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| ONR Technical Assessment Guide  Ageing and Degradation Management |



ONR Technical Assessment Guide (TAG)

Ageing and Degradation Management

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# Introduction

1. ONR has established its [Safety Assessment Principles](http://www.onr.org.uk/saps/saps2014.pdf) (SAPs) [1] which apply to the assessment by ONR specialist inspectors of safety cases for nuclear facilities that may be operated by potential licensees, existing licensees, or other duty-holders. The principles presented in the SAPs are supported by a suite of guides to further assist ONR’s inspectors in their technical assessment work in support of making regulatory judgements and decisions. This technical assessment guide (TAG) is one of these guides.
2. The TAGs assist ONR inspectors to interpret and apply the assessment principles. They also include guidance on principles relevant to Licence Conditions (LCs), which supplement the technical inspection guides (TIGs). Thus, the TAGs are relevant to all ONR inspectors, regardless of their function. The guides also inform licensees of ONR expectations of the nature and content of the relevant technical elements of licensees' submissions.
3. This guide explains what ONR considers relevant good practice (RGP) when looking at ageing, degradation and obsolescence (A&D). This RGP may be used to assess dutyholders activities and safety submissions. Examples of these include:

* periodic reviews of safety cases;
* design, construction or installation of new plant;
* modification or experiment on existing plant; and
* changes to examination, inspection maintenance and testing (EIMT).

# Purpose and Scope

1. This TAG has two principal purposes. These are to:

* promote consistency in inspector’s A&D adequacy judgements on structures, systems and components (SSCs); and
* support SSC beyond design life (BDL) considerations.

1. Obsolescence is considered a sub-set of ageing and degradation. Thus, in this TAG, the term 'A&D' includes ageing, degradation and obsolescence, unless otherwise stated.
2. The guidance within this TAG covers relevant ONR’s SAPs and the LCs.   
   It also includes advice published by other organisations. These include the International Atomic Energy Agency (IAEA) and the Western European Nuclear Regulators' Association (WENRA).
3. The TAG applies to all sites regulated by ONR at all plant lifecycle stages   
   (including Generic Design Assessment (GDA)). This includes nuclear power plants (NPPs) and non-reactor nuclear facilities. Existing facilities may have been designed and constructed to earlier standards. For these facilities, the suitability of A&D measures against the as low as reasonably practicable (ALARP) principle will be judged on a case-by-case basis. Further guidance on demonstration of ALARP is provided in ONRs TAG [2].

# Relationship to Licence and other Relevant Legislation

## Licence Conditions

1. The Nuclear Installations Act 1965 includes a set of 36 standard LCs.   
   These are attached to each nuclear site licence [3]. These LCs cover the whole facility life cycle. This includes:

* design;
* construction;
* commissioning;
* operation;
* decommissioning; and
* management oversight and reviews.

1. LCs require licensees to implement arrangements to ensure compliance.   
   The following LCs are considered to be particularly relevant to A&D, but the list is not exhaustive:

* **LC6 – Documents, Records, Authorities and Certificates:**   
  This relates to quality management of safety documentation.   
  This includes the arrangements for recording and retrieving lifetime SSC data. This includes SSC:
  + construction;
  + manufacture;
  + testing;
  + inspection; and
  + maintenance.
* **LC 7 – Incidents on the Site**: This applies to the mitigation of ageing effects, corrective action and Quality Management Arrangements (QMA) related attributes of A&D management.
* **LC 10 – Training:** Operations and maintenance can affect the A&D of SSCs. Hence, these activities shall be performed by personnel with an adequate level of training.
* **LC12 – Duly authorised and other suitably qualified and experienced persons (SQEP):** SQEP shall undertake A&D management activities. Requirements for each A&D roles shall be clearly defined.
* **LC15 – Periodic Review:** A&D management arrangements shall be periodically reviewed to determine their suitability. Areas associated with continuous improvement include:
  + operating experience (OPEX) learning; and
  + research and development (R&D).
* **LC17 – Management Systems:** This applies to knowledge management and QMA related aspects of an A&D management system. Loss of A&D knowledge can, for example, result in ageing mechanisms being inadequately mitigated and SSCs becoming prematurely obsolete. Arrangements shall be implemented to ensure that A&D related knowledge is retained and shared as necessary.
* **LC19 – Construction or installation of new plant:**   
  Activities undertaken can influence SSCs A&D and have a long-term impact on their service life behaviour/performance.
* **LC22 – Modification or Experiment on Existing Plant:** Modifications can influence SSCs A&D. LC22 also considers acceptance criteria and corrective actions.
* **LC23 – Operating Rules:** Operating rules shall be implemented to control service conditions within the safety case limits.
* **LC25 – Operational Records:** This applies to QMA related attributes of A&D management.
* **LC27 – Safety Mechanisms, Devices and Circuits (SMDCs)**:   
  A&D can threaten an SSC’s operational readiness.
* **LC28 – Examination, Inspection, Maintenance and Testing (EIMT):** This applies to establishing preventative actions to minimise and control ageing effects through:
  + detection;
  + monitoring and trending;
  + mitigation;
  + evaluation; and
  + corrective action.
* **LC34 – Leakage and Escape of Radioactive Material and Radioactive Waste:** A&D management is required to ensure SSCs providing containment of radioactive materials and radioactive wastes can fulfil their safety function throughout life.
* **LC35 – Decommissioning:** A&D management applies to SSCs ensuring safety during decommissioning activities.
* **LC36 – Organisational Capability:** A&D management requires adequate financial and human resources.

## Other Relevant Legislation

1. Several statutory instruments relate to management of A&D. These include:

* The Health and Safety at Work etc. Act 1974;
* The Management of Health and Safety at Work Regulations 1999;
* The Pressure Systems Safety Regulations 2000;
* The Lifting Operations and Lifting Equipment Regulations 1998;
* The Control of Major Accident Hazards Regulations 2015;
* The Provision and Use of Work Equipment Regulations 1998;
* The Construction (Design and Management) Regulations 2015; and
* The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013.

# Relationship to Safety Assessment Principles, WENRA Reference Levels, and IAEA Safety Standards and Guides

## Safety Assessment Principles

1. The SAPs [1] directly addressed by this TAG are:

* EAD.1 (Safe Working Life). This relates to considering the safe working life of SSCs at the design stage.
* EAD.2 (Lifetime Margins). This relates to SSC margins of safety, which should consider A&D.
* EAD.3 (Periodic Measurement of Material Properties). This relates to material properties measurement.
* EAD.4 (Periodic measurement of parameters). This relates to parameters measurement.
* EAD.5 (Obsolescence). This relates to SSC obsolescence management.

## WENRA

1. This TAG considers guidance given in the WENRA Safety Reference Levels for Existing Reactors 2020 [4].
2. WENRA Reference Level ‘I’ is dedicated to ‘Ageing Management’. This is considered in Section 5 and Appendix 2 of this TAG.

## IAEA

1. This TAG considers A&D IAEA guidance. These are considered in Section 5 and Appendix 2 of this TAG.
2. From Appendix 2, the following IAEA documents are considered key RGP sources:

* IAEA Safety Standards Series No. SSR-2/1: Safety of Nuclear Power Plants: Design [5];
* IAEA Safety Standards Series No. SSR-2/2. Safety of Nuclear Power Plants: Commissioning and Operation [6];
* IAEA SSG-48: Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants [7];
* IAEA Safety Reports Series No. 109: Regulatory Oversight of Ageing Management and Long Term Operation Programme of Nuclear Power Plants [8];
* IAEA Safety Reports Series No. 82: Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL) [9];
* IAEA NR-T-3.34: Management of Ageing and Obsolescence of Instrumentation and Control Systems and Equipment in Nuclear Power Plants and Related Facilities through Modernization [10]; and
* IAEA SSG-69: Equipment Qualification for Nuclear Installations [11]

# Advice to Inspectors

## General

1. This TAG provides advice within the following subsections:

* General A&D management arrangements; and
* ONR EAD.1-5 SAPs considerations [1].

1. In line with guidance provided by the IAEA [12], the following definitions are provided:

* **ageing:** general process in which characteristics of an SSC gradually change with time or use;
* **degradation**: physical ageing effects that could impair the ability of an SSC to function within its acceptance criteria; and
* **obsolescence** (non-physical ageing): the process of becoming out of date owing to the evolution of knowledge, technology and associated changes in codes and standards.

1. Further sub-division of physical ageing processes specific to the civil engineering discipline can be found in Annex 5 of ONR’s Civil Engineering TAG [13].
2. A&D also affects conventional non-nuclear safety (e.g., conventional health and safety, and life fire safety) and security. ONR inspectors should refer to those specialisms to target interventions.

## A&D Management Arrangements

1. A&D management should be employed through life to ensure related risk is effectively managed. Inspectors should consider the following attributes when judging the dutyholders A&D management arrangements.
2. Ageing management key expectations:

* identify and understand the ageing mechanisms impacting the SSC under consideration;
* understand their associated effects;
* undertake appropriate monitoring and data trending to identify issues in a timely manner; and
* take appropriate steps to prevent or mitigate them.

1. Obsolescence management key expectations:

* identify and record details of the equipment on the facility subject to obsolescence;
* identify the obsolescence status of the equipment;
* prioritise the obsolescence issues; and
* mitigate the obsolescence issues.

1. **Ageing Management Programme**: A specific ageing management programme should be implemented. This could be in the form of a dedicated programme or other written arrangements that manages the ageing of SSCs. Applicable refs.: [4], [6] - [11], [14] and [15].
2. **SSCs**: SSCs important to nuclear safety, conventional safety and security should be included. This includes those whose failure may prevent other SSCs important to safety fulfilling their intended functions.   
   Applicable refs.: [4] - [11], and [16].
3. **A&D Mechanisms:** Relevant A&D mechanisms should be identified.   
   This should include appropriate acceptance criteria along with suggested corrective actions. Applicable refs.: [4] - [11], and [16].
4. **Obsolescence**: Arrangements for A&D management should identify all nuclear safety related SSCs potentially subject to obsolescence.   
   Strategies to manage obsolescence of SSCs should exist.   
   Applicable refs.: [4], [6] - [11], and [16].
5. **Proportionality**: A graded A&D management approach should exist.   
   This should be commensurate with the SSCs safety significance.   
   This includes control measures to prevent, limit, or mitigate the effects of ageing. Applicable refs.: [4] - [11], and [16].
6. **Optioneering**: Optioneering should be considered at the design phase and included as part of plant modification proposals. Applicable refs.: [2] - [7], [9], and [10].
7. **Safety Case**: The safety case should explain the A&D requirements and be traceable. Applicable refs.: [2], [4], [6], [7], [8], [10], [11] and [17].
8. **Training**: Personnel training should emphasise the importance of effective A&D management. Facility personnel covering plant operators, maintainers, supervisors, and supply chain organisations (including Technical Support Organisations (TSOs)) should be provided with adequate training to enable them to effectively support the management of A&D. Personnel should be provided with sufficient information to enable them to identify A&D mechanisms, effects and their significance. The importance of timely action should be emphasised. Personnel should be made aware of the potential for them to damage SSCs during maintenance activities and operation. Appropriate equipment handling precautions should be made clear.  
   Applicable refs.: [4], [6], [7], [8], [10], [11], [16] and [17].
9. **SQEP**: A&D management roles should identify qualification and experience requirements. This may include requirements for individuals who design, construct, operate, maintain, modify and decommission SSCs.   
   Competency of third-party organisations should also be considered.  
   Applicable refs.: [4], [6], [7], [8], [10], [11], [14], [16] and [18].
10. **EIMT**: EIMT requirements that support A&D should be defined at the design stage and re-evaluated through life. EIMT methods and frequency of application should be effective in detecting or mitigating A&D mechanisms before they adversely impact safety. The EIMT basis should be appropriately documented. Applicable refs.: [4] - [11], [15] and [19].
11. **Performance Indicators**: Leading and lagging A&D performance indicators should be developed. Trending of performance indicators should be considered. Applicable refs.: [4], [6] - [11], [14] and [18].
12. **OPEX**: Internal and external OPEX, including R&D, should inform A&D arrangements. OPEX reviews should include trend identification to inform EIMT practice updates. Adverse trend root causes should be investigated. The range of data used should allow the identification of gradual degradation. Applicable refs.: [4] - [11], and [20].
13. **Participation**: A&D Management should include participation from various dutyholder’s teams. With representatives from (but not limited to):

* senior management;
* engineering;
* maintenance;
* operations;
* design authority;
* safety case practitioners;
* training;
* procurement / supply chain organisations;
* finance; and
* work planning.

Applicable refs.: [4] - [7], [9] and [10].

1. **Senior Management**: Dutyholder’s senior management should support A&D implementation. Suitable resources and funding should be identified and allocated. Applicable refs.: [4], [6] - [8], [10], [15], [16], and [21].
2. **Strategies and Controls**: A&D strategies and controls should be identified, formally implemented, and captured in operational documentation. Applicable refs.: [4] - [11], [14] and [16].
3. **Roles, Responsibilities and Accountabilities:** A&D management roles, responsibilities and accountabilities should be defined. Applicable refs.: [4] - [8], [10], [11] and [14] - [16].
4. **Other Programmes**: A&D management should integrate with other relevant programmes. These may include:

* periodic review;
* equipment reliability;
* asset management; and
* risk management.

Applicable refs.: [4] - [11], and [22].

1. **Supplementary Methods**: Supplementary methods should support A&D management. These methods may include (but are not limited to):

* parallel manufacture (for destructive testing purposes);
* use of decommissioned SSCs;
* coupons/surveillance specimens;
* use of test rigs; and
* laboratory testing and other accelerated ageing studies.

Applicable refs.: [4] - [8], [10], [11], [14], [16] and [23].

1. **Knowledge Management**: An A&D management information system should exist. The system should:

* consider A&D knowledge management and its retention;
* enable A&D knowledge transfer to new staff; and
* include sufficient data, including EIMT, to support effective A&D management.

Applicable refs.: [4] - [11], [15], [16] and [20].

1. **Supply Chain**: Supply chain organisations should contribute to A&D management and assist in identification of design requirements. Long term requirements should consider alternative and diverse suppliers of services and equipment. Applicable refs.: [4], [6] - [8], [10], [11], [21], [24] and [25].
2. **Spare Parts and Consumables**: SSCs should be stored in suitable conditions. This may require the provision of dedicated environmental control systems. SSC packaging should be in line with the manufacturer’s recommendations. Original Equipment Manufacturer (OEM) recommended shelf-life spare parts EIMT requirements should be followed.   
   Applicable refs.: [4] and [6] - [11].
3. **Configuration Control**: SSC supporting documentation requires configuration control. This ensures compliance with operating and EIMT requirements. Applicable refs.: [4] - [8], [10], [11], [22] and [24].
4. **Design Changes and Concessions:** Concession and design change control is fundamental to successful A&D management. This includes submissions associated with operation of SSCs BDL.   
   Applicable refs.: [4] - [8], [10], [11], [13], [17], [18] and [26].
5. **Uncertainties**: Gaps may be identified in historical SSC documentation. Prioritisation of corrective actions should be commensurate with the SSC safety classification and the consequences associated with the uncertainty. Uncertainties and knowledge gaps should be identified and used to inform the future A&D management arrangements development.   
   Applicable refs.: [4], [5], [7], [8], [10], [11], [16] and [22].
6. **Re-evaluation**: A&D management arrangements should be re-evaluated throughout the lifetime of the facility (e.g., during periodic review or a dedicated Ageing Management Review (AMR)). The revaluation should:

* support A&D management arrangements continuous improvement;
* ensure safety case assumptions remain valid; and
* be undertaken alongside modifications to plant or operational states.

Applicable refs.: [4] - [11] and [16].

1. **Human Factors**: Human factors analyses should be used to support A&D management. This includes optimising implementation of A&D management arrangements and integration with the supply chain. Human factors analysis for SSC access and EIMT should be considered. Applicable refs.: [4] - [7], [10] and [24].
2. **Inaccessible SSCs**: SSCs that are inaccessible or impracticable to EIMT in-service should be identified. The use of remote monitoring techniques should be considered. Applicable refs.: [4], [5], [7], [8], [10], [16], [18], [21] and [25].
3. **Plant Walkdowns:** Plant walk downs should be undertaken to visually inspect SSCs and support A&D management. A record of the plant walkdown should also be recorded. Applicable refs.: [4], [6] - [8], [10], [11], [14] and [16].
4. **Intelligent Customer**: Dutyholders should maintain an Intelligent Customer (IC) capability. This IC capability should ensure that optioneering, design or repair works are undertaken by SQEP. The scope of works, and associated contracts and specifications, should be checked by a SQEP IC function. Applicable refs.: [8], [13], [14] and [26].
5. **Pictorial Data**: Evidence to support SSCs A&D management should be used. This may include photographs and video recordings of the SSCs condition. Applicable refs.: [10], [16] and [21].
6. **Extreme Events**: Non-routine inspections should be considered.   
   The inspections may follow extreme events or faults that could accelerate ageing and degradation. For example, this may include accidental impacts and extreme weather events. Applicable refs.: [7], [8], [14] and [24].
7. **End Users**: End users requiring A&D information should be identified.   
   The information purpose should be identified. Applicable refs.: [10] and [25].
8. **Unrevealed Ageing Mechanisms**: Revealed and unrevealed ageing mechanisms should be considered. Safety cases which consider the effects of unrevealed A&D mechanisms are encouraged. Applicable refs.: [13].
9. **Facility Lifecycle Phases**: The potential for introduction of new A&D mechanisms between facility lifecycle phases should be considered.   
   This should include both pre-inactive and pre-active commissioning.   
   The effect of changes to safety functional requirements across facility lifecycle phases should also be considered. Applicable refs.: [10] and [13].

## Ageing and Degradation Safety Assessment Principles

1. When using the following EAD SAPs, ONR inspectors should also consider the generic aspects discussed in subsection 5.2. In particular the following aspects should support the substantiation:

* optioneering;
* the use of OPEX;
* other information sources;
* supplementary methods; and
* periodic re-evaluation to show reduction of risk ALARP throughout life.

### EAD.1 – Safe Working Life

1. For new facilities, evaluation of SSC safe working life should be undertaken during the design phase. The results should inform the development of SSC specification requirements. This includes their:

* manufacture;
* packaging;
* transport;
* storage;
* construction/installation;
* commissioning/decommissioning;
* EIMT; and
* associated Quality Assurance (QA) levels.

Applicable refs.: [10], [19] and [27].

1. Service conditions, associated A&D mechanisms and failure modes should be reviewed when considering safe working life. The potential unintended consequences on other parts of the plant should also be considered. Applicable refs.: [10] and [14].
2. For existing facilities, records should be used to evaluate the safe working life. Adequate arrangements should be in place to demonstrate that all aspects of the design specification have been met. Service conditions should be monitored throughout life to demonstrate that SSCs are being operating within their design envelope. In cases where records are not available, demonstrably bounding assumptions, safety factors, and sensitivity analysis should be considered. Applicable refs.: [4], [10], [16] and [24].
3. Evaluation of safe working life may need to be supported by analytical models. This could include the use of stress analyses, fracture mechanics or fatigue assessment. The analysis should reflect the real or predicted physical condition of SSCs. It should also include the effects of ageing and degradation (e.g., corrosion, creep, fatigue). Analytical models and criteria used to assess the safe working life of SSCs should be appropriately verified and validated. Applicable refs.: [14], [16], [26] and [28].

### EAD.2 – Lifetime Margins

1. Factors affecting lifetime margins should be systematically identified.   
   These should include (but are not limited to) safe working life, applicable A&D mechanisms, and current SSC condition. Applicable refs.: [10] and [18].
2. The analytical models, and criteria, that are used to evaluate the SSCs lifetime margins should be verified and validated. These lifetime margins should consider the accuracy, reliability and conservatism of analysis and test results. Applicable refs.: [28].
3. A&D analysis should use conservative assumptions, to ensure adequate lifetime margins. This applies to all factors influencing the rate and severity of A&D mechanisms including the physical attributes of the SSCs and the service conditions. Applicable refs.: [23] and [26].
4. Over the lifetime of the facility, suitable margin should exist between the operating and fault envelope and the conservative failure limit. Also, due allowance should be given for uncertainties. Applicable refs.: [26].
5. For novel and/or complex materials and equipment, uncertainty in lifetime margins may be greater. This may be because of the absence of established codes and standards. In such cases, dutyholder’s should consider supplementary methods to fully justify lifetime margins (refer to subsection 5.2). Applicable refs.: [7], [8], [23] and [26].
6. Reviews of EIMT output and OPEX should be used to identify A&D trends and justify lifetime margins. Applicable refs.: [4], [7] - [11] and [16].
7. A&D indicators, acceptance criteria and action levels should be used to ensure the retention of lifetime margins. Applicable refs.: [7] - [10], [14] and [18].
8. The early replacement of SSCs, that are potentially vulnerable to A&D effects, to restore lifetime safety margins should be considered.   
   Applicable refs.: [19] and [29].
9. Gaps may be identified in historic SSC documentation. The response should be commensurate with the SSC’s safety classification and the potential consequences associated with the gap. The SSC’s material condition and predicted safe working life should be considered. Applicable refs.: [16].
10. Uncertainties in evaluating lifetime margins should be considered, e.g., for environmental conditions and/or imposed loadings. Applicable refs.: [7], [8], [14], [16] and [22].

### EAD.3 – Periodic Measurement of Material Properties

1. The extent and frequency of measurements should be justified at the design phase. These measurements should be commensurate with the safety classification of the SSC. The extent and frequency should also be re-evaluated throughout the life of the facility (e.g., during periodic review). Applicable refs.: [21] and [26].
2. Measurement uncertainties should be identified. The impact on safe working life and lifetime margins should be considered. Any changes in procedure should not adversely impact the quality of the data collected.   
   Applicable refs.: [26].
3. Radiation doses (both individual and collective) should be considered.   
   Also, the techniques used should be evaluated through-life. This should provide optimal results and ensure radiation doses to workers are ALARP. Minimising access maintenance dose by design or promoting remote inspection/maintenance capability should also be considered.   
   Applicable refs.: [30].
4. A human factors assessment should consider how measurements can be best achieved. The assessment should include facility layout, accessibility, and visibility. The methods to measure should be demonstrably and usable. These systems should include appropriate management systems.   
   Applicable refs.: [15], [21] and [24].
5. Uncertainties in material properties, and their associated degradation mechanisms, should be considered. These should be confirmed during in-service monitoring. Also, material properties should contain adequate margins to cater for any uncertainties. Uncertainties in extrapolations and correlations should also be considered. Applicable refs.: [26].
6. SSC manufacturing records should be retained. The records should include details of material properties both at the end of fabrication and at the start of service. Through life SSC material property measurements should consider fabrication flaws; damaging events and the potential interactions of different ageing mechanisms. Applicable refs.: [26] and [29].
7. Long-term SSC material property trend predictions should be provided.   
   These predictions:

* should be supported by material surveillance programme research;
* should consider uncertainties in material property data; and
* may be influenced by the technical understanding of the related material and the manufacturing route.

Applicable refs.: [29].

1. Methods to measure changes in material properties, and the structural behaviours of SSCs, should have a suitable sensitivity. This is important when using new or novel techniques. When using imbedded instrumentation, its testing and calibration should be possible during operation.   
   Applicable refs.: [31].

### EAD.4 – Periodic Measurement of Parameters

1. When using EAD.4, ONR inspectors should consider the aspects discussed against EAD.3 in paragraphs 72 to 75.
2. Plant parameters should be recorded for trending purposes. This should aid proactive and reactive A&D EIMT. Applicable refs.: [4], [7], [8], [10] and [11].

### EAD.5 – Obsolescence

1. Both reactive and proactive strategies should be used to manage obsolescence. If possible, these strategies should form part of the design specification process (e.g., by specifying expected life, lifetime support of spare parts, multiple supplies). Applicable refs.: [29] and [30].
2. A replacement SSC’s substantiation should be the same as the original SSC’s. Where reasonably practicable, replacement SSCs should:

* be identical to the replaced SSCs;
* use a proven technology, or
* be tested for the specific application.

Applicable refs.: [16] and [29].

1. A&D management arrangements should consider technical obsolescence.   
   This may include solutions through:

* procurement (including procurement of surplus items on the market);
* special manufacturing runs;
* evaluation of equivalent items;
* plant engineering including reverse engineering items;
* repair or rebuild of items;
* utilisation of spares from other components; and
* design (such as design change).

Applicable refs.: [7], [8], [10] and [25].

1. Licensees / dutyholder’s should consider other factors that relate to obsolescence. These factors include the arrangements for:

* last time buy and storage;
* after market buy;
* recycled user stock;
* alternative fit-for-function SSCs;
* remanufacturing/re-engineering;
* reverse engineering;
* sub-system replacement; and
* system replacement.

Applicable refs.: [10].

1. Obsolescence effects on software security should be considered. This may include:

* vulnerability to attack from existing or new cyberthreats; and
* the ability to recover a system using backup on secure compatible equipment.

Applicable refs.: [10].

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# Glossary and Abbreviations

## Glossary

| Term | Description |
| --- | --- |
| Ageing | General process in which characteristics of an SCC gradually change with time or use [12]. |
| Ageing Management | Engineering, operations and maintenance actions to control within acceptable limits the ageing degradation of SSCs [12]. |
| Ageing Management Programme | A set of policies, processes, procedures, arrangements and activities for managing the ageing of SSCs [22]. |
| Ageing Degradation | Ageing effects that could impair the ability of a structure, system or component to function within its acceptance criteria [12]. |
| Arrangements (for operations) | The integrated set of infrastructural elements necessary to provide the capability for performing a specified function or task required to carry out a specified operation. The infrastructural elements may include authorities and responsibilities, organization, coordination, personnel, plans, procedures, facilities, equipment or training [12]. |
| Design Code | A standard with industry, national or international status, that defines the technical and possibly organisational rules by which an item or process can be described and realised [1]. |
| Design Life | The period of time during which a facility or component is expected to perform according to the technical specifications to which it was produced [12]. |
| Dutyholder | Any organisation or person that holds duties under legislation that ONR regulates. Dutyholders include Licensees, Requesting Parties, Potential Future Licensees, Operational Licence Dutyholders, Decommissioning Site Licensees, New Build Site Licensees, budget holders, vendors and supply chain members [13]. |
| Intelligent Customer | The capability of an organisation to understand where and when work is needed; specify what needs to be done; understand and set suitable standards; supervise and control the work; and review, evaluate and accept the work carried out on its behalf [1]. |
| Lagging (performance indicators) | Performance indicators which enable failures to be detected and so highlight incidents and/or deficient performance of assets [16]. |
| Leading (performance indicators) | Performance indicators which can be used to predict future performance and so forewarn of non-compliance with performance standards [16]. |
| Modification | Any alteration to buildings, plants, operations, processes or safety cases and includes any replacement, refurbishment or repairs to existing buildings, plants or processes and alterations to the design of plants during the period of construction [3]. |
| Non-Physical Ageing | The process of becoming out of date (i.e., obsolete) owing to the evolution of knowledge and technology and associated changes in codes and standards [12]. |
| Physical Ageing | Ageing of structures, systems and components due to physical, chemical and/or biological processes (ageing mechanisms) [12]. |
| Revealed Ageing Mechanism | A process which results in some measurable effect, which can be detected via non-destructive or non-invasive means [13]. |
| Service Conditions | Physical conditions prevailing or expected to prevail during the service life of a structure, system or component. Service conditions include environmental conditions and operating conditions and conditions during and after events [12]. |
| Safety Case | The totality of a licensee’s (or dutyholder’s) documentation to demonstrate safety [1]. |
| Safety Culture | The assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance [12]. |
| Structures, Systems and Components (SSCs) | A general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety, except human factors [12]. |
| Unrevealed Ageing Mechanism | A process which results in effects which will only become apparent via intrusive or destructive testing, or when the SSC is subject to design basis event or accident loading conditions [13]. |

## Abbreviations

A&D Ageing, degradation and obsolescence

ALARP As Low As Reasonably Practicable

AMR Ageing Management Review

ASME American Society of Mechanical Engineers

ASN Autorité de Sûreté Nucléaire (The French Nuclear Safety Authority)

BDL Beyond Design Life

C&I Control and Instrumentation

EIMT Examination, Inspection, Maintenance and Testing

HSE Health and Safety Executive

HVAC Heating, Ventilating, and Air Conditioning

IAEA International Atomic Energy Agency

IC Intelligent Customer

IGALL International Generic Ageing Lessons Learned

LC Licence Condition

LTO Long Term Operation

MS&I Maintenance, Surveillance and In-service inspection

NPP Nuclear Power Plant

OEM Original Equipment Manufacturer

OPEX Operating Experience

PSR Periodic Safety Review

PWR Pressurised Water Reactor

QA Quality Assurance

QMA Quality Management Arrangements

R&D Research and Development

RIM Reliability and Integrity Management

RGP Relevant Good Practice

SAP Safety Assessment Principle

SMDC Safety Mechanism, Device and Circuit

SSC Structure, System and Component

SQEP Suitably Qualified and Experienced persons

TAG Technical Assessment Guide

TIG Technical Inspection Guide

TLAA Time Limited Ageing Analysis

TSO Technical Support Organisation

WENRA Western European Nuclear Regulators’ Association

# Appendix 1 – Beyond Design Life (BDL) Expectations

1. The following BDL considerations, which relate to the operation of an SSC are summarised from [32]. Whilst most of the considerations identified below should be detailed in an LC22 submission to justify SSC operation BDL, some may be covered by periodic review under LC15. Where there is a requirement for the periodic review to provide additional supporting information, this should be a clearly identified.
2. **Arrangements for A&D Management:** Do the arrangements for A&D management need to be updated to support BDL operation? This may include infrastructure, resourcing, high-level policies and strategies, standards, processes and procedures, and other supporting information.
3. **A&D Mechanisms:** Are there any new A&D mechanisms associated with BDL operation? Is the rate of ageing and degradation from existing mechanisms changed? Particular attention should be given to predicted service conditions, especially if the period of BDL operation extends into a new lifecycle phase.
4. **Supporting SSCs:** Do any related SSCs that support delivery of the SSC safety function need to be re-substantiated for operation BDL? For example; electrical supplies, air supplies, and mechanical fixtures. SSCs that are required for control of service conditions and environmental qualification should also be considered; for example, heating, ventilating, and air conditioning (HVAC) systems and fire barriers. Are the necessary SSC spare parts and consumables available to support operation BDL?   
   Has consideration been given to the increased potential for obsolescence of supporting SSCs during operation BDL; especially Control and Instrumentation (C&I) equipment?
5. **Safety Case:** Are safety case assumptions on SSC reliability still valid?   
   Has SSC reliability over the period of BDL operation been reassessed? Have reviews been undertaken to revalidate any Time Limited Ageing Analysis (TLAA)? Where SSC reliability has changed, does this affect the safety classification of SSC? Has the safety case been updated? Do severe accident management guidelines and emergency preparedness and response plans need to be updated?
6. **Periodic Safety Review (PSR):** Has information from periodic reviews been considered? This should include any previous reviews of arrangements for A&D management. Information relevant to facility-wide factors, future programme requirements and the cumulative impact of SSC operation BDL should also be considered.
7. **Safe Working Life and Lifetime Margins:** Does the SSC safe working life and lifetime margins cover the period of BDL operation? If not, are strategies in place for replacement or refurbishment? Have limits and margins determined from design codes or fitness-for-service assessments been updated?
8. **Trending:** Is their sufficient data available to support BDL operation?   
   Has the data been trended to predict potentially unsafe conditions; support justification of safe working life and lifetime margins; and confirm delivery of safety function at all times during BDL operation?
9. **Equipment Qualification:** Has equipment qualification been undertaken? Does it substantiate delivery of safety function over the period of BDL operation? Are there any changes to service conditions that should be considered?
10. **EIMT:** Have EIMT requirements been reviewed? Is the EIMT regime suitable to manage any new or accelerated A&D mechanisms? Has a requirement to review effectiveness of any changes to EIMT been identified? Has both preventative and predictive maintenance been considered? Are surveillance and monitoring programmes available to support revised TLAA for BDL operation?
11. **Performance Management:** Has performance management been reviewed and if should it be updated? This may need new, or more regular monitoring of existing performance indicators. The approach to corrective measures should be considered. This is important if novel or complex solutions have been implemented.
12. **Plant Programmes:** Have the requirements for supporting plant programmes been identified? These requirements may include extension of existing programmes or introduction of new ones. These programmes may include equipment qualification, plant parameter control, (e.g., water chemistry), QA, radiation protection, environmental monitoring, fire protection and radioactive waste management. Reliability and Integrity Management (RIM) Programmes should also be considered for American Society of Mechanical Engineers (ASME) applicable components.
13. **Capabilities and resources:** Does the dutyholder have staff capabilities and resources to support BDL operation? Does additional staff training need to be implemented? Will all necessary documentation and records be available?
14. **Human Factors:** Is additional human factors analyses needed to support BDL operation? This may include support for implementation of changes to arrangements for A&D management and EIMT regimes. Human factors analysis should also be used where access requirements have changed (e.g. due to increased dose levels).
15. **OPEX:** Has internal and external OPEX been used to support BDL operation? This may include the use of data trending and review of A&D mechanisms observed at other nuclear facilities. Research and Development including accelerated ageing studies may also be used to support BDL operation.
16. **Knowledge Management:** Is knowledge management information to support BDL operation available? Is operational and EIMT documentation available? Do the management systems support data recording, storage and availability during BDL operation? Is the ageing workforce, churn of personnel, changing skill sets, and succession planning over the period of BDL operation considered?
17. **Software Management:** Is software needed to support the function of SSCs during BDL operation? This includes any necessary software updates and third party support. Has consideration been given to software security over the period of BDL operation?
18. **Supply Chain:** Can the supply chain support the replacement parts and consumables required during BDL operation? Can external organisations support the maintenance or repair of plant during BDL operation?
19. **Economic Factors:** Have economic factors been considered? Are financial resources in place to support safe operations during BDL operation?
20. **Decommissioning:** Will BDL operation undermine assumptions that underpin the decommissioning strategy? Have all the waste-streams and the environmental impact been considered? Has the potential for creating extra waste, or items having increased dose levels at end of service, been considered?
21. **Self-Assessment:** Have self-assessments been used to identify gaps in knowledge or areas of uncertainty regarding BDL operation? Have questionnaires and check-lists been considered?
22. **Timing:** Has the timing of the BDL submission been considered?   
    Has sufficient time been allowed before design life limits are exceed for procurement of long-lead items, update of the safety case and interaction with other programmes of work? Has the timing of periodic reviews been considered where they are required to provide additional substantiation for operation BDL? Has the timing of facility-wide factors and future programme requirements been considered? The ongoing availability of third-party support, spare parts and consumables should also be considered.

# Appendix 2 – WENRA Reference Levels and IAEA Sources

## WENRA

1. This TAG considers WENRA [4] for specific applicability to existing reactors.
2. WENRA Reference Level ‘I’ concerns ‘Ageing Management’. It requires arrangements to proactively manage A&D over the life of the facility.   
   It describes that this is required to prevent the effects of A&D from occurring, and to mitigate their severity where reasonably practicable. A&D requirements include the:

* systematic identification of A&D mechanisms and their consequences;
* monitoring, testing, and sampling to provide timely detection their occurrence; and
* corrective actions, prioritised by safety significance.
* requirement to regularly review and update arrangements for A&D management.

## IAEA

1. This TAG considers guidance provided in several IAEA sources for specific applicability.
2. IAEA SSR-2/1 [5] establishes requirements for the safe design of NPPs.   
   It contains:

* Requirement 31 (ageing management). It describes that the design life of items important to safety at a nuclear power plant shall be determined. Appropriate margins shall be provided in the design to take due account of relevant mechanisms of ageing, neutron embrittlement and wear out and of the potential for age related degradation.
* Requirement 30 (qualification of items important to safety). It describes the qualification programme for items important to safety shall include the consideration of ageing effects caused by environmental factors (such as conditions of vibration, irradiation, humidity or temperature) over the expected service life of the items important to safety.

1. IAEA SSR-2/2 [6] establishes the requirements for the safe commissioning and operation of NPPs. It contains:

* Requirement 14 (ageing management). It describes that the operating organization shall ensure that an effective Ageing Management Programme is implemented to ensure that required safety functions of SSCs are fulfilled over the entire operating lifetime of the plant.
* Requirement 16 (Programme for Long Term Operation (LTO)).   
  It outlines the need for the operating organization to implement a comprehensive programme to ensure the long term safe operation of the plant beyond a time-frame established in the licence conditions, design limits, safety standards and/or regulations.

1. IAEA SSG-48 [7] identifies that ageing management covers all activities that aim to prevent or control ageing effects, within acceptable limits, throughout the lifetime of the NPP. This includes design; fabrication or construction; commissioning; operation, including LTO; and decommissioning, including long term shutdown.   
   It also identifies that TLAA should show that the analysed ageing effects will not adversely affect the capability of an SSC to perform its intended function(s) throughout operational life.
2. IAEA Safety Reports on Regulatory Oversight of Ageing Management and Long-Term Operation Programme of Nuclear Power Plants [8] provides technical and practical information based on the existing regulatory approaches and practices of Member States concerning safety oversight of ageing management and LTO of NPPs. The report also describes differences in approaches to justification of operation BDL and LTO across IAEA member states.
3. IAEA Safety Reports on Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL) [9] provides practical guidance based on proven practices for managing A&D with reference to the IAEA safety standards for design, commissioning and operation. It also discussed ageing management of passive and active SSCs for water-moderated reactors that can have an effect, directly or indirectly, on the safe operation of the plant.
4. IAEA NR-T-3.34 [10] provides guidance on strategies for managing ageing and obsolescence of C&I equipment. Includes considerations associated with A&D mechanisms and effects, ageing identification techniques, data capture and trending, life cycle considerations and maintenance strategies.   
   It also includes considerations associated with obsolescence management including configuration control, software security, knowledge management and details of modernisation strategies that can be employed
5. IAEA SSG-69 [11] provides recommendations on equipment qualification in nuclear installations. It discusses strategies to provide confirmation of the reliable performance of SSCs in operational states and accident conditions and to avoid vulnerability due to common cause failure. Includes discussion of methods to simulate ageing effects (pre-ageing) in type tests for equipment qualification.
6. IAEA NP-T-3.24 [22] discusses PSR requirements and their relation to A&D management. It describes that a PSR may be used to support BDL operation, or for the restart of a NPP, following a prolonged shutdown or lay-up period. It also includes discussion on integration of ageing and economic planning to optimise NPP investments in favour of safety, commercial profitability and competitiveness.
7. IAEA INSAG-14 [19] proposes a general safety objective for safe management of the operating lifetimes of NPPs. A number of A&D mechanisms are described and associated considerations for design and construction presented. Considerations associated with management of A&D on operating plants are also discussed.
8. IAEA TECDOC 1556 [33] provides ageing management guidance for Pressurised Water Reactor (PWR) reactor pressure vessels. It describes that the material properties of welds should be considered. This is especially important for large welds, as neutron irradiation may significantly impact material properties. For high temperature plant, cyclic (i.e., fatigue) and creep behaviour of weldments should be understood. This should be considered, even where irradiation is not an issue.
9. IAEA NS-G-2.6 [21] describes that effective Maintenance, Surveillance and In-service inspection (MS&I) are essential for the safe operation of an NPP.   
   They ensure not only that the levels of reliability and availability of all plant SSCs having a bearing on safety remain in accordance with the assumptions and intent of the design, but also that the safety of the plant is not adversely affected after the commencement of operation. It provides recommendations and guidance for MS&I activities to ensure delivery of safety function throughout life.
10. IAEA TECDOC 1399 [20] provides information regarding retention and transfer of knowledge needed to design, build, operate, and maintain NPPs in the context of the ageing nuclear workforce. It identifies information to be provided on the transfer of knowledge including lessons learned in NPP operating organisations. Selected examples are provided of management strategies for retention of both explicit and tacit knowledge.
11. IAEA NR-T-2.12 [24] discusses the role of Human Factors in I&C system design to successfully support plant personnel functions and tasks. Several considerations associated with optimisation of arrangements for A&D management are included. This includes optimising implementation of arrangements for A&D management and integration with the supply chain.   
    It describes that human factors analysis for SSC access and EIMT should be considered.