. The processes to address initial concerns on these topics, at an international level, can be traced back to the early-2000's, which largely developed Ageing Management and LTO independently. This continued for many years and as a result of various national and international studies and sharing of experience the processes continued to evolve. However, within the recently issued IAEA guidance (Reference 5) these topics have now been brought together, recognising the impact the management of ageing & degradation will have on a facility to operate beyond the original design life.

Reference 5 separates ageing of SSCs into two aspects, physical and non-physical ageing. Where physical ageing is a general process in which the physical characteristics of SSCs gradually deteriorate with time or use owing to physical degradation or chemical or biological processes (i.e. degradation mechanisms). Non-physical ageing of SSCs is the process of their becoming out of date (i.e. obsolete) owing to the availability and evolution of knowledge and technology, and the associated changes in requirements, codes and standards.

The Safety Guide provides guidance for operating organisations on implementing and improving ageing management and on developing a programme for safe long term operation for nuclear power plants that, among other aspects, takes due account of ageing management. In addition, the document notes that this Safety Guide may also be used by the regulatory body in preparing regulatory requirements, codes and standards and in verifying effective ageing management in nuclear power plants. Whether an operating organisation meets the requirements or intent of Reference 5 is a function of the Period Safety Review (PSR), which is governed by Licence Condition 15 and the associated TAG (NS-TAST-GD-050 (Rev 6)).

Therefore, the review of the SAPs against this Safety Guide will focus on whether the SAPs can facilitate an operating organisation to meet the IAEA requirements; i.e. do the SAPs prompt or encourage the right approaches, behaviours and programmes to effectively manage ageing and degradation appropriately for nuclear safety significant SSCs. To support this review the Safety Guide identifies nine generic attributes of an effective ageing management programme and three basic steps that should be included in a technological obsolescence programme. The SAPs will be reviewed against these attributes and steps to identify if there are any potential gaps.

Appendix 3 identifies the nine attributes of an effective ageing management programme (Table A3-1) and the three basic steps that should be included in a technological obsolescence programme (Table A3-2). Each table compares these to the SAPs to determine if these items are covered by existing SAPs. This included the in scope Principles EAD.1 to EAD.5 and ENC.2; in addition, other relevant SAPs are identified that may cover parts of the attribute or a step not specifically covered by Principles EAD.1 to EAD.5 and ENC.2. The output from this review is presented in Appendix 3 and summarised in the sub-sections below.

3.1 Review of Physical Ageing

Reference 5 identifies that effective ageing management throughout the lifetime of SSCs requires the use of a systematic approach to managing the effects of ageing that provides a framework for coordinating all activities relating to the understanding, prevention, detection, monitoring and mitigation of ageing effects on facilities SSCs . This approach is illustrated in Figure 3, which is an adaptation of Deming's 'PLAN–DO–CHECK–ACT' cycle to the ageing management of SSCs.

Figure 3: Systematic Approach to Ageing Management

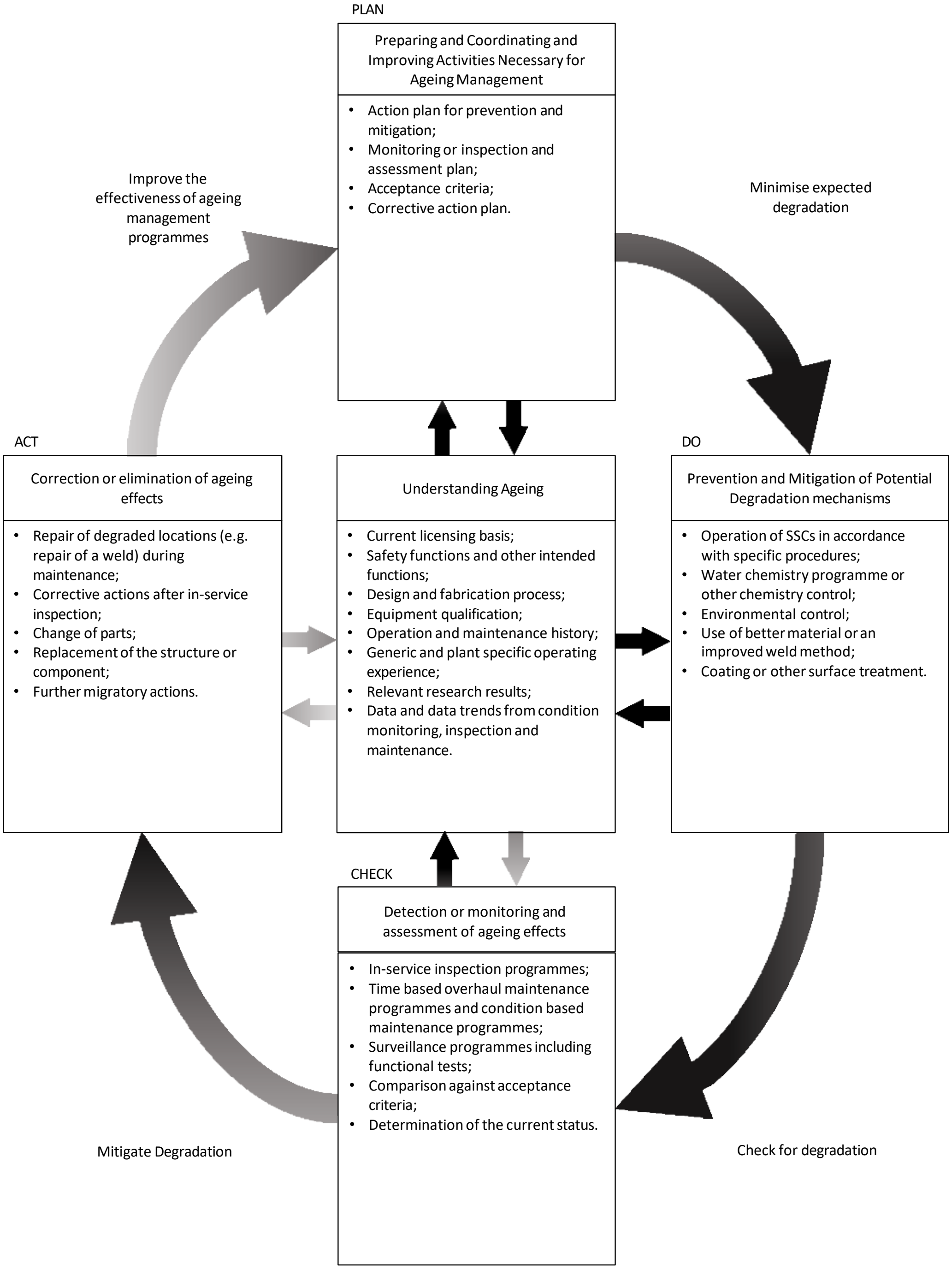


Table A3-1 identifies the nine attributes of an effective ageing management programme, it can be seen that in most cases that various SAPs are applicable to each of the attributes and in many cases, this includes the in scope SAPs. However, there are a few exceptions notably Attribute 6 (Acceptance criteria), Attribute 8 (Operating experience feedback) and Attribute 9 (Quality management).

In the cases of Attributes 8 and 9 some applicable SAPs are identified but none of these are Principles EAD.1 to EAD.5 or ENC.2; these two attributes are also covered by a number of Licence Conditions, which are also identified in Table A3-1. The subjects covered around the use of operating experience, including use of R&D, and the quality management systems are not explicitly identified in the ageing and degradation Principles or associated notes. The use of operating experience feedback in Principles EAD.2, EAD.3 and EAD.4 would provide an additional resource to demonstrate lifetime margins or give greater confidence in the frequency of periodic measurements of parameters or performance. Given the nature of these attributes the intent is captured in other SAPs, mainly by the Principle associated with the management systems (Principle MS.4), which does not directly identify a link to ageing and degradation. Therefore, consideration should be given to either amending the guidance supporting Principles EAD.2 to EAD.4 to reflect the link to operating experience, including use of R&D, and the quality management systems and the role they play OR amending Principle MS.4 to reflect the link to the management of ageing and degradation. This issue is also highlighted in the wider review of RGP, covered in Section 4 and discussed further in Section 4.9.

The other potential area not directly covered by the SAPs is associated with Attribute 6, which relates the development / identification of Acceptance Criteria against which the need for corrective actions is evaluated. Review of the existing SAPs has not identified any requirement for an operating organisation to develop and record acceptance criteria for associated with periodic measurements of parameters or performance. Principle EAD.2 identifies the need for timely mitigation to ensure adequate safety margins; however, there is no explicit reference for the need to establish acceptance criteria. In addition, Principle EMC.33 identifies that data used in analyses and acceptance criteria should be clearly conservative, taking account of uncertainties in the data and their contribution to the safety case. This is also applicable for the EIMT SAPs, which do not identify the need to identify acceptance criteria or action levels. LC28 notes that if the EIMT reveals any matter indicating that the safe operation or safe condition of that plant may be affected then this needs to be raised & recorded. To determine if safety may be affected some success or acceptance criteria will be required, but again this is not explicit. The extent to which acceptance criteria and mitigations are identified will vary depending on the nature of the SSC and the importance to nuclear safety; however, for certain items proactive identification by an operating organisation of acceptance criteria and planned mitigations seems a prudent exercise prompted by the SAPs. Therefore, consideration should be given to amending Reference 1 (para 219) to include additional text that incorporates "*Consideration should be given to how modes of failure can be predicted or revealed and then mitigated or repaired. This will lead to the identification of acceptance criteria and / or actions levels as appropriate. The identified action levels should be defined to ensure that appropriate mitigating actions are taken and completed in a timely manner*". This issue is also highlighted in the wider review of RGP, covered in Section 4.

3.2 Review of Non-Physical Ageing

Reference 5 outlines the three basic steps of obsolescence management, which are:

- Identify technological obsolescence issue
- Prioritise technological obsolescence issues
- Implement solutions for technological obsolescence issues

Figure 4 below identifies these and provides additional information against each of the steps. The SAPs were reviewed against these basics steps to identify if they prompt or encourage the right behaviours and programmes to enable an operating organisation to achieve these steps.

Figure 4: Basic Steps of Obsolescence Management

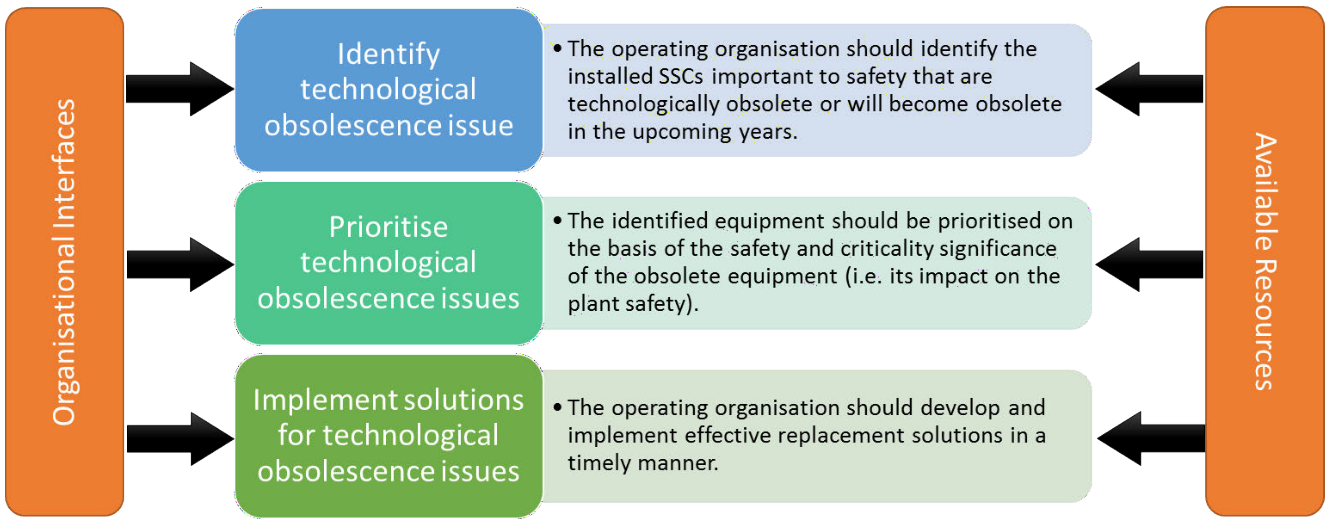


Table A3-2 identifies all three of the steps identified above are covered by predominantly one Principle EAD.5, which specifically covers Obsolescence. The principle states that ‘a *process for reviewing the obsolescence of structures, systems and components important to safety should be in place*’. The supporting notes provide additional information, but the focus is around identification of issues and the types of solutions that may be available, and there is no explicit requirement to prioritise the issues. The supporting text to Principle EAD.5 notes that the threat from obsolescence should be identified; although, it is not clear if this is simply identification of SSCs or the wider risk posed by the obsolescence. The nuclear safety significance of the SSCs will contribute to the prioritisation of the obsolescence issues and as a result Principles ECS.1 and ESC.2 have been included in the table. However, other factors (such as novelty or complexity of the SSCs and the available resources) will also have an impact on the prioritisation of the issues. Therefore, considerations should be given to amending the supporting text (Ref 1 Paragraph 221) to recognise that an obsolescence process should include the prioritisation of issues as this would remove this potential gap. In addition, strengthening the links between the Obsolescence Management and Asset Management processes would enable connections to the Asset Management TAG to be made. This issue is also highlighted in the wider review of RGP, covered in Section 4.

4. Summary of Key Themes and Considerations

4.1 Theme 1: Safe Working Life (Principle EAD.1)

The text below presents a summary of all the findings & recommendations identified against Theme 1 (Safe Working Life), this consolidated list combines the output from each of the discipline reports. The additional considerations for this theme include:

- The design phase is key to setting the fundamental capability of a plant to achieve the vision of assured and predictable safe operation over life. The design phase includes the development of equipment procurement specifications and system design specifications, as well as defining operating requirements, limits, and margins
- Substantiation of the Safe Working Life, where appropriate, should include analysis to demonstrate the loadings over the lifetime of the structure, including the structural analysis and modelling and demonstrating defect tolerance where required.
- The environmental conditions in operational states and accident conditions should be taken into account in the design and in the equipment qualification programme. In addition, the Equipment Qualification should consider accelerated ageing testing for appropriate SSCs to support Safe Working Life demonstration.
- Other factors to consider associated with this theme include:
  - Consideration should be given to the use of materials with greater resistant properties to the foreseeable physical ageing effects.
  - Consideration should be given to designing in additional equipment redundancy if this could provide greater flexibility for operational and ageing management
  - The effective technology (inspection, testing and monitoring methods) for detecting ageing effects before SSC failure should be clearly identified at the design stage
  - Planning for the ageing management of inaccessible SSC at the design stage should be a priority, because replacement and repair is not usually a feasible option
- Safe working life requirements should be specified to the SSC manufacturers, along with the expected SSC service conditions, so that they can be fabricated taking these into account.
- Work management and surveillance activities at the construction stage should be managed in order to avoid any life limiting consequences for the plant (e.g. by controlling the construction environment and providing adequate QA levels). In addition, the SSC should be checked in accordance with an appropriate QA process to ensure that they have been manufactured, stored and transported appropriately.

In general, the considerations identified above would not lead to recommended changes to Principle EAD.1 or the supporting paragraphs (Ref 1 Para 213 & 214). In part, this is due to the considerations being part of other Principles within the SAPs; for instance, relating to Equipment Qualification (Principle EQU.1). However, the considerations do provide additional guidance from the review of RGP that should be taken into account when assessing the 'Safe Working Life' of an SSC. It is recommended that this information should be captured as part of an ageing and degradation TAG. The TAG could then identify the links between these considerations and other parts of the SAPs where these items are encompassed.

It should be noted that across the RGP reviewed many of the documents contain Operating Experience (OPEX) that relates to various aspects of ageing and degradation, such as degradation mechanisms, monitoring methods and approaches to analysis. The international experience from various sources includes factors to consider in determining a Safe Working Life and substantiation of SSCs. While these may have limited applicability for UK nuclear facilities there is a significant pool of information on this topic that could prove a valuable resource. This is discussed further against Theme 9.

4.2 Theme 2: Lifetime Margins (Principle EAD.2)

The text below presents a summary of all the findings & recommendations identified against Theme 2 (Lifetime Margins), this consolidated list combines the output from each of the discipline reports. The additional considerations for this theme include:

- The SAPs discuss retaining SSC capability through-life in excess of that needed to for the effective delivery of the associated safety functions. Additional aspects within other Principles that link to this theme include:
  - Principle ESS.10 also states that such margins should take into account uncertainties in foreseeable degradation mechanisms.
  - Principle ESS.12 also states that degradation of the SSC supporting services should also be taken into account.
  - Principle EHA.11 states that the effects of climate change should be taken into account within the facility safety justification (particularly during Periodic Safety Reviews). Where such effects could influence SSC degradation mechanisms then these should be considered.
  - The points raised in Principles ESS.10, ESS.12 and EHA.11 should be considered for inclusion within the supporting notes to Principle EAD.2 or as part of additional guidance in an ageing and degradation TAG.
- The list of the equipment of a nuclear facility that may technically limit its operating lifetime should be established and reviewed periodically. These plant items should be subject to specific surveillance and to periodic reassessment of their residual operating lifetimes, account being taken of existing operating experience and improvements in knowledge of degradation mechanisms.
- The service conditions (i.e. environmental conditions and operating conditions) to be maintained and operating practices aimed at slowing down potential SSC degradation should be clearly identified.
- Suitably conservative considerations of the effects of ageing and degradation on safety margins throughout plant life should be made. Also, the SSC lifetime safety margins should consider all relevant statutory regulations as well as safety case requirements when deriving and managing safety margins.
- Relevant codes and standards should be regularly reviewed as part of assessing lifetime margins. Where relevant design codes change over the life of the facility then such changes should be appropriately factored into the considerations of the available safety margins. In addition, where there are impending changes to design codes and standards that affect SSC, a comparison of these standards should be undertaken to demonstrate that appropriate conservatisms and safety margins are maintained.

- Ensure that all specified design margins for SSC are tested and verified prior to delivery to the site. For SSC subject to novel and/or complex manufacturing and/or operational processes, parallel manufacture for destructive testing purposes should be considered.
- The EMIT of SSC should be commensurate with their nuclear safety significance, take into account their operational history and support the justification that their 'design intent' is maintained over the lifetime of the facility. Operational histories of SSC, in-service inspection results and knowledge of (older) SSC in similar facilities should all be taken into account. In addition, SSC data monitoring should be used to identify trends in failures or gradual degradation over time. The analytical models and criteria used should be adequate to evaluate the residual life of SSC. If adverse trends are identified then the results should be investigated to determine potential causes, (e.g. stressful environmental or operational factors) and enable appropriate mitigating measures to be taken to eliminate these factors or to make vulnerable SSCs suitably robust.
- SSC acceptance criteria should be developed, against which the need for corrective action should be evaluated. Timely mitigation of ageing and its effects should be undertaken to ensure that adequate safety margins are maintained. Consideration should be given to how modes of failure can be predicted or revealed and then mitigated or repaired. This will lead to the identification of evaluation or acceptance criteria and / or actions levels. The identified action levels should be defined to ensure that appropriate mitigating actions are taken and completed in a timely manner.
- Degradation of equipment is usually strongly linked to the process operating conditions in terms of the environment, loads and duty. Process control is therefore an important part of the equipment ageing management strategy.
- The remaining SSC life will depend upon a number of sources of information, for example:
  - Original design life (specified in years or number of operating cycles);
  - Current equipment age and condition;
  - How long ago any damage initiated and how fast it may be accumulating;
  - Rate of degradation (whether constant, variable, or exponential);
  - Expected operating regime and degradation mechanisms;
  - Changes in material properties;
  - Fatigue life (based on the S-N design or fracture mechanics);
  - Corrosion life (determined from the corrosion rate, allowance and thickness limit);
  - Limits determined from design or fitness-for-service assessment;
  - Safety margins.
- The potential effects of operational changes or SSC modifications should be taken into account and particular attention to SSC margins has to be paid when changes are proposed in the operating conditions of a nuclear facility.
- Where SSC are planned to be replaced through-life, an adequate safety margin should be in place to prevent failure before replacement. The early replacement of SSC potentially sensitive to degradation should be considered in order to enlarge safety margins.

In general, the considerations identified above would not lead to recommended changes to Principle EAD.2; however, it is recommended that some of the items above be reflected in the supporting paragraphs under Principle EAD.2. There are two considerations above that are not currently identified against this theme in the SAPs. The first relates to the potential impact changes to the operating regime and / or an SSC and impact these may have on the Lifetime Margins. Consideration should be given to amending Reference 1 (para 218) to include additional text that states, "*In addition, the impact that changes to the operating conditions / environment or modification to the structure, system or component have on the remaining life should be considered*".

The second potential gap relates to the identification of acceptance criteria; consideration should be given to amending Reference 1 (para 219) to include additional text that incorporates "*Consideration should be given to how modes of failure can be predicted or revealed and then mitigated or repaired. This will lead to the identification of acceptance criteria and / or actions levels as appropriate. The identified action levels should be defined to ensure that appropriate mitigating actions are taken and completed in a timely manner*".

The other considerations identified above provide additional guidance from the review of RGP that should be taken into account when assessing the 'Lifetime Margins' for an SSC. It is recommended that this information should be captured as part of an ageing and degradation TAG. The TAG would also identify the links between these considerations and other parts of the SAPs where these items are potentially already accounted for.

It should be noted that across the RGP reviewed many of the documents contain OPEX that relates to various aspects of ageing and degradation, such as degradation mechanisms, monitoring methods and approaches to analysis. The international experience from various sources includes factors to consider in determining Lifetime Margins and demonstration of these for a range of SSCs. While these may have limited applicability for UK nuclear facilities there is a significant pool of information on this topic that could prove a valuable resource. This is discussed further against Theme 9.

4.3 Theme 3: Periodic Measurement of Material Properties (Principle EAD.3)

The text below presents a summary of all the findings & recommendations identified against Theme 3 (Periodic Measurement of Material Properties), this consolidated list combines the output from each of the discipline reports. The additional considerations for this theme include:

- Uncertainties in material properties and the associated degradation mechanisms should be considered during the design process and confirmed or otherwise during in-service monitoring. In addition, any extrapolation or correlation used to derive material properties should contain adequate margins to cater for uncertainties.
- Any time dependent material properties used within design basis calculations should take into account anticipated relevant material property changes over the period of operations being justified.
- Where practicable designs should allow key elements SSCs to be inspected and, where necessary, maintained. If elements cannot be inspected, the safety case should demonstrate with high confidence that the performance of these elements will remain adequate for the design life.
- Manufacturing records of SSC should be retained. Understanding actual SSC material properties at the end of fabrication and start of service is vital. Through-life SSC material

property measurements should take into account fabrication flaws, damaging events and the potential interactions of different ageing mechanisms.

- Particular attention should be paid to the assessment of material properties of welds, especially for large welds subject to neutron irradiation where significant material property variations may occur.
- Long-term SSC material property trend predictions, supported by material surveillance programmes and research, are necessary to support continued operation justifications. Such predictions should take into account uncertainties in material property data.
- Methods which are able to measure in-situ the material properties of the SSC may be advantageous, especially if historical SSC data is not available. The effects of operational history should be taken into account when assessing the potential degradation in material properties through-life.
- The material properties to be monitored or measured should be clearly defined along with the data assessment methods, relevant acceptance criteria, action levels and any corrective actions that may be necessary.
- Programmes developed to measure material properties of SSCs should be capable of measuring changes in properties to the level of sensitivity required. This is particularly relevant when deploying new or novel techniques. In addition, where instrumentation is imbedded to measure material properties or performance it is worth noting that the instrumentation should be able to be tested and calibrated during operation.
- Uncertainties associated with the monitoring and measuring methods should be identified and the impact on lifetime margins considered. Any changes to examination procedures should be such that consistent and comparable material property data is determined through-life.

In general, the considerations identified above would not lead to recommended changes to Principle EAD.3; however, it is recommended that some of the items above be reflected in the supporting paragraphs under Principle EAD.2. The structure of the ageing and degradation Principles presents supporting information regarding Lifetime Margins and the development of monitoring programmes under Principle EAD.2. The information presented applies to both the measurement of material properties (Principle EAD.3) and performance parameters (Principle EAD.4). The considerations above that identify potential gaps in the existing text could also equally apply to Principles EAD.3 or EAD.4; therefore, the proposed amendments are recommended in the supporting paragraphs to Principle EAD.2.

The considerations that identify potential gaps relate to the identification of acceptance criteria and recognising uncertainties in the monitoring or measuring methods. Consideration should be given to amending Reference 1 (para 216) to include additional text that incorporates "*The material properties to be monitored or measured should be clearly defined along with the data assessment methods, relevant acceptance criteria, action levels and any corrective actions that may be necessary*". In addition, paragraph 216 should be amended to include the following text, "*Uncertainties associated with the monitoring and measuring methods should be identified and the impact on lifetime margins considered*".

The other considerations identified above provide additional guidance from the review of RGP that should be taken into account when identifying, performing or assessing 'Periodic measurement of material properties'. It is recommended that this information should be captured as part of an ageing and degradation TAG. The TAG would also identify the links between these considerations and other parts of the SAPs where these items are potentially already accounted for.

It should be noted that across the RGP reviewed many of the documents contain OPEX that relates to various aspects of ageing and degradation, such as measurement or monitoring methods and approaches to analysis. The international experience from various sources includes factors to consider as part of the periodic measurement of material properties for a range of SSCs. While these may have limited applicability for UK nuclear facilities there is a significant pool of information on this topic that could prove a valuable resource. This is discussed further against Theme 9.

4.4 Theme 4: Periodic Measurement of Parameters (Principle EAD.4)

The text below presents a summary of all the findings & recommendations identified against Theme 4 (Periodic Measurement of Parameters), this consolidated list combines the output from each of the discipline reports. The additional considerations for this theme include:

- Through-life parameter measurements should be formally managed and reported. Parameters to be monitored or inspected should be clearly defined along with the data assessment methods, relevant acceptance criteria and any corrective actions that may be necessary.
- For the specific parameters that will be periodically monitored or inspected a description of how those parameters will be capable of identifying SSC degradation before a loss of intended function occurs should be defined.
- Provisions for on-line monitoring should be considered, particularly when this would provide forewarning of degradation leading to the failure of SSCs and when the consequences of failure could be important to safety. For certain SSCs provision should be made for non-routine inspections following extreme events or faults that could accelerate degradation mechanisms, e.g. extreme weather events.
- The extent and periodicity of the examination proposals should be commensurate with the SSCs operational duty and associated safety functional requirements. The frequency of SSC parameter measurement should be determined on the basis of their relative importance to safety and the assessed potential for degradation in operation and ageing characteristics. Formal periodic safety reviews may also affect the required SSC parameter measurement frequency.
- In-service inspections should be carried out at intervals whose length shall be chosen in order to ensure that any deterioration of the most exposed component is detected before it can lead to failure. Parameter measurement is particularly important at the commencement of operation just after commissioning and when ageing mechanisms could significantly deteriorate SSC performance. In addition, where SSC are comprised of multiple components, the individual components most susceptible to ageing should be identified and monitored through-life.
- In-service conditions that affect SSC ageing should be identified and monitored through-life to help mitigate potential ageing effects. The operating organisation should verify that the actual environmental conditions are consistent with those considered in the design of SSCs
- All items of equipment used for examinations and tests together with their accessories should be qualified and calibrated before they are used. Uncertainties and limitations in any inspection should be explicitly reported along with the results.
- Personnel performing parameter measurements should be Suitably Qualified and Experienced Persons (SQEP).

- The ways in which the facility layout ensures accessibility of SSCs to enable their inspection, maintenance and repair should be considered in the design stages. Human factors should also be considered when defining how the identified parameter measurement will be undertaken.
- Radiation doses (both individual and collective) that could be received by workers during surveillance activities should be taken into account when defining the parameters to be periodically measured. In addition, the techniques used should be evaluated through-life in order to provide optimal results and maintain radiation doses to workers ALARP.
- Data recording and trending of performance parameters should be used as tools for assessing equipment ageing. In addition, periodic measurement of SSC performance data should be used to trend and predict when non-conformances against defined acceptance criteria are likely to occur.
- Records of baseline data (design, manufacturer, equipment qualification and commissioning), operational histories (operating performance, process/system and environmental conditions, etc.) and maintenance histories of plant components should be sufficiently comprehensive and readily retrievable to allow:
    - Trend analysis and prediction of component performance and remaining service life;
    - The identification and evaluation of degradation, failures and malfunctions of components caused by ageing effects.
- Sufficient data and records should be captured to support effective ageing management. Effective quality control should be used to capture such data and records consistently through-life using appropriately qualified and experienced personnel, within an appropriate information management system.
- A formal system for through-life data management should be implemented, which will support the following:
    - Decisions on the type and timing of preventative maintenance actions, including repair, refurbishment and replacement;
    - Identification and evaluation of degradation, failures and malfunctions of components caused by ageing effects;
    - Optimisation of operating conditions and practices that would reduce excessive ageing degradation;
    - Identification of new emerging ageing effects before they jeopardise plant safety, production reliability and service life;
    - Assessments concerning continued operation of plants, including reviews of licence renewal applications;
    - Sharing experience with other nuclear facilities to further the industry's collective understanding and support research and development work.
- Where either new ageing mechanisms are discovered or where known ageing mechanisms become more significant than originally expected, then an increase in parameter monitoring and/or inspection may be appropriate. As long as such inspections do not adversely affect the operating conditions. In addition, SSC parameter measurement frequencies may justifiably change through the equipment life and advances in RGP for SSC monitoring and surveillance techniques should be routinely reviewed in order to permit a better evaluation of existing margins.

In general, the considerations identified above would not lead to recommended changes to Principle EAD.4; however, it is recommended that some of the items above be reflected in the supporting paragraphs under Principle EAD.2. As noted in Section 4.3 the structure of the ageing and degradation Principles presents supporting information regarding Lifetime Margins and the development of monitoring programmes under Principle EAD.2.

The considerations that identify potential gaps relate to the identification of acceptance criteria and recognising uncertainties in the monitoring or measuring methods. Consideration should be given to amending Reference 1 (para 216) to include additional text that incorporates "*The through-life parameters to be measured should be clearly defined along with the data assessment methods, relevant acceptance criteria, action levels and any corrective actions that may be necessary*". In addition, paragraph 216 should be amended to include the following text, "*Uncertainties and limitations in any measurements should be explicitly reported along with the results*".

In addition to the recommended amendments above, other considerations were identified that are not included against Principle EAD.4 (or even Principle EAD.2). The considerations, which were identified from various sources, focused on accessibility to undertake measurements, ensuring SQEP resource performs the measurements and ensuring there is sufficient data and records to support effective ageing management. These considerations will be captured in other parts of the SAPs (outside of the scope of this task); however, as these items were repeatedly identified consideration should be given to including these somewhere in the SAPs to recognise the cross-referencing. This could either be in Principle EAD.2 supporting text referring out to the other SAPs (e.g. Principle ELO.1 (Access) or Principle MS.2 (Capable Organisation)) or the other Principles making reference to Principle EAD.2.

The other considerations identified above provide additional guidance from the review of RGP that should be taken into account when identifying, performing or assessing 'Periodic measurement of parameters'. It is recommended that this information should be captured as part of an ageing and degradation TAG. The TAG would also identify the links between these considerations and other parts of the SAPs where these items are potentially already accounted for.

It should be noted that across the RGP reviewed many of the documents contain OPEX that relates to various aspects of ageing and degradation, such as measurement or monitoring methods and approaches to analysis. The international experience from various sources includes factors to consider as part of the periodic measurement of parameters for a range of SSCs. While these may have limited applicability for UK nuclear facilities there is a significant pool of information on this topic that could prove a valuable resource. This is discussed further against Theme 9.

4.5 Theme 5: Obsolescence (Principle EAD.5)

The text below presents a summary of all the findings & recommendations identified against Theme 5 (Obsolescence), this consolidated list combines the output from each of the discipline reports. The additional considerations for this theme include:

- Obsolescence is the non-physical ageing of SSCs, i.e. the process of their becoming out of date owing to the availability and evolution of knowledge and technology, and the associated changes in requirements, codes and standards. The overall Ageing Management Strategies should incorporate an Obsolescence Management Plan that takes into account technical obsolescence, the ageing of documentation and personnel ageing. The management plan should look to incorporate the use of both reactive and proactive obsolescence strategies.

- The objective of the obsolescence management plan should be to describe strategies for identification and mitigation of the effects of obsolescence through all stages of the facility life cycle. Obsolescence issues should be considered as early as possible in the facility life cycle to reduce risks. The risks associated with obsolescence should be reviewed when changes occur such as obsolete components being replaced.
- Obsolescence Management Plans should include planning for, designing for and checking for obsolescence and then acting upon in-service findings in accordance with the plan. In addition, the management plan should ensure adequate prioritisation, selection and timely implementation of relevant obsolescence activities. Licensees should involve the suppliers in pro-actively managing obsolescence from the design stage onwards. Regular obsolescence reviews should be considered to support the identification of new issues and the management of known issues.
- The Obsolescence Management Plan should be incorporated to safety management processes and consider reducing future obsolescence issues by using equipment that is designed and constructed to common industry standards. Consider including obsolescence strategies in the design specification process (e.g. expected life, lifetime support of spare parts, multiple suppliers).
- Over the lifetime of an NPP there is a high probability that original equipment manufacturers may cease trading. Unavailability of the OEM could make it difficult to obtain parts and/or the original design drawings. SSCs that may become obsolete should be identified and contingency arrangements made. Where it is practical to do so any replacement SSC should be either identical, or a proven technology or tested for the specific application.
- The obsolescence review process should resolve any SSC issues before any associated decrease in reliability or availability occur. The storage of spare parts for identified SSCs parts should be in an appropriately controlled environment to help reduce their degradation mechanisms.
- The obsolescence review process should include the exchange of information and collaborative participation within the nuclear industry and should make use of industry tools to identify and resolve common occurrences of technological obsolescence. In order to identify aging or obsolescence issues consider the following methods:
  - participation in relevant industry groups;
  - review of relevant obsolescence and reliability databases;
  - results of industry research;
  - system health reports, procurement process, vendor notices, planned environmental qualification parts replacement, supply chain capability.

In general, the considerations identified above would not lead to recommended changes to Principle EAD.5; however, it is recommended that some of the items above be reflected in the supporting text (paragraph 221).

The consideration above that are potential gaps in the existing information relate to the prioritisation of the obsolescence issues and reinforcing that the obsolescence process is an on-going activity. Therefore, it is recommended that Ref 1 Paragraph 221 be amended to state:

"*This principle is more likely to be applicable to systems and components rather than the main structural elements of a facility. The process should include planning for, designing for and checking for obsolescence and then acting upon in-service findings in accordance with the plan. In* *addition, the management plan should ensure adequate prioritisation, selection and timely implementation of relevant obsolescence activities. The obsolescence process should resolve any SSC issues before any associated decrease in reliability or availability occur. The solution will depend on the particular circumstances but may involve providing alternative components or items of equipment that can carry out the same safety duty, or it may involve redesigning the plant to remove the need for the obsolescent system or components. The process should include regular reviews to support the identification of new issues and the management of known issues*".

The other considerations identified above provide additional guidance from the review of RGP that should be taken into account when assessing 'Obsolescence' programmes. It is recommended that this information should be captured as part of an ageing and degradation TAG. The TAG would also identify the links between these considerations and other parts of the SAPs where these items are potentially already accounted for.

It should be noted that across the RGP reviewed many of the documents contain OPEX that relates to various aspects of ageing and degradation, including obsolescence. The international experience from various sources contains information regarding obsolescence programmes for a range of SSCs; however, these largely relate to SSCs typically found in Light Water Reactors (LWR). While these may have limited applicability for UK nuclear facilities there is a significant pool of information on this topic that could prove a valuable resource. This is discussed further against Theme 9.

4.6 Theme 6: Examination Through-Life (Principle ENC.2)

The text below presents a summary of all the findings & recommendations identified against Theme 6 (Examination Through Life), this consolidated list combines the output from each of the discipline reports. It should be noted that this theme (and the associated principle – Principle ENC.2) relates to non-metallic components and is reflected in other parts of the SAPs relating to other disciplines. For instance, Principle EMC.27 for metal components or Principle ECE.20 within the civil engineering Principles. The additional considerations for this theme include:

- The design process should identify the requirements for examination, inspection, maintenance and testing of SSC as necessary to assure their continued safe operation. Due regard should be made during the design process to visibility and accessibility of SSC to meet this requirement . Specific attention should also be paid to facilitate the replacement of items which are intended to be renewed within the design life of the overall facility. Detailed ageing management actions on SSCs may be focussed where they are most beneficial from both a safety and an economic point of view. Risk based or risk informed methodologies may be used to facilitate appropriate decisions.
- Inspection activities are essential to reveal at an early stage previously unknown degradation mechanisms or unexpected levels of degradation. In-service inspection procedures should be effective in detecting degradation and it should be demonstrated that ageing effects will be adequately detected with the proposed inspection or monitoring technique before they can impact safety.
- Inspection and monitoring should be directed both at the whole plant and at specific SSCs, operating experience indicates that many ageing mechanisms are discovered not with NDE techniques but with more global monitoring (e.g. visual inspection, loose parts monitoring, leak monitoring).
- A major challenge to performing inspections on nuclear plants is access. Depending upon the risk associated with SSC failure, the design should allow for effective through-life inspection

SFAIRP. Where through-life access is impractical, alternatives to inspection should be considered and appropriately demonstrated within the Safety Case.

- When inspection results show that the actual behaviour of an SSC is worse than expected, the necessary corrective actions are taken in due time, depending on the safety importance of the SSC; these actions include, as appropriate, modifications to the operating conditions of the plant, increased monitoring, more frequent testing, and immediate or early replacement of the SSC. Moreover, corrective actions are considered for other similar items, including items at other plants.

In general, the considerations identified above would not lead to changes to Principle ENC.2 or the supporting paragraph (Ref 1 Para 330). However, one consideration noted above does perhaps need to be incorporated in the SAPs at an appropriate point. Above it notes that 'Inspection and monitoring should be directed both at the whole plant and at specific SSCs, operating experience indicates that many ageing mechanisms are discovered not with NDE techniques but with more global monitoring (e.g. visual inspection, loose parts monitoring, leak monitoring)'. While this statement could be added to paragraph 330, it probably has wider applicability and may need to be considered as part of Principles EMT.1 to EMT.8. However, this is outside of the scope of this task, as such it is recommended that this consideration is recorded in the proposed ageing and degradation TAG (against Principle EAD.4 potentially) and the link to the appropriate principle is identified.

The other considerations above provide additional guidance from the review of RGP that should be taken into account when assessing 'Examination through life'. However, as this principle focusses on Non-Metallic Components including this information in an ageing and degradation TAG may not be the most appropriate document for this specific theme. It is recommended that, if it is determined to be appropriate, this information should be captured as part of an ageing and degradation TAG. The TAG could then identify the links between these considerations and other parts of the SAPs where these items are encompassed.

It should be noted that across the RGP reviewed many of the documents contain OPEX that relates to various aspects of ageing and degradation associated with through-life examination for a range of SSCs. While these may have limited applicability for UK nuclear facilities there is a significant pool of information on this topic that could prove a valuable resource. This is discussed further against Theme 9.

4.7 Theme 7: Definition of Ageing Mechanisms

An additional Principle (e.g. Principle EAD.6) should be considered, which would propose that ageing mechanisms of SSCs should be defined at the concept and design phases in a risk-informed manner and should be included within the safety case. Notes to such a Principle could then propose that the defined SSC ageing mechanisms should be monitored and measured (where possible) through-life. This would potentially allow the justification of safety margins through-life and also then support beyond design life estimations of such margins. How defined ageing mechanisms develop (or new ageing mechanisms appear) in the future should also be considered, e.g. as a result of equipment modifications or operational changes. By assessing SSC ageing mechanisms proportional to their associated nuclear safety risk, then this could potentially support facility ALARP arguments for on-going and future life-cycle phases. Pre-operational safety case deliverables and Periodic Safety Reviews (PSR) could be appropriate points at which to document and review such ageing management issues.

The additional Principle would propose that the SSC subject to ageing management should be defined and that the ageing mechanisms of these SSCs should be included within the safety case and should take into account operational experience and the results of research. Additional considerations for this theme include:

- On a nuclear safety risk basis, the understanding of ageing mechanisms should be maintained over life, e.g. using operational experience and research.
- Aging mechanisms of SSCs should be evaluated in order to avoid failures earlier than expected.
- Uncertainties in evaluating SSC ageing mechanisms should be clearly stated, e.g. for environmental conditions and/or imposed loadings.
- Through-life variations in environmental conditions and/or imposed loadings as a function of operating modes should be understood, including how SSC fabrication processes may affect ageing.
- For each defined ageing mechanism, potential ageing mitigation strategies should be identified (if possible), which could be employed to maintain safety margins, extend service life and maintain SSC reliability through-life.
- Reviewing operational experience at older similar facilities can provide significant ageing management benefits, e.g. in terms of understanding SSC ageing mechanisms, component failure rates and causes, generic failures of vulnerable components, impact of abnormal operations, failure indicators and methods of detection.

Within each of the of the previous themes understanding the applicable ageing and degradation mechanisms for the SSC will have an important role in determining safe working life, demonstrating lifetime margins and determining the appropriate methods to measure material properties or performance parameters. However, there is currently no requirement to systematically identify the degradation mechanism for SSCs important to safety, security or the environment. Given the importance this exercise has it is recommended that a new principle located after Principle EAD.1, which states:

Engineering principles: ageing and degradation	Ageing and degradation mechanisms	EAD.6
The applicable ageing and degradation mechanisms of structures, systems and components that are important to safety should be evaluated and defined at the design stage.		

Para No. The ageing mechanisms of structures, systems and components that are important to safety should be defined at the concept and design phases in a risk-informed manner and should be included within the safety case. For each defined ageing mechanism, potential ageing mitigation strategies should be identified (where practicable), which will be employed to maintain lifetime margins and maintain structures, systems and components reliability through-life. Uncertainties in evaluating SSC ageing mechanisms should be clearly stated, e.g. for environmental conditions and/ or imposed loadings.

The other considerations identified above provide additional guidance from the review of RGP that should be taken into account when determining ageing and degradation mechanisms. It is recommended that this information should be captured as part of an ageing and degradation TAG. The TAG would also identify the links between these considerations and other parts of the SAPs where these items are potentially already accounted for.

4.8 Theme 8: Ageing Management Programme

An additional Principle (e.g. Principle EAD.7) should be considered, which would propose that the management of ageing and degradation, including Obsolescence for SSCs important to Safety, Security and the Environment are formally managed through an Ageing Management Programme.

Historically the management of ageing & degradation has been formed of a number of diverse processes and programmes that are notionally (and in some cases actually) linked together to form the Ageing Management Programme (AMP). However, this has the potential for some of the themes and considerations identified above to be omitted or unconnected. The development of an effective AMP should consider:

- The operating organisation should ensure that an effective AMP is implemented to ensure that required safety functions of SSCs are fulfilled over the entire operating lifetime of the facility, including long term operations beyond the originally planned lifetime of the facility.
- Ageing management of SSCs should be implemented proactively (with foresight and anticipation) throughout the whole facility life stages, i.e. design, fabrication and construction, commissioning, operation (including maintenance or modification), decommissioning and dismantling. In addition, ageing management should be performed on an ALARP basis, with SSC ageing considered proportionate to their contribution to overall facility risk.
- The AMP should consider:
  - Physical ageing: The ageing of SSCs due to physical, chemical and/or biological processes (degradation mechanisms), and
  - Non-physical ageing: The fact that some SSCs may become out of date (i.e. obsolete) owing to the evolution of knowledge and technology and/or changes in requirements, codes and standards.
- In addition, the AMP should consider non-technical aspects such as organisational and human factors, data collection and record keeping and reviews of the management of ageing. This requires associated necessary resources (human resources, financial resources, tools and equipment, and external resources).
- All potential ageing mechanisms for passive or active SSCs, that could affect their ability to perform their safety functions, should be identified, evaluated and taken into account. Potential combined effects should also be identified.
- Appropriate quality management arrangements should be in place to collect data, record practices, update models and indicators and ensure that preventive actions are appropriate and all corrective actions are effective.
- An AMP may be developed either as a standalone process or integrated across a number of management system processes. In either case, it should be possible to describe how the totality of the AMP supports the justification of continued safe facility operations. Licensees should consider all programs and activities associated with the SSC to determine to what degree they already manage SSC aging and degradation.
- In its AMP, the licensee should take account of environmental conditions, process conditions, duty cycles, maintenance schedules, service life, testing schedules and replacement strategy.
- The AMP should be reviewed and updated as a minimum with the PSR, in order to incorporate new information as it becomes available, to address new issues as they arise, to use more sophisticated tools and methods as they become accessible and to assess the performance of maintenance practices considered over the life of the plant.

- Feedback from relevant operational experience at other facilities, from other regulatory bodies (e.g. US NRC) and data from research programmes concerning ageing effects should be reviewed and used by designers and suppliers to inform the AMP.

The additional Principle (e.g. Principle EAD.7) to be proposed should also consider the links between AMPs and Asset Management. Asset Management is not currently discussed within the SAPs. As such consideration should be given to introducing specific Asset Management Principle(s), e.g. based upon the principles presented in the Asset Management Nuclear Safety TAG (NS-TAST-GD-098), noting that this document is outside of the scope of this review.

Within each of the of the previous themes there is lots of information such as defining the safe working life (and identification of underlying assumptions), data gathered from periodic measurements (and the impact these have on Lifetime Margins) and potential obsolescence. This information, along with longer-term planning, form the basis of an Ageing Management Programme, which may be captured across various parts of the management systems and not linked. The role of the AMP is to connect these different aspects, so the related information can be brought together to inform decision making. Currently there is no requirement for a formal AMP; however, the introductory paragraph to the ageing and degradation section (Ref 1 - para 212) identifies that *"Effective management of ageing is needed...",* it goes on to note that *"This may be achieved through a specific ageing management programme or through other arrangements appropriate to the structure, system or componenf'.* Based on the review of RGP it is recommended that a principle is added to formalise the need for an AMP but recognising that this maybe achieved through a number of processes or programmes at facility. Therefore, it is recommended that a new principle located before or after Principle EAD.1, which states:

Engineering principles: ageing and degradation	Ageing management programme	EAD.7
An effective ageing management programme should be implemented to ensure that the safety functions of structures, systems and components are delivered throughout the full lifetime of the facility.		

Para No. The ageing management of structures, systems and components that are important to safety should be implemented proportionately and proactively (with foresight and anticipation) throughout the whole facility life stages, i.e. design, fabrication and construction, commissioning, operation (including maintenance or modification), decommissioning and dismantling. In addition, ageing management should be performed on an ALARP basis, with SSC management of ageing considered proportionate to their contribution to overall facility risk.

Para No. An ageing management programme may be developed either as a standalone process or integrated across a number of management system processes. In either case, it should be possible to describe how the totality of the ageing management programme supports the justification of continued safe facility operations.

Para No. The ageing management programme should be actively maintained throughout each of the lifecycle stages and reviewed regularly. The ageing management programme is to be kept up to date so that it continuously meets the needs of all its users. In particular, the knowledge used at the time of writing the first individual plans for SSCs needs to be supplemented by subsequent monitoring of the facility and data, e.g. from commissioning, operation, periodic measurements, research or experience from other facilities.

The other considerations identified above provide additional guidance from the review of RGP that should be taken into account when determining ageing and degradation mechanisms. It is recommended that this information should be captured as part of an ageing and degradation TAG. The TAG would also identify the links between these considerations and other parts of the SAPs where these items are potentially already accounted for.

4.9 Theme 9: Use of Operating Experience

Contained within the RGP, especially those that relate to specific types of SSC or disciplines, the documents record a significant amount of information around various aspects of ageing and degradation. This includes listing a range of degradation mechanisms and identifying various monitoring methods. The degradation mechanisms identified relate to various SSCs or materials commonly used in the manufacture of SSCs or the construction of structures within the nuclear industry or other high-hazard industries. The range of monitoring methods outlined are often linked to specific degradation mechanisms and include various destructive and non-destructive techniques employed around the world.

Many of the themes identified above highlight the importance of OPEX to inform the various aspects associated with ageing and degradation, including considerations covered under Principles EAD.2, EAD.3 and EAD.4. In addition, OPEX would be valuable in the identification of degradation mechanisms (Theme 7) and developing appropriate (and proportionate) AMPs (Theme 8). The requirements to ensure continuous learning through a facility's whole lifecycle is underpinned by Principle MS.4. While the ageing and degradation Principles currently do not explicitly identify the use of OPEX consideration should be given to amending the text within the ageing and degradation Principles to encourage the use of OPEX to help support the identification and development of aspects associated with ageing and degradation. It is recommended that this is included in the proposed text for the new principle, Principle EAD.7, see Section 4.8 above.

It should be noted that much of the OPEX identified originates from international civil Nuclear Power Plant (NPP) programmes and as such much of the information is based on Light Water Reactor (LWR) structures and technology. While this information may have limited applicability within the UK, they do contain information on ageing and degradation mechanisms and monitoring methods for a number of different materials and SSCs. This may include some information applicable to some UK facilities and SSCs. A summary of the information from different RGP sources is included in each of the Discipline Reports (Ref 2 to Ref 4) and this may be used to inform further reading on specific SSCs or materials.

5. Future Considerations

The text below presents a summary of all the Future Considerations, this consolidated list combines the output from each of the discipline reports.

The themes and considerations discussed in previous sections with respect to RGP were reviewed in order to identify potential future considerations associated with them. These future considerations are presented within the structured bulleted list of themes and considerations below to align with the headings in Section 4.

Theme 1: Safe Working Life (Principle EAD.1)

- The development of new materials, or the use of existing materials for different applications, will need to demonstrate that nuclear safety will not be compromised by the ageing and degradation over the full life-cycle of the SSCs. The development of materials with greater resistant properties to the foreseeable physical ageing effects would improve SSC reliability. In addition, the use of new materials should not introduce new degradation mechanisms that can adversely affect existing SSCs.
- Improvements in technologies for the detection of ageing effects before SSC failure would reduce unexpected failures. Embedded performance and condition monitoring of SSC, taking advantage of modern technologies, would improve the understanding of SSC ageing and degradation.
- The standardisation of equipment qualification programmes would improve the understanding of expected SSC operating conditions. In addition, the standardisation of QA arrangements for the construction, storage and/or transportation of SSC would improve the understanding of SSC condition at the start of in-service operation.

Theme 2: Lifetime Margins (Principle EAD.2)

- Lists of SSCs that may technically limit nuclear facility operating lifetime should be better understood in future. Assessments of their residual operating lifetimes should be more accurate in future.
- Future analytical techniques should be better able to quantitatively calculate residual lifetime safety margins. Future codes and standards should be better able to support the more accurate calculation of lifetime margins.
- The periodic replacement of SSC potentially sensitive to degradation should be made easier, e.g. via the use of qualified 3D printed components or via the greater standardisation of components.

Theme 3: Periodic Measurement of Material Properties (Principle EAD.3)

- Future materials and construction techniques (e.g. welding) will improve, leading to better predictions of uncertainties in material properties. Also, future performance of SSCs will be supported by better understanding of their material properties and improvements in analytical methods to support the generation of this data.
- Future developments of robust non-destructive examination (NDE) technologies to measure material conditions such as local stress in components, local strain that could be used to monitor loss of pre–load, void swelling, embrittlement and fatigue damage will allow better future monitoring of material properties.

- Long-term SSC material property trend data and research results will increase in future, leading to increased experience based benefits. In addition, through-life SSC material property measurements (including in-situ methods) should be more accurate, as a result of the development of more accurate measurement techniques.

Theme 4: Periodic Measurement of Parameters (Principle EAD.4)

- Nuclear facility SSCs most susceptible to ageing will be increasingly designed out as operational experience increases.
- On-line monitoring of SSC performance and condition monitoring parameters should provide better forewarning of SSC degradation/failure. Future on-line monitoring may involve the use of Artificial Intelligence and machine learning. This would need to be appropriately integrated into safety cases, which would be a step change from existing practice.
- One of the most significant challenges in the area of applied diagnostics will be incorporating technological advances in prognostic and diagnostic sciences into plants for extended operation, e.g. the economics of incorporating advanced diagnostic technology in existing operating plants, regulatory acceptance of advanced diagnostic technology and the harmonisation of international standards for diagnostic systems.
- Worker radiation doses incurred during SSC inspection activities may be further mitigated or even eliminated, e.g. via the use of remote monitoring techniques and/or better plant design. In addition, the verification of the effectiveness of water chemistry programmes could be enhanced by on-line, remote monitoring techniques to enable ‘real-time’ changes to maximise SSC life.
- Continuous on-line SSC parameter measurement may eliminate the need to assess optimal inspection timescales. In addition, it could remove the need for SQEP to perform parameter measurements, leading to a reduction in the human error measurement component. However, this would lead to the challenge of larger amounts of data and analysis. Also, continuous on-line SSC parameter measurement would allow continuous trend analysis of data, giving advanced warning of SSC degradation.
- An automatically generated database of SSC parameter information would reduce the quality control burden on organisations.
- Establishing a harmonised approach to equipment qualification and associated minimum acceptable standards is a future challenge. The development of international standard practices or guidance for carrying out maintenance that will enable licensees to evaluate the effectiveness of maintenance practices is a future challenge. In addition, the development of international standard practices or guidance for carrying out component functional testing with harmonised approaches to acceptance criteria, monitoring and trending criteria is a future challenge.

Theme 5: Obsolescence (Principle EAD.5)

- Future obsolescence strategies should reduce (or even eliminate) the potential for SSC obsolescence. It may be possible to use 3D printers to produce SSC spares on demand and eliminate the need for holding spares in storage.
- Future obsolescence issues may be reduced by using equipment that is designed and constructed to common industry standards. In addition, increasing collaborative participation within the nuclear industry should help to identify and resolve common occurrences of technological obsolescence.

Theme 6: Examination Through-Life (Principle ENC.2)

- Future use of advanced techniques for performance and condition monitoring may make physical SSC inspections by workers unnecessary and be more effective in detecting through-life degradation.

Theme 7: Definition of Ageing Mechanisms

- All aspects of ageing and degradation mechanisms of nuclear facility SSC will be better understood in future, which will lead to better designs and potentially longer operating lives of nuclear facilities.

Theme 8: Ageing Management Programme

- Ageing Management Programmes may become routine activities in future and be standardised across the nuclear industry. Future challenges to AMPs include:
  - The need for harmonisation of industrial standards and regulatory requirements applicable to AMPs;
  - Identification of knowledge gaps to be covered in future research, such as life assessment technologies, NDE and monitoring techniques, repair techniques and the development of material property databases.
- It is noted that in the latest revision of part of the ASME Code (ASME XI Div 2, 2019 revision – Reference 10) there includes a requirement for a Reliability and Integrity Management Program (RIM Program). A RIM program must have:
  (1) RIM Program scope definition;
  (2) Degradation mechanism assessment;
  (3) Plant and SSC Reliability Target allocations originating from the probabilistic risk assessment (PRA);
  (4) Identification and evaluation of RIM strategies;
  (5) Evaluation of uncertainties;
  (6) RIM Program implementation;
  (7) Performance monitoring and RIM Program updates.
- The requirements identified above are aligned to many of the Themes and Considerations outlined in Section 4, this demonstrates that the nuclear industry is starting to standardise these types of management programmes through the development and updates to Codes.

Theme 9: Use of OPEX

- Increased levels of international nuclear facility ageing and degradation experience and RGP should improve the industry's understanding of ageing and degradation mechanisms in the future and identify mitigations more readily. Operational histories of SSC will only ever increase in future, leading to increasing experience based benefits.

In addition to the items noted above future considerations specific to Civil Engineering were also noted. Reference 3 identifies that construction practices are continually changing due, in part, to advances in analysis processes and materials science. Although it is not possible to predict what standard construction processes will be in use in the future, a number of innovative approaches to construction outlined in Reference 3 and are briefly discussed below.

Novel Reactor Designs

New reactor designs may require a change in construction processes. For example, small modular reactors are likely to be constructed in factory conditions rather than on-site. Likewise, such reactors may be decommissioned at the end of their life at a purpose built facility. This offers the potential for increased quality through better control of environmental factors during construction.

It is recognised that this consideration will also have an impact on the Mechanical and EC&I disciplines also. The approach to modular manufacture, construction, installation and commissioning in order to demonstrate appropriate QA throughout and ensure an auditable trail should be considered with the development of the modularisation process.

Novel Construction Materials

Fibre-reinforced polymer (FRP) is a construction material which has seen limited use in the construction industry, e.g. for pedestrian bridges or walkways. Advances continue to be made by industry to produce better materials and design guidance which will allow for the wider use of FRP. Work is currently underway to develop codified design rules which will ease the acceptance of FRP designs.

In recent years there has been much research into the use of nanomaterials to improve the material properties of concrete. Nanoscale particles are highly reactive due to their increased surface area relative to their volume. Examples of nanomaterials used to date include Nano-silica, Nano-titanium oxide, graphene, nanosized cement particles, etc. These materials could potentially yield concrete with higher tensile strength, greater ductility and improved toughness.

Novel Construction Methods

3D concrete printing is currently under research by a number of parties in the UK including Skanska, Loughborough University and the Manufacturing Technology. 3D concrete printing offers the potential to construct highly efficient structural forms which are tailored to the applied design loads.

6. Conclusions and Recommendations

6.1 Conclusions

Reviews were undertaken to consider whether the extant ONR SAPs (Reference 1) related to ageing and degradation (Principles EAD.1 to EAD.5 and ENC.2) adequately cover the key themes and considerations currently identified in the following sources of RGP:

- ONR Technical Assessment Guides (TAGs) and other ONR guidance documents;
- Other nuclear industry RGP;
- Non-nuclear, high-hazard industry RGP.

The reviews undertaken were recorded in three discipline reports, which focused on Mechanical SSCs and generic ageing and degradation information (Reference 2), Civils (Reference 3) and EC&I (Reference 4). A total of 98 documents were identified across the different sources of RGP identified above. Given some documents were excluded for various reasons (e.g. due to being superseded) and the scope overlapped the discipline reports, a total of 115 reviews were undertaken across the three documents. The reviews undertaken identified a number of common themes that were identified across all documents and a series of considerations that were unique to the discipline report or had applicability across all reports. A summary of the consolidated list of themes and considerations is presented in Section 4.

In general, the themes and considerations identified in the review of ageing and Degradation RGP aligns to the existing Principles identified in the scope of this task. The information identified in the RGP does not lead to any recommended changes to the current Principles. However, in a number of cases considerations were identified against specific themes that should be considered in updates to the supporting paragraphs to specific Principles. It is recommended that these amendments be considered in order to closer align the Principles to RGP. The proposed changes are identified in Section 6.2 below.

In addition, some further themes were identified that are not currently reflected in the existing ageing and degradation Principles or are currently incorporated in supporting paragraphs to existing Principles. In order to align the ageing and degradation related Principles with current RGP it is recommended that two new Principles be added to the SAPs. The proposed changes are identified in Section 6.2 below.

Finally, the identified themes and considerations provide additional guidance from the review of RGP that should be taken into account when considering what is involved with each of the Principles. In a number of cases the considerations identified did not need to be included in the ageing and degradation Principles as they are directly or indirectly included in other SAPs outside the scope of this task. It is recommended that this information should be captured as part of an ageing and degradation TAG, which would also identify the links between the considerations and other parts of the SAPs where the items are already accounted for. It is proposed that the scope of the ageing and degradation TAG align to the structure of themes and considerations presented in this document and the order of the revised / updated Principles.

6.2 Recommendations

Additional of new Principles

In order to align the ageing and degradation related Principles with current RGP it is recommended that two new Principles be added to the SAPs.

The first new Principle would be located before Principle EAD.1, which states:

Engineering principles: ageing and dearadation	Ageing management oroaramme	EAD.7
An effective ageing management programme should be implemented to ensure that the safety functions of structures, systems and components are delivered throughout the full lifetime of the facility.		

Para No. The ageing management of structures, systems and components that are important to safety should be implemented proportionately and proactively (with foresight and anticipation) throughout the whole facility life stages, i.e. design, fabrication and construction, commissioning, operation (including maintenance or modification), decommissioning and dismantling. In addition, ageing management should be performed on an ALARP basis, with SSC management of ageing considered proportionate to their contribution to overall facility risk.

Para No. An ageing management programme may be developed either as a standalone process or integrated across a number of management system processes. In either case, it should be possible to describe how the totality of the ageing management programme supports the justification of continued safe facility operations.

Para No. The ageing management programme should be actively maintained throughout each of the lifecycle stages and reviewed regularly. The ageing management programme to be kept up to date so that it continuously meets the needs of all its users. In particular, the knowledge used at the time of writing the first individual plans for SSCs needs to be supplemented by subsequent monitoring of the facility and data, e.g. from commissioning, operation, periodic measurements, research or experience from other facilities.

The second new principle located after Principle EAD.1, which states:

Engineering principles: ageing and degradation	Ageing and degradation mechanisms	EAD.6
The applicable ageing and degradation mechanisms of structures, systems and components that are important to safety should be evaluated and defined at the design stage.		

Para No. The ageing mechanisms of structures, systems and components that are important to safety should be defined at the concept and design phases in a risk-informed manner and should be included within the safety case. For each defined ageing mechanism, potential ageing mitigation strategies should be identified (where practicable), which will be employed to maintain lifetime margins and maintain structures, systems and components reliability through-life. Uncertainties in evaluating SSC ageing mechanisms should be clearly stated, e.g. for environmental conditions and/ or imposed loadings.

Amendments to paragraphs supporting extant Principles

It is recommended that amendments to the existing paragraphs that support the extant ageing and degradation Principles be considered in order to closer align the Principles to RGP. The amendments include:

- Paragraph 216 to include additional text that incorporates
  - "*The material properties and through life parameters to be monitored or measured should be clearly defined along with the data assessment methods, relevant acceptance criteria, action levels and any corrective actions that may be necessary*".
  - "*Uncertainties and limitations associated with the monitoring and measuring methods should be explicitly reported along with the results and the impact on lifetime margins considered*".
- Paragraph 218 to include additional text that states, "*In addition, the impact that changes to the operating conditions / environment or modification to the structure, system or component have on the remaining life should be considered*".
- Paragraph 219 to include additional text that incorporates "*Consideration should be given to how modes of failure can be predicted or revealed and then mitigated or repaired. This will lead to the identification of acceptance criteria and / or actions levels as appropriate. The identified action levels should be defined to ensure that appropriate mitigating actions are taken and completed in a timely manner*".
- Paragraph 221 be amended to state "*This principle is more likely to be applicable to systems and components rather than the main structural elements of a facility. The process should include planning for, designing for and checking for obsolescence and then acting upon in-service findings in accordance with the plan. In addition, the management plan should ensure adequate prioritisation, selection and timely implementation of relevant obsolescence activities. The obsolescence process should resolve any SSC issues before any associated decrease in reliability or availability occur. The solution will depend on the particular circumstances but may involve providing alternative components or items of equipment that can carry out the same safety duty, or it may involve redesigning the plant to remove the need for the obsolescent system or components. The process should include regular reviews to support the identification of new issues and the management of known issues*".

It is recommended that additional consideration identified from the review of RGP be captured as part of an ageing and degradation TAG, which would also identify the links between the considerations and other parts of the SAPs. It is proposed that the scope of the ageing and degradation TAG align to the structure of themes and considerations presented in this document and the order of the revised / updated Principles.

7. References

1. ONR - Safety Assessment Principles for Nuclear Plants, 2014 edition (Revision 0, November 2014)
2. Review of Current ONR Guidance and Industry RGP on Management of Ageing and Degradation of SSCs: Mechanical Aspects, 203171/0026/001
3. Review of Current ONR Guidance on Management of Ageing and Degradation of SSCs: Civil Engineering Aspects, 203171/0026/002
4. Review of Current ONR Guidance on Management of Ageing and Degradation of SSCs: EC&I Aspects, 203171/0026/003

5 Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants, Specific Safety Guide, No. SSG-48, International Atomic Energy Agency, 2018

6. Approaches to Ageing Management for Nuclear Power Plants - International Generic Ageing Lessons Learned (IGALL) Final Report, IAEA-TECDOC-1736, International Atomic Energy Agency, 2014
7. Handbook on Ageing Management for Nuclear Power Plants, IAEA Nuclear Energy Series, No. NP-T-3.24, International Atomic Energy Agency, 2018
8. IAEA Safety Glossary, Terminology used in Nuclear safety and Radiation Protection, 2007 Edition
9. Glossary of Nuclear Power Plant Ageing, Nuclear Energy Agency, Organisation for Economic Co-Operation and Development, 1999
10. 2019 ASME Boiler & Pressure Vessel Code – Section XI Rules for Inservice Inspection of Nuclear Power Plant Components – Division 2 Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Power Plants

Appendix 1
List of Identified Nuclear Industry and High-Hazard RGP

Table **A1-1** **Lists of Identified Ageing & Degradation RGP**

Ref	Title	Notes	Mech	EC&I	Civil
Extant	**ONR Guidance**				
A1	ONR - Safety Assessment Principles for Nuclear Plants, 2014 edition (Revision 0, November 2014)	Relevant SAPs: EAD.1(Safe working life), EAD.2 (Lifetime margins), EAD.3 (Periodic measurement of material properties), EAD.4 (Periodic measurement of parameters), EAD.5 (Obsolescence), ENC.2 (Examination through life)	y	y	y
		EMC.3 (Evidence), EMC.26 (Forewarning of failure), EMC.33 (Use of data), ECE.2 (Independent arguments), ECE.13 (Use of data), ECE.23 (Inspection of sea and river flood defences), ESS.10 (Definition of capability), ESS.12 (Prevention of service infringement), EHA.11 (Weather conditions), AV.8 (Update and review)	y	N/A	N/A
		ESS.10 (Definition of capability), ESS.12 (Prevention of service infringement)	N/A	y	N/A
		ECE.2 (Independent arguments), ECE.8 (Inspectability), ECE.23 (Inspection of sea and river flood defences), ECE.24 (Settlement)	N/A	N/A	y
A2	NS-TAST-GD-009 (Rev 4) - Examination, Inspection, Maintenance and Testing of Items Important to Safety		y	N	N
A3	NS-TAST-GD-016 (Rev 4) - Integrity of Metal Components and Structures		y	N/A	N/A
A4	**NS-TAST-GD--017 (Rev 3)-Civil Engineering**	**Document withdrawn pending review & update.**	**N/A**	**N/A**	**N**
A5	NS-TAST-GD-022 (Rev 5) - Ventilation		y	N/A	N/A
A6	NS-TAST-GD-056 (Rev 5) - Nuclear Lifting Operations		y	N/A	N/A
A7	NS-TAST-GD-057 (Rev 5) - Design Safety Assurance		y	N	N

Ref	Title	Notes	Mech	EC&I	Civil
A8	NS-TAST-GD-067 (Rev 1) - Pressure Systems Safety		y	N/A	N/A
A9	NS-TAST-GD-098 (Rev 0) -Asset Management		y	**N**	**N**
A10	NS-INSP-GD-028 - LC28 Examination, Inspection, Maintenance & Testing (EIMT)		y	**N**	**N**
A11	NS-TAST-GD-003 (Rev 8)- Safety Systems		N/A	y	N/A
A12	NS-TAST-GD-031 (Rev 5)- Safety Related Systems & Instrumentation		N/A	y	N/A
Other Nuclear Industry RGP					
HSE Research Reports					
B1	RR912, Management of Ageing. A framework for nuclear chemical facilities		y	y	y
International Atomic Energy Agency (IAEA)					
B2	INSAG-14 - Safe Management of the Operating Lifetime of Nuclear Power Plants	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
B3	INSAG-19 - Maintaining the Design Integrity of Nuclear Installations throughout their Operating Life	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
B4	IAEA Safety Series 15 - Implementation and Review of a Nuclear Power Plant Ageing Management Programme	Document superseded by SSG-48	N/A[1]	N/A[2]	N/A[2]
B5	IAEA Safety Series 62 - Proactive Management of Ageing for Nuclear Power Plants	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report. In addition, aspects of this document have been superseded by SSG-48.	y	N/A[2]	y
B6	IAEA Safety Series 57 - Safe Long Term Operation of Nuclear Power Plants	Document superseded by SSG-48	N/A[1]	N/A[2]	N/A[2]
B7	IAEA Safety Series 82 - Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL)	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	y
B8	IAEA NS-G-2.12 - Ageing Management for Nuclear Power Plants	This document was superseded by SSG-48 in November 2018, this document was the valid IAEA RGP early in this task, so has been reviewed. SSG-48 has also been reviewed, see below.	N/A[1]	y	N/A[1]

Ref	Title	Notes	Mech	EC&I	Civil
B9	IAEA SSG-48 (November 2018), Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants	Thispublication revises and supersedes the Safety Guide on Ageing Management for Nuclear Power Plants issued in 2009, (NS-G-2.12) and also supersedes two Safety Reports issued by the IAEA in 1999 (SRS-15) and 2007 (SRS-57).	y	N	N
B10	IAEA GS-G-1.2 - Review and Assessment of Nuclear Facilities by the Regulatory Body	Superseded by GSG-13	N/A[5]	**N/A[2]**	**N/A[2]**
B11	IAEA GSG-13 Functions and Processes of the Regulatory Body for Safety (2018)	New reference for Mech (supersedes GS-G-1.2), information on generic themes to be considered under Mechanical aspects	y	**N/A[2]**	**N/A[2]**
B12	IAEA NS-G-2.6 Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants (2002)	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	**N/A[2]**	**N/A[2]**
B13	IAEA-TECDOC-1556 - Assessment and management of ageing of major nuclear power plant components important to safety: PWR Pressure Vessels	Mechanical SSCs main focus of document, not relevant to EC&I or Civils.	y	**N**	**N**
B14	Technical Report Series No 338- Methodology for the Management of Ageing of Nuclear Power Plant Components Important to Safety	An early AM document that presents an early approach to various aspects of Ageing Management. Many of the approaches have evolved or have been superseded, current approach presented in SSG-48.	y	y	N
B15	Safety Series No. 50-P-3 - Data Collection and Record Keeping for the Management of Nuclear Power Plant Ageing	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report. Document identifies that this publication is no longer valid.	y	**N/A[2]**	**N/A[2]**
B16	IAEA-EBP-SALTO IAEA. IAEA (2007) - Final Report of the Programme on Safety Aspects of Long Term Operation of Water Moderated Reactors		y	y	y
B17	STI/PUB/1260 - IAEA ProceedingsSeries - Materials Degradation and Related Managerial Issues at Nuclear Power Plants, Proceedings of a Technical Meeting Vienna, 15-18 February 2005,		y	N	N
B18	IAEA-CN-194-1P28 - Material aging and degradation detection and remaining life assessment for plant life management,	Thisis one of the papers presented at the 3rd International Conference on NPP Life Management (PLIM) for Long Term Operations (LTO) on the 14-18 May 2012. Web-link to all papers resented below.	y	N	N

Ref	Title	Notes	Mech	EC&I	Civil
B19	IAEA NP-T-3.24, (2017) - IAEA Nuclear Energy Series, Handbook on Ageing Management for Nuclear Power Plants		y	y	N
B20	IAEA-TECDOC-1188 - Assessment and management of ageing of major nuclear power plant components important to safety: In-containment instrumentation and control cables Volume I, 2000	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A	y	N/A
B21	IAEA-TECDOC-1402, Aug 2004 - Management of life cycle and ageing at nuclear power plants: Improved I&C maintenance	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A	y	N/A
B22	IAEA-TECDOC-1147, Jun 2000 - Management of ageing of I&C equipment in nuclear power plants	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A	y	N/A
B23	IAEA Safety Aspects of Long Term Operation (SALTO) Reports from various facilities around the world.	Documents from various missions are available through IAEA website, documents provide an overview of the findings from each review. These may include information that relates to all SSCs.	N	y	N
B24	IAEA-TECDOC-1736, Apr 2014, The International Atomic Energy Agency [IAEA) extra budgetary Programme on International Generic Ageing Lessons Learned [IGALL) for Nuclear Power Plants Committee	The associated website was also reviewed within the mechanical interim report. The TECDOC lists NPP AMPs available in the IGALL database and constitutes the final IGALL report. However, the IGALL Database contains information that is relevant to EC&I and Civils, a **link** to the database is identified in XX.	y	N	N
Western European Nuclear Regulators' Association [WENRA)					
B25	Reactor Harmonization Group. WENRA Reactor Reference Safety Levels. WENRA. January 2008		y	N	N
B26	Updated Reference Levels for existing NPP - September 2014		y	N	N
Institute					
B27	AP-913, Equipment Reliability Process Description	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N	N
Electric Power Research Institute **(EPRI)**					
B28	EPRI 1011709, May 2005- Evaluating the effects of ageing on electronic and control circuit boards and components in nuclear power plants	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A[4]	y	N/A

Ref	Title	Notes	Mech	EC&I	Civil
B29	EPRI 1003568, Sep 2002 - Collected field data on electronic part failures and ageing in nuclear power plant instrumentation and control (I&C) systems	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A[4]	N3	N/A
B30	EPRI 1001413, May 2001- Safety system obsolescence and maintainability	Although the scope of this report is obsolescence planning for I&C components, the principles outlined in this report would also be useful for mechanical SSC obsolescence planning	y	y	N/A
B31	EPRI 1008166, Oct 2004 - Guidelines for the Monitoring of Ageing in I&C Electronic Components	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A[4]	N3	N/A
Nuclear E					
B32	NEI AP-940, SS002 Nuclear Asset Management Process Description and Guidelines, Nuclear Energy Institute	Nuclear asset management **(NAM)** is the process of making operational, resource allocation, and risk management decisions at all levels of a nuclear generation business to maximize nuclear power plant value to stakeholders, while maintaining safety to the public and the plant staff. To support nuclear utilities in achieving these goals, the Nuclear Energy Institute (NEI) issued NEI AP 940, Nuclear Asset Management Process Description and Guideline, in May 2005. However, after several years of use by utility personnel responsible for implementation of NAM, it became apparent that significantly more detail was needed to support effective and efficient implementation of NAM activities. This document is not freely available (NEI Member only?); however, it is likely that the information has been superseded by more recent documents on Asset Management.	N/A	N/A	N/A
Nuclear Regulatory Commission (NRC) documentation					
B33	Regulatory Guide 1.207 - Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to The Effects of The Light-Water Reactor Environment for New Reactors	Document appears to have been superseded by NUREG/CR-6909; however, considered **N/A** to the mechanical interim report	N/A[4]	N	N
834	NUREG/CR-6909 - Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials	**N/A** to the mechanical interim report	N/A[4]	N	N

Ref	Title	Notes	Mech	EC&I	Civil
B35	NUREG-1611-Aging Management of Nuclear Power Plant Containments for License Renewal	N/A to the mechanical interim report, Civil related?	N/A[4]	N	y
B36	NUREG-2214 - Managing Aging Processes in Storage (MAPS) Report		y	N	y
B37	NUREG/CR-7111- A Summary of Aging Effects and Their Management in Reactor Spent Fuel Pools, Refuelling Cavities, Tori, and Safety-RelatedConcrete Structures	Reviewed by mechanical, but the content is at too detailed a level to affect the in-scope SAPs	y	N	y
B38	NUREG/CR-6679 - Assessment of Age-Related Degradation of Structures and Passive Components for U.S. Nuclear Power Plants		y	N	y
B39	NUREG 1801Rev2. Generic Aging Lessons Learned (GALL) Report		y	y	y
B40	NUREG 1800 Rev 1 Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
OECD / NEA					
B41	NEA/CSNI/R(2018)8 - OECD/NEA Cable Ageing Data and Knowledge Project CADAK Final Report First and Second Term	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A[4]	y	N
B42	NEA/CSNI/R(2017)3 - Operating Experience Insights into Pressure Boundary Component Reliability and Integrity Management - Topical Report by the Component Operational Experience, Degradation and Ageing Programme (CODAP) Group		y	N	N
B43	NEA/CSNI/R(2015)7 - Component Operational Experience, Degradation & Ageing Programme (CODAP): First Term (2011-2014) Status Report	Information on generic themes on Ageing, Degradation & **AM** to be reviewed as part of the Mechanical Interim Report.	y	N	N
B44	NEA/CSNI/R(2012)7 - CSNI Technical Opinion Papers No. 15, Ageing Management of Nuclear Fuel Cycle Facilities Nuclear Safety	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N
B45	NEA/CSNI/R(2002)26 - Technical Aspects of Ageing for Long-term Operation	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N	y
Additional Information Sources					

Ref	Title	Notes	Mech	EC&I	Civil
B46	Topical Peer Review 2017(ENSREG) - October 2018	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
B47	ENSREG Topical Peer Review on Ageing Management - United Kingdom National Assessment Report- December 2017	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
B48	SKI Report 94:15, Aging Degradation of Concrete Structures in Nuclear Power Plants, September 1994, ISSN 1104-1374	Not relevant to Mechanical or EC&I.	N/A[4]	N	y
B49	TB-05-4, 06/08/05, Westinghouse Technical Bulletin - Potential Tin Whiskers on Printed Circuit Board Components	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A[4]	y	N
B50	IEC62342 Ed 1.0 2007-08 Nuclear power plants - Instrumentation and control systems important to safety - Management of ageing	This document has been reviewed as part of the I&C interim report, not relevant to mechanical or Civils.	N/A[4]	y	N
B51	A Nuclear Industry Good Practice Guide - This issue of the Good Practice Guide was produced by the cross-industry Internal Regulation Working Group (IRWG) and published on behalf of the Nuclear Industry Safety Directors Forum (SDF)	Identified in list of publications from the Nuclear Industry SDF	y	N	N
B52	NVF DG00I Ventilation Design Guide issue 1 2009	Identified in list of publications from the Nuclear Industry SDF	y	N	N/A
B53	NVF DG002 Glovebox Ventilation Design Guide Issue 1 2012	Identified in list of publications from the Nuclear Industry SDF	y	N	N/A
B54	European Union, EUR 19843, Safe Management of NPP ageing in the European Union, 2001	This study provides recommendations for the development of a methodology to monitor, control and anticipate the ageing of Nuclear Islands, in order to maintain their level of safety during the whole NPP life cycle. This study evaluated ageing management practices in Belgium, France and Spain.	y	N	N
B55	NuPEER Dijon 2005 Symposium. Ageing issues in nuclear power plants	The French Nuclear Safety Authority (ASN) organized an international symposium on regulatory aspects of ageing issues for nuclear pressure equipment.	y	N	N
B56	Report on Evaluation and Repair of Existing Nuclear Safety-Related Concrete Structures, ACI 349.3-18	The French Nuclear Safety Authority (ASN) organized an international symposium on regulatory aspects of ageing issues for nuclear pressure equipment.	y	N	y

Ref	Title	Notes	Mech	EC&I	Civil
	"Materials Degradation in Light Water Reactors: Life After 60", J.T. Busby, R.K. Nanstad, R. E. Stoller, Z. Feng, and D.J Naus, Materials Science and Technology Division Oak Ridge National Laboratory, circa 2010	Report identified by Mechanical Document only, numbering reflects identified after the development of this table.	y	N	N
Useful Websites					
B57	The British Standards Committee NCE['.9 nuclear installations, processes and technologies	Website for Standards relating to Nuclear Industry, which outlines current status and identifies review/ pending documents as well as published documents.	y	N	N
B58	European Nuclear Safety Regulators Group (ENSREG)	Website for ENSREG, including the first topical peer review reports on AM. Report issued Oct 2018, plus Country Specific Findings. Individual contributor reports (specifically for the UK) are included elsewhere in thislist.	y	N	N
B59	OECD Committee on the Safety of Nuclear Installations	The mission of the Committee on the Safety of Nuclear Installations (CSNI) is to assist member countries in maintaining and further developing the scientific and technical knowledge base required to assess the safety of nuclear reactors and fuel cycle facilities. Website includes links to various working groups and reports.	y	N	N
B60	NEA Working Grou12 on Integrity and Ageing of Com12onents and Structures (IAGE)	OECD-NEA Website listing various document relating to Ageing of SSCs	y	N	N
N/A	Nuclear Industr::i:: Safet::i:: Directors Forum [SDF)	Part of the Nuclear Institute and includes links to publications	y	N	N
N/A	Nuclear Engineering Directors Forum [NEDF]	Part of the Nuclear Institute, the NEDF first met in April 2016 no publications identified as yet.	y	N	N
N/A	IAEA IGALL Database	Database contain a collection of proven Ageing Management Programmes (AMPs) for various SSCs and a collection of typical time limited ageing analyses (TLAAs).	N	N	N
N/A	IAEA Link to Conference Papers on LTO	Link to the papers presented at the 3rd International Conference on NPP Life Management (PLIM) for Long Term Operations (LTO) Salt Lake City, USA 14-18 May 2012 (Conference ID: 41982 CN-194)	N	N	N

Ref	Title	Notes	Mech	EC&I	Civil
Other High-Hazard Industries RGP					
HSE Research Reports:					
C1	RR509, Plant Ageing, Management of equipment containing hazardous fluids or pressure		y	y	N
C2	RR823, Plant Ageing Study		y	y	N
C3	Key Project 4 - Ageing and Life Extension Key Programme		y	y	y
C4	EEMUA Publication 231- Ed 1- The mechanical integrity of plant containing hazardous substances: A guide to inspectors		y	N	N
C5	Contract Research Report 363/2001 - Best practice for risk based inspection as a part of plant integrity management		y	N	N
United Kingdom Offsl					
C6	Guidance on the Management of Ageing and Life Extension for UKCS Oil and Gas Installations		N	y	N
Nationa					
C7	ISO 55000 specifies the overview, concepts and terminology in Asset Management	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
C8	ISO 55001 defines the requirements for a "management system" for Asset Management	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
C9	ISO 55002 provides interpretation and implementation guidance for such a management system	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
C10	15O/IEC17021:2011 Conformity assessment -- Requirements for bodies providing audit and certification of management systems [Part 5 - Asset Management]	Information on generic themes on Ageing, Degradation & AM to be reviewed as part of the Mechanical Interim Report.	y	N/A[2]	N/A[2]
C11	PAS55 Institute of Asset Management [1AM] Publicly Available Standard for Asset Management	Superseded by 15055000	y	N/A	N/A
C12	IEC62402:2007 Obsolescence Management - Application Guide	This standard is applicable to mechanical and I&C systems	y	y	N/A
The Petroleum Safety Authority Norway					

Ref	Title	Notes	Mech	EC&I	Civil
C13	CGI Report 06:21- Performance Monitoring of Systems and Active Components		y	y	N
C14	CGI Report 06.22 - Condition Monitoring of passive systems, structures and components.		y	y	y
C15	CGI Report 06:23 - Aging Management and Life Extension in the US Nuclear Power Industry -		y	y	N
C16	SINTEF Report A15322 - Ageing and life extension for offshore facilities in general and for specific systems	Not reviewed by Mech Interim report as the report was not listed in the bid document.	N	y	y
C17	17554/1/08 - Requirements for Life Extension of Ageing Offshore Production Installations	Not reviewed by Mech Interim report as the report was not listed in the bid document.	N	y	N
Additional information sources					
C18	OSL-804-R04, Ageing of Offshore Concrete Structures		N	N	y
C19	ACI 201.IR-08, Guide for Conducting a Visual Inspection of Concrete in Service		N	N	y
C20	ACI 228.2R-13, Report on Non-Destructive Test Methods for Evaluation of Concrete in Structures		N	N	y
C21	Corrosion Detection in Steel-Reinforced Concrete Using a Spectroscopic Technique		N	N	y

Table Notes			
N/A[1]	SSG-48 reviewed, which supersedes these documents.	(green)	Document reviewed by at least 1 of the interim specialist reports
N/A[2]	Document related to generic Ageing & Degradation issues, which are being assessed part of the Mechanical document.	(blue)	Document NOT reviewed as has been superseded
N3	Not reviewed - data from this report is used in EPRI 1011709, May 2005	(orange)	Document NOT reviewed or not available and may need high-level review to determine if applicable
N/A[4]	Not applicable to this 'mechanical' SSC document	(red)	Document NOT reviewed yet
N/A[5]	GSG-13 supersedes GS-G-1.2		Website not subject to formal review

Appendix 2
Relevant ONR SAPs

Ageing and degradation

212 *Effective management of ageing is needed so that the safety functions of structures, systems and components are delivered throughout the period needed, which may be the full lifetime of the facility. This may be achieved through a specific ageing management programme or through other arrangements appropriate to the structure, system or component.*

Engineering principles: ageing and dearadation	Safe working life	EAD.1
The safe working life of structures, systems and components that are important to safety should be evaluated and defined at the desian staae.		

213 Particular attention should be given to the evaluation of those components that are judged to be difficult or impracticable to replace.

214 There should be an adequate margin between the intended operational life and the predicted safe working life of such structures, systems and components

Engineering principles: ageing and degradation	Lifetime margins	EAD.2
Adequate margins should exist throughout the life of a facility to allow for the effects of materials ageing and de radation recesses on structures, s stems and com onents.		

216 Programmes for monitoring, inspection, sampling, surveillance and testing, to detect and monitor ageing and degradation processes, should be used to verify assumptions and assess whether the margins will be adequate for the remaining life of the structure, system or component.

217. Appropriate testing of material aged under representative conditions should be undertaken and the results reviewed against the safety case expectations for such changes.

218. The effects of, and interactions between the mechanical, thermal, chemical, physical, biological and radiation environment on materials properties, materials ageing and degradation processes should be considered.

219. Timely mitigation of ageing and its effects should be undertaken to ensure that adequate safety margins are maintained.

Engineering principles: ageing and dearadation	Periodic measurement of material properties	EAD.3
Where material properties could change with time and affect safety, provision should be made for periodic measurement of the properties.		

220 The properties should be obtained from fully representative samples of the material especially when the component or structure performs a principal role in ensuring nuclear safety.

Engineering principles: ageing and degradation	Periodic measurement of parameters	EAD.4
Where parameters relevant to the design of plant could change with time and affect safety, provision should be made for their periodic measurement.		

Engineering principles: ageing and degradation	Obsolescence	EAD.5
A process for reviewing the obsolescence of structures, systems and components important to safety should be in place.		

221 This principle is more likely to be applicable to systems and components rather than the main structural elements of a facility. The process should identify threats from obsolescence and ensure that an adequate supply of spare parts is available until a solution to any obsolescence issues can be found. The solution will depend on the particular circumstances, but may involve providing alternative components or items of equipment that can carry out the same safety duty, or it may involve redesigning the plant to remove the need for the obsolescent system or components.

Engineering principles: integrity of non-metallic components and structures	Examination through life	ENC.2
The design of non-metallic components or structures should include the ability to examine the item throuah life for sians of dearadation.		

330 Principles EMT.1 to EMT.8 and EMC.27 to EMC.30 provide guidance on in-service examination, inspection and testing in general and for structural integrity aspects in particular. The superior corrosion or chemical resistance of some non-metallic materials may, however, lead to claims that there is no need to provide for examination (etc) since the material is not expected to degrade through life. Such claims should be subject to a robust demonstration in the safety case that unexpected degradation cannot occur; otherwise suitable provisions for examination (etc) should be made.

Appendix 3
Review of ONR Safety Assessment Principles Against Key Nuclear RGP

The latest guidance from the IAEA regarding Ageing Management and Long-Term Operation is presented in IAEA SSG-48 (Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants – Reference 5). The Safety Guide provides guidance for operating organisations on implementing and improving ageing management and on developing a programme for safe long term operation for nuclear power plants that, among other aspects, takes due account of ageing management. In addition, the document notes that this Safety Guide may also be used by the regulatory body in preparing regulatory requirements, codes and standards and in verifying effective ageing management in nuclear power plants.

The tables below support Section 3 and compare key aspects of effective ageing management and management of obsolescence against the extant SAPs. The purpose of this comparison is to identify whether the existing SAPs can facilitate an operating organisation to meet the IAEA requirements; i.e. do the SAPs prompt or encourage the right approaches, behaviours and programmes to effectively manage ageing and degradation appropriately for nuclear safety significant SSCs. Table A3-1 identifies the nine attributes of an effective Ageing Management programme, while Table A3-2 identifies the three basic steps of Obsolescence Management. Both of these tables compare the identified RGP against the extant principles within the 2014 SAPs (Reference 1).

In both tables those principles that fall within the scope of this task are highlighted in red. The findings of the comparisons are presented in Section 3.

Table A3-1 Generic Attributes of an Effective Ageing Management Programme and Links to SAPs

Ref	Attribute	Description	SAPs	Notes
1.	Scope of the ageing management programme based on understanding ageing	• Structures (including structural elements) and components subject to ageing management • Understanding of ageing phenomena (significant degradation mechanisms, susceptible sites): ○ Structure or component materials, service conditions, stressors, degradation sites, degradation mechanisms and ageing effects ○ Structure or component condition indicators and acceptance criteria ○ Quantitative or qualitative predictive models of relevant ageing phenomena	ECS.1, ECS.2, ECS.3, EQU.1, EAD.1 & EAD.2	There are a range of SAPs that contribute to defining the scope of an AMP. This includes aspects around CAT & Class, Codes & Standards, Equipment Qualification and Safe Working Life / Lifetime Margins for SSCs. Throughout the life of the facility the scope should be reviewed at regular intervals to determine if the scope of the AMPs needs to be amended, (as min with PSR). Therefore, LC15 would also apply to this Attribute.
2.	Preventive actions to minimize and control ageing effects	• Specification of preventive actions • Determination of service conditions (i.e. environmental conditions and operating conditions) to be maintained and operating practices aimed at precluding potential degradation of the structure or component	SC.4, SC.6, EQU.1, EAD.2, EMC.21 & ESS.10	There are no direct requirements to minimise and control ageing; however, it is assumed that by ensuring lifetime margins are maintained that the appropriate preventative actions are in place. The SAPs do refer to the environmental conditions of the SSCs and ensuring limits and conditions are appropriately derived, which also relates to EQ. In addition to the SAPs identified LC28 would also apply to this Attribute. It states that the licensee shall make and implement adequate arrangements for the regular and systematic examination, inspection, maintenance and testing of all plant which may affect safety.
3.	Detection of ageing effects	• Specification of parameters to be monitored or inspected • Effective technology (inspection, testing and monitoring methods) for detecting ageing effects before failure of the structure or component	EAD.2, EAD.3, EAD.4 & EMC.26	EAD.2 identifies that programmes for monitoring, inspection, sampling, surveillance and testing, to detect and monitor ageing and degradation processes, should be used to verify assumptions and assess whether the margins will be adequate for the remaining life of the SSC. In addition, EAD.3 and EAD.4 relate directly to the periodic measurement of material properties and plant parameters that could change with time. In addition to the SAPs identified LC28 would also apply to this Attribute. It states that the licensee shall make and implement adequate arrangements for the regular and systematic examination, inspection, maintenance and testing of all plant which may affect safety.

Ref	Attribute	Description	SAPs	Notes
4.	Monitoring and trending of ageing effects	• Condition indicators and parameters monitored • Data collected to facilitate assessment of structure or component ageing • Assessment methods (including data analysis and trending)	MS.4, SC.7, EQU.1, EAD.3, EAD.4, EMC.26, EMC.33, ECE.13, EGR.13	As noted above EAD.3 & EAD.4 relate to the collection of material property and parameter measurements to monitor degradation. The SAPs also note that EQ procedures should ensure that adequate arrangements exist (Licence Condition 6) for the recording and retrieval of lifetime data covering the item's construction, manufacture, testing, inspection and maintenance to demonstrate that any assumptions made in the safety case remain valid throughout operational life. How the data is used and analysed is not explicitly covered; however, there are areas around Learning and Use of Data that potentially guide a facility to assess the data and trend it. In addition, the PSR process should cover aspects of this Attribute for safety significant SSCs over a 10-year period. In addition to the SAPs identified LC28 would also apply to this Attribute.
5.	Mitigating ageing effects	• Operations, maintenance, repair and replacement actions to mitigate detected ageing effects and/or degradation of the structure or component	EAD.2 & EMC.26	In the supporting text to EAD.2 (para 219) it notes that 'timely mitigation of ageing and its effects should be undertaken to ensure that adequate safety margins are maintained'. In addition to these SAPs LC28 would also apply to this Attribute, which identifies that When any examination, inspection, maintenance or test of any part of a plant reveals any matter indicating that the safe operation or safe condition of that plant may be affected, the suitably qualified and experienced person appointed to control or supervise such examination, inspection, maintenance or test shall bring it to the attention of the licensee forthwith who shall take appropriate action and ensure the matter is then notified, recorded, investigated and reported in accordance with arrangements made under LC7.

Ref	Attribute	Description	SAPs	Notes
6.	Acceptance criteria	• Acceptance criteria against which the need for corrective actions is evaluated		As noted above, EAD.2 identifies the need for timely mitigation to ensure adequate safety margins; however, there is no explicit reference to the need to establish acceptance criteria. In addition, EMC.33 identifies that data used in analyses and acceptance criteria should be clearly conservative, taking account of uncertainties in the data and their contribution to the safety case. This is also applicable for the EIMT SAPs, which do not identify the need to identify acceptance criteria or action levels. LC28 notes that if the EIMT reveals any matter indicating that the safe operation or safe condition of that plant may be affected then this needs to be raised & recorded. To determine if safety may be affected some criteria will be required, but again this is not explicit.
7.	Corrective actions	• Corrective actions if a structure or component fails to meet the acceptance criteria	EAD.2 & EMC.26	As noted above the supporting text to EAD.2 (para 219) notes that 'timely mitigation of ageing and its effects should be undertaken to ensure that adequate safety margins are maintained'. In addition, EMC.26, which relates to forewarning of failure, identifies the need to identify actions to be taken in response to monitoring results. However, this relates to the integrity of metal components & structures only. LC28 notes that a licensee shall take appropriate action and ensure any unsafe condition is then notified, recorded, investigated and reported in accordance with arrangements made under LC7.
8.	Operating experience feedback and feedback of research and development results	• Mechanism that ensures timely feedback of operating experience and research and development results (if applicable), and provides objective evidence that they are taken into account in the ageing management programme	MS.4, SC.7	There are two key areas associated with continuous improvement and learning from OPEX or R&D, which will feed into any AMP if established and this is a key part of the PSR process (covered under LC15). However, if an organisation is solely reliant on PSR to provide this feedback then it would be questionable if this would be considered 'timely'. But this will largely depend on the aging mechanisms, the lifetime margins and the time between degradation being observed and an SSC being in an unsafe condition.

Ref	Attribute	Description	SAPs	Notes
9.	Quality management	• Administrative controls that document the implementation of the ageing management programme and actions taken • Indicators to facilitate evaluation and improvement of the ageing management programme • Confirmation (verification) process for ensuring that preventive actions are adequate and appropriate and that all corrective actions have been completed and are effective • Record keeping practices to be followed	MS.1	Much of this Attribute would fall out of the requirements for MS.1 - Leadership, within the principles on leadership and management for safety. It is not explicitly linked to the Ageing & Degradation SAPs. In addition, LC17 requires the implementation of appropriate management systems, which should include systems that can support this Attribute. Furthermore LC6, (documents, records, authorities and certificates), and LC25 (operational records) would also apply to this attribute.

Table A3-2 The Basic Steps for Obsolescence Management and Links to SAPs

Ref	Step	Description	SAPs	Notes
1.	Identify technological obsolescence issue	The operating organisation should identify the installed SSCs important to safety that are technologically obsolete or will become obsolete in the upcoming years.	EAD.5	EAD.5 identifies that there should be a process for reviewing the obsolescence of structures, systems and components important to safety should be in place.
2.	Prioritise technological obsolescence issues	The identified equipment should be prioritised on the basis of the safety and criticality significance of the obsolete equipment (i.e. its impact on the plant safety).	EAD.5, ECS.1 & ECS.2	EAD.5 notes that the process should identify threats from obsolescence. ECS.1 and ECS.2 are focussed on a systematic approach to the identification of the category of Safety Function and Safety Classification of SSCs. These along with the issues around novelty, complexity and Risk should enable the obsolescence issues to be prioritised.
3.	Implement solutions for technological obsolescence issues	The operating organisation should develop and implement effective replacement solutions in a timely manner.	EAD.5	EAD.5 notes that the process should ensure that an adequate supply of spare parts is available until a solution to any obsolescence issues can be found. The solution will depend on the particular circumstances but may involve providing alternative components or items of equipment that can carry out the same safety duty, or it may involve redesigning the plant to remove the need for the obsolescent system or components.

Appendix 4
Summary of RGP Reviews and Identified Themes

Table A4-1 Extant ONR Guidance – Themes & Document Sources

Themes (Applicable SAP Refs)	Extant ONR Guidance										
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A11	A12
Theme 1: Safe Working Life (SAP EAD.1)	✓										
Theme 2: Lifetime Margins (SAP EAD.2)	✓	✓	✓		✓	✓		✓		✓	✓
Theme 3: Periodic Measurement of Material Properties (SAPEAD.3)	✓		✓						✓		✓
Theme 4: Periodic Measurement of Parameters (SAP EAD.4)	✓		✓		✓						
Theme 5: Obsolescence (SAP EAD.5)	✓		✓								
Theme 6: Examination Through-Life (SAP ENC.2)	✓						✓				
Theme 7: Definition of Ageing Mechanisms	✓		✓						✓		
Theme 8: Ageing Management Programme									✓		
Theme 9: Use of Operating Experience											

203171/0026/001 - Mechanical & Generic A&D
203171/0026/002 - Civil
203171/0026/003 - EC&I

Table A4-2 Nuclear Industry RGP – Themes & Document Sources

Themes (Applicable SAP Refs)	HSE	International Atomic Energy Agency [IAEA]															WENRA	INPO	EPRI	
	B1	B2	B5	B7	B8	B9	B12	B13	B14	B15	B16	B19	B20	B21	B22	B23	B25	B27	B28	B30
Theme 1: Safe Working Life (SAP EAD.1)	✓	✓				✓							✓					✓		
Theme 2: Lifetime Margins (SAP EAD.2)	✓	✓				✓			✓				✓				✓	✓		
Theme 3: Periodic Measurement of Material Properties (SAPEAD.3)	✓							✓												
Theme 4: Periodic Measurement of Parameters (SAP EAD.4)	✓	✓	✓			✓	✓		✓	✓			✓		✓		✓	✓	✓	
Theme 5: Obsolescence (SAP EAD.5)	✓					✓								✓				✓		✓
Theme 6: Examination Through-Life (SAP ENC.2)	✓	✓	✓			✓			✓											
Theme 7: Definition of Ageing Mechanisms	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓	✓
Theme 8: Ageing Management Programme				✓		✓					✓	✓	✓	✓	✓	✓	✓		✓	✓
Theme 9: Use of Operating Experience	✓		✓		✓				✓		✓	✓	✓	✓	✓				✓	✓

203171/0026/001 - Mechanical & Generic A&D
203171/0026/002 - Civil
203171/0026/003 - EC&I

Table A4-3 Nuclear Industry RGP – Themes & Document Sources (Continued)

Themes (Applicable SAP Refs)	NRC					OECD / NEA					Other Nuclear								
	B35	B36	B37	B38	B39	B41	B42	B43	B44	B45	B47	B49	B50	B52	B53	B54	B55	B56	B61
Theme 1: Safe Working Life (SAP EAD.1)				✓	✓				✓							✓			
Theme 2: Lifetime Margins (SAP EAD.2)									✓						✓	✓	✓	✓	
Theme 3: Periodic Measurement of Material Properties (SAPEAD.3)		✓								✓				✓			✓		
Theme 4: Periodic Measurement of Parameters (SAP EAD.4)		✓							✓				✓		✓	✓			
Theme 5: Obsolescence (SAP EAD.5)																	✓		
Theme 6: Examination Through-Life (SAP ENC.2)																✓			
Theme 7: Definition of Ageing Mechanisms	✓	✓	✓	✓	✓	✓				✓		✓	✓				✓	✓	✓
Theme 8: Ageing Management Programme		✓	✓		✓	✓			✓	✓	✓		✓						
Theme 9: Use of Operating Experience	✓		✓	✓	✓	✓	✓	✓				✓	✓					✓	

203171/0026/001 - Mechanical & Generic A&D
203171/0026/002 - Civil
203171/0026/003 - EC&I

Table A4-4 High-Hazard Industry RGP – Themes & Document Sources

Themes (Applicable SAP Refs)	HSE Research Reports:				UKOOS	ISO/ BS	The Petroleum Safety Authority Norway				Other HH			
	C1	C2	C3	C4	C6	C12	C13	C14	C15	C17	C18	C19	C20	C21
Theme 1: Safe Working Life (SAP EAD.1)		✓ (003)							✓ (001)					
Theme 2: Lifetime Margins (SAP EAD.2)	✓ (001)		✓ (001, 002)											
Theme 3: Periodic Measurement of Material Properties (SAPEAD.3)			✓ (001, 002)											
Theme 4: Periodic Measurement of Parameters (SAP EAD.4)	✓ (001, 003)	✓ (003)	✓ (003)	✓ (001)	✓ (003)		✓ (003)							
Theme 5: Obsolescence (SAP EAD.5)			✓ (003)		✓ (003)	✓ (001, 003)								
Theme 6: Examination Through-Life (SAP ENC.2)														
Theme 7: Definition of Ageing Mechanisms		✓ (003)						✓ (003)	✓ (001, 003)	✓ (003)	✓ (002)			
Theme 8: Ageing Management Programme	✓ (003)	✓ (003)	✓ (003)		✓ (003)				(001)					
Theme 9: Use of Operating Experience								✓ (002)				✓ (002)	✓ (002)	✓ (002)

Key
203171/0026/001 - Mechanical & Generic A&D (001)
203171/0026/002 - Civil (002)
203171/0026/003 - EC&I (003)

Appendix 5
Table of Abbreviations

Abbreviation	Description
AIM	Asset Integrity Management
ALARP	As Low As Reasonably Practicable
ALE	Ageing and Life Extension
AM	Asset Management
AMP	Asset Management Program
AMS	Asset Management System
BS EN	British Standard (British adoption of a European (EN) standard)
CADAK	Cable Ageing Data and Knowledge
CODAP	Component Operational Experience, Degradation and Ageing Programme
COMAH	Control of Major Accident Hazards Regulations
EAD	Engineering -Ageing and Degradation (SAP topic)
EC&I	Electrical Control and Instrumentation
ECE	Engineering - Civil Engineering (SAP topic)
EEMUA	Engineering Equipment and Materials Users' Association (EEMUA)
EIM&T	Examination, Inspection, Maintenance and Testing
EMC	Engineering -Ageing and Degradation (SAP topic)
EMT	Engineering - Maintenance, Inspection and Testing (SAP topic)
ENC	Engineering - Integrity of non-metal components and structures (SAP topic)
ENSREG	European Nuclear Safety Regulators Group
EPRI	Electric Power Research Institute
GALL	Generic Ageing Lessons Learned
HEPA	High Efficiency Particulate Arrestor
HSE	Health and Safety Executive
I&C	Instrumentation and Control
IAEA	International Atomic Energy Agency
IAGE	Integrity and Ageing of Components and Structures
IGALL	International Generic Ageing Lessons Learned
INPO	Institute of Nuclear Power Operators
IRWG	Internal Regulation Working Group
LC	Licence Condition
LOLER	Lifting Operations and Lifting Equipment Regulations

Abbreviation	Description
LTO	Long Term Operation
MAPS	Managing Aging Processes in Storage
NDE	Non-Destructive Examination
NDT	Non-Destructive Testing
NEA	Nuclear Energy Agency
NEDF	Nuclear Engineering Directors Forum
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission (US)
OECD	Organisation for Economic Co-operation and Development
ONR	Office for Nuclear Regulation
PSR	Periodic Safety Review
PSSR	Pressure Systems Safety Regulations
QA	Quality Assurance
R&D	Research and Development
RBI	Risk Based Inspection
RSD	Regulatory Support Directorate
SAFed	Safety Assessment Federation
SDF	(Nuclear Industry) Safety Directors Forum
RGP	Relevant Good Practice
S-N	Stress versus Number of cycles to failure (fatigue design graph)
SALTO	Safety Aspects of Long-Term Operation
SAP	Safety Assessment Principle
SFR	Safety Functional Requirement
SME	Subject Matter Expert
SQEP	Suitably Qualified Experienced Personnel
SSC	Structure, System and Component
TAG	Technical Assessment Guide
UKOOA	United Kingdom Offshore Operators Association
WENRA	Western European Nuclear Regulators' Association