Radiation and Nuclear Safety Authority

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Guide YVL A.8, Ageing management of nuclear facility

1 Introduction

The Guide addresses the ageing management of a nuclear facility. The systems, structures and components of a nuclear facility are subjected to numerous stresses that may reduce their integrity and operability. The requirements for systems, structures and components may also change during the service life of the nuclear facility and the available technology may develop, which will lead to the systems, structures and components no longer meeting the prevalent level of requirement. These factors, i.e. the ageing of systems, structures and components, are prepared for in the design phase with correct design solutions and during use by monitoring and maintaining the operability of systems, structures and components until they are decommissioned.

2 Scope of application

The Guide presents the requirements relating to the ageing management of the systems, structures and components (SSC) of a nuclear facility for the design, operation and maintenance activities of the licensee (the license applicant before the granting of the construction licence) and describes the regulatory control STUK uses to monitor the adherence to these requirements. The Guide is applied to all nuclear facilities in all phases of their life cycle to the extent where this is required to ensure the operability of the systems, structures and components of these facilities important to nuclear and radiation safety.

3 Justifications of the requirements

The requirements of Guide YVL A.8 are based on:

- Nuclear energy and other legislation
- IAEA Safety Standards Series No. NS-G-2.12, Ageing Management for Nuclear Power Plants, Safety Guide, Vienna (2009)
- IAEA Safety Standards Series No. NS-G-2.6, Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants, Safety Guide, Vienna (2002)
- WENRA Reactor Safety Reference Levels, May 2014, Issue I: Ageing Management
- WENRA Reactor Safety Reference Levels, May 2014, Issue K: Maintenance, in-service inspection and functional testing
- IAEA Safety Standards No. SSR-2/1, Safety of Nuclear Power Plants: Design (Vienna 2012)
- IAEA Safety Standards No. SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation (Vienna 2011)
- Experiences, threat scenarios and possibilities from nuclear power plants

The Guide complies with IAEA's and WENRA's requirement level for the ageing management of nuclear power plants.

The justifications of the requirements are presented below for each Guide chapter.

3.1 Chapter 3 General requirements

The chapter presents the general requirements relating to the implement of ageing management at the nuclear facility. The following chapters present more detailed requirements for the different phases of the life cycle from design to use. Reference level "WENRA, Issue I: Ageing Management" can be considered the requirement basis in principle for the guide requirements:

1.1 The operating organization shall have an Ageing Management Programme to identify all ageing mechanisms relevant to structures, systems and components (SSCs) important to safety, determine their possible consequences, and determine necessary activities in order to maintain the operability and reliability of these SSCs.

However, WENRA does not recognise obsolescence, the management of which is part of the topic of the Guide, as is physical ageing. The requirement basis for requirements concerning obsolescence is "IAEA NS-G-2.12, Chapter 5 Management of Obsolescence*"*.

3.2 Chapter 4 Design and procurement

The chapter presents requirements for the design of SSC from the perspective of ageing management. Design can be considered the first phase of the ageing management of SSC. Appropriate design solutions can be used to avoid or at least slow down ageing and ensure the inspectability and maintainability of SSC. When the SSC are easily inspectable and maintainable, the conditions for these most essential areas of ageing management have already been created.

Guide "IAEA NS-G-2.12" may be considered the requirement basis:

3.7 Appropriate measures should be taken or design features should be introduced in the design stage to facilitate effective ageing management throughout the lifetime of the plant. Such measures should also be applied to the design of modifications or of replacements of equipment or components. Reference [Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. NS-R-1, IAEA, Vienna (2000)] establishes the following design related requirements on the management of ageing of SSCs important to safety: "Appropriate margins shall be provided in the design for all structures, systems and components important to safety so as to take into account relevant ageing and wear-out mechanisms and potential age related degradation, in order to ensure the capability of the structure, system or component to perform the necessary safety function throughout its design life. Ageing and wear-out effects in all normal operating conditions, testing, maintenance, maintenance outages, and plant states in a postulated initiating event and post-postulated initiating event shall also be taken into account. Provision shall also be made for monitoring, testing, sampling and inspection, to assess ageing mechanisms predicted at the design stage and to identify unanticipated behaviour or degradation that may occur in service."

The chapter includes requirement 405 for the determination of the service life that has been specified in this revision round. The basis of this requirement is that if there are known ageing mechanisms that can limit the service life of SSC, the licensee shall, based on technical facts, estimate the time the SSC will reliably maintain its operability in the planned operation and with the planned maintenance actions. Service life estimates are needed in long-term planning and spare part management, for example, to schedule and perform SSC replacements in a controlled manner. The service life of SSC can be extended if the operability of the SSC can be verified over a service life longer than the original estimate, and the SSC shall be replaced sooner than planned if the loss of operability has been observed in inspections or tests before the end of the estimated service life.

Justification for the requirement may also be presented using the international requirement levels “IAEA/Safety of Nuclear Power Plants: Design; Specific Safety Requirements (No. SSR-2/1)”:

Requirement 31: *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, to ensure the capability of items important to safety to perform their necessary safety functions throughout their design life.*

and “IAEA Safety Standards Series No. NS-G-2.12, Ageing Management for Nuclear Power Plants”:

4.30 Results of the condition assessment should be documented in an appropriate report and should provide information on:

- *The current performance and condition of the structure or component, including assessment of any ageing related failures or indications of significant material degradation;*
- *Estimation of future performance, ageing degradation and service life, where feasible, of the structure or component.*

4.39 The qualified life of equipment should be reassessed during its lifetime, with account taken of the progress in knowledge of ageing mechanisms. If the qualified life is to be increased, a thorough safety demonstration should be provided by the operating organization.

3.3 Chapter 5 Fabrication

The chapter sets requirements for the fabrication stage of SSC. Fabrication methods may be significant for the progress of SSC ageing in operating circumstances. Inspections during fabrication can be used to rule out any fabrication faults that may lead to premature inoperability. Requirements are also presented for inspections during fabrication, the results of which are needed as reference values for in-service condition monitoring of SSC.

The requirement basis is “IAEA NS-G-2.12”:

3.10 The operating organization should ensure that the suppliers adequately address factors affecting ageing management and that sufficient information and data are provided to the operating organization.

3.4 Chapter 6 Operation

The chapter sets requirements for the operation of the nuclear plant and the instruction of operators from the perspective of ageing management. The reason for this is that different modes of operation can be used to avoid unnecessary stresses that speed up the development of various ageing mechanisms.

The requirement basis is “IAEA NS-G-2.12”:

2.9 The DO activity in Fig. 1 means minimizing expected degradation of a structure or component through its ‘careful’ operation or use in accordance with operating procedures and technical specifications. (Careful operation or use minimizes the rate of degradation of an SSC while maintaining the required levels of power production.)

“DO activity” refers to the *Operation/use of a structure/component*, and it is one phase in the PLAN-DO-CHECK-ACT action model described in more detail in the above-mentioned IAEA guide.

3.5 Chapter 7 Condition monitoring and maintenance

Condition monitoring and maintenance are the most important parts of ageing management. The general requirement basis for this chapter is WENRA, Issue K: Maintenance, in-service inspection and functional testing.

Condition monitoring refers to methods that yield information and/or predictions regarding the integrity and functionality (operability) of SSC. It may be based on visual inspections, non-destructive testing, functional tests, pressure and leak tests and other corresponding inspections. Condition monitoring is also considered to include measurements, samples and other collection of information enabling the indirect assessment of the operability of SSC (for example, cumulative fatigue and material samples) or yielding information on conditions affecting operability (for example, water chemistry measurements).

Maintenance refers to measures with which the failure risk of SSC is minimised pre-emptively and the operability is restored when a need of overhaul or a failure is observed through condition monitoring. For SSC important to safety, which Guide YVL A.8 exclusively applies to, corrective maintenance is not allowed as a maintenance strategy in cases where failure causes a safety risk.

The chapter includes requirement 715 for the individual tracking of SSC, the necessity of which was commented on in the draft phase. Information on the inspections and tests as well as service, repair and modification work of SSC shall be recorded, and this information shall be added to the item (not to the equipment location). When the history of an item is known, this enables viewing future overhaul or replacement needs of SSC using the historical data. Previous operating

experience is also important in the procurement of replacement SSC in order to avoid known problematics in the future. Any SSC in maintenance rotation whose service place at the facility may change shall be furnished with indelible identification marking (requirement 716) to ensure traceability. Individual tracking may also be justified with guide “IAEA No. NS-G-2.6”:

4.29 The operating organization should ensure that an adequate quality assurance programme is effected at all stages in the preparation and implementation of MS&I. Quality assurance has a broad scope in the context of this Safety Guide. It should be applied to ensure that safety principles and criteria have been observed. Quality assurance in MS&I should include the proper identification, evaluation and, eventually, approval of changes in approaches and technology, and uses of qualified materials and parts for replacement, including records and traceability. *For further guidance on quality assurance in MS&I see Ref. [Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations, Safety Series No. 50-C/SG-Q, IAEA, Vienna (1996).], in particular Safety Guide Q2 on Non-conformance Control and Corrective Actions, Safety Guide Q4 on Inspection and Testing, and Safety Guide Q13 on Quality Assurance in Operation.*

The requirements of the chapter for documented instruction of condition management and maintenance are justified in “WENRA, Issue K: Maintenance, in-service inspection and functional testing”:

1.1 The licensee shall prepare and implement documented programmes of maintenance, testing, surveillance, and inspection of SSCs important to safety to ensure that their availability, reliability, and functionality remain in accordance with the design over the lifetime of the plant. They shall take into account operational limits and conditions and be re-evaluated in the light of experience.

Requirement 724 concerns the spare part stock. The aim of the requirement is to reduce the risk of losing all subsystems during prolonged transients and accidents. The SSC have been designed to comply with the design requirements, but long-term use under real plant conditions requires the maintenance of SSC and also the availability of spare parts. For this reason, it shall be determined which subsystems are needed in abnormal events lasting for several months, and it shall be assessed, for example, on the basis of operating experience, which of the components that are critical to the operability of subsystems are most susceptible to failure and repairable with spare parts. These spare parts typically include wearing spare parts such as bearings and seals but not whole SSC or subsystems, the operability of which is ensured with the principle of redundancy when necessary. The spare part stock pursuant to requirement 724 shall be specified in the licensee’s ageing management programme.

3.6 Chapter 8 Modifications

Modification refers to the alteration of SSC (its structure or function) in such a manner that it no longer corresponds to the earlier designs. Modifications are typically performed to improve the performance, availability or nuclear safety of a nuclear facility or to extend its service life through the improvements. For this reason, the

Guide includes requirements for modifications as a part of the ageing management of a nuclear facility.

The requirements of the chapter are justified with the requirements of guide “IAEA NS-G-2.12”:

2.11 The ACT activity in Fig. 1 means the timely mitigation and correction of component degradation through appropriate maintenance and design modifications, including component repair and replacement of a structure or component.

3.18 In the event of reactor power uprating, important modifications or equipment replacement, the operating organization should identify and justify possible associated changes in process conditions (e.g. flow pattern, velocity, vibration) that could cause accelerated or premature ageing and failure of some components.

“ACT activity” refers to the *Maintenance of a structure/component*, and it is one phase in the PLAN-DO-CHECK-ACT action model described in more detail in the above-mentioned IAEA guide.

3.7 Chapter 9 Documents to be submitted

The licence applicant shall append a **conceptual plan for ageing management** including the following items to the construction licence application:

a. organisation of ageing management
b. preparation for ageing in the design, procurement and fabrication of SSC and during the construction of the nuclear facility
c. ageing management during the operation of the nuclear facility
d. preliminary specification of time-limited qualifications and analyses

The licence applicant shall describe (**a.**) how it aims to organise ageing management at a nuclear facility under construction. The plan shall present the parties participating in the condition monitoring and maintenance of SSC and their roles, tasks and expertise requirements.

The licence applicant shall describe (**b.**) the methods it uses to prepare for the ageing of SSC before the operation of the plant unit begins. The plan shall describe what kinds of design solutions are used to slow down the ageing of SSC, how inspectability and maintainability are invested in during the planning stage, how manufacturing quality assurance in the procurement phase shows ageing management and how experiences and comparison data from other nuclear facilities and investigations are utilised in order to develop the ageing management of the nuclear facility under construction. Because the construction phase of a nuclear facility lasts for several years, the ways to prevent the reduction of the operability of the installed and possibly tested SSC during construction shall be described in addition to the above.

The licence applicant shall describe (**c.**) how the condition monitoring and maintenance of SSC is intended to be performed during the operation of the nuclear facility and how ageing management is paid attention to in the operation of the nuclear facility. In principle, the plan shall describe the periodic or continuous

inspections, tests etc., planned maintenance strategies and modes of operations to avoid unnecessary stresses to the SSC.

The license applicant shall present (**d.**) a preliminary list of the SSC for which a time-limited qualification or analysis is to be conducted. An example of SSC for which a time-limited qualification is carried out is an insulated cable whose electrical and mechanical qualities degrade due to the stress caused by high temperatures and whose safe service life is demonstrated experimentally by accelerated ageing. An example of SSC for which a time-limited analysis is made is a reactor pressure vessel that becomes brittle under stress caused by neutron flux and whose safe service life is demonstrated by means of calculations.

The licence applicant shall append an **ageing management programme** to the operating licence application in the following scope. If the nuclear facility has been in use before the Guide's entry into force and the licence applicant does not have an ageing management programme as per the Guide, the ageing management programme shall even then be prepared and supplied to STUK for the approval procedure in accordance with requirement 302.

a. the coordination, responsibilities and duties of ageing management in the licensee's organisation
b. the measurement of the effectiveness of ageing management and its objectives
c. the utilisation of feedback data in ageing management
d. graded approach applied to ageing management according to the safety significance of SSC
e. procedures for managing the obsolescence of SSC
f. spare parts for the nuclear facility in case of prolonged transient and accident conditions
g. information on the SSC covered by ageing management:
    - service place codes
    - design basis operating conditions and modes
    - identified ageing mechanisms
    - condition monitoring and preventive maintenance programmes
    - time-limited qualifications and analyses

The licensee shall describe (**a.**) the administrative organisation of ageing management, specify the responsibilities, duties and mutual interaction of the parties participating in ageing management and describe how the responsibilities and duties are carried out and how the organisation serves the ageing management of plant units.

In the measurement of the effectiveness (**b.**), the licensee presents the meters with which it assesses its success in maintaining the operability of SSC. The meters may include the trend monitoring of the faults, overhaul needs or process parameters of SSC or the use of indicators suitable for the purpose. The targets for the results of measurement are also reported.

The licensee shall describe (**c.**) how it acquires and utilises information and experiences from its own plants and other domestic and foreign nuclear facilities

relating to the monitoring and maintenance of the operability of SSC. The management programme describes from what sources the information is gathered, where the information is directed and who utilises the information in practice.

The licensee shall describe (**d.**) how the safety significance (and/or availability significance) of SSC affects its ageing management (graded approach). The management programme shall describe the principles and the graded effects on the extent of preventive maintenance, inspection or test intervals, spare parts service, etc. of SSC with practical examples.

The licensee shall present (**e.**) the procedures it uses to monitor the conformity to requirements of SSC, the availability of spare parts and technical support and the technical correspondence of SSC to the prevalent level of development, and to prepare for this kind of technological ageing in advance.

The licensee shall define (**f.**) the spare parts required to be stored at the plant site by the Guide's requirement 723.

The information on the SSC covered by ageing management (**g.**) is intended as a summary with which the information essential for ageing management on the systems, structures and components of the nuclear facility can be identified and traced. The SSC are identified with location codes. The operating conditions and situations of SSC as well as the resulting stresses and loads shall be presented in all design basis conditions (from normal operation to severe accidents). The ageing mechanisms assumed to deteriorate the operability of SSC shall be listed. The procedures for ageing management shall present the whole range of methods that the licensee uses to monitor and maintain the operability of SSC. Depending on the SSC, this may include inspections, tests, preventive maintenance, time-limited environmental qualifications, time-limited fatigue analyses etc. The licensee may use its own discretion in the way the information is presented, for example, by referring to documents that have been submitted earlier or are otherwise available. The information may also be grouped in a way deemed suitable for the purpose, for example, by equipment group and/or system. What is most important is that the information listed above on all SSC covered by ageing management can be found as such or through references in the management programme.

During operation, the licensee shall annually submit an ageing **follow-up report** including the following information on the SSC covered by ageing management:

a. long-term trends in the number of failures by failure type;
b. a summary of major servicing, repair, replacement and modification work carried out during the reporting period or to be implemented later;
c. an assessment of current operability and the development trend of operability;
d. any development and research needs related to ageing management and maintenance in both the short and long term;
e. the validity of time-limited qualifications and analyses;
f. a summary of the number and condition of spare parts.

The aim of the follow-up report is to summarise the state of the operability of the plant unit and SSC and to replace all other reporting by licensees to STUK concerning ageing management. The information is presented on all SSC covered by ageing

management. The way of grouping the information includes free choices. For example, the method can be similar to what the licensee uses when presenting the basic information of SSC for the ageing management programme. The reporting interval may be longer than a year for SSC in which the ageing phenomena reducing operability progress more slowly than in other SSC, if the justification for extending the reporting interval is acceptable. For electric and I&C cables inside the containment, for example, mechanical and electrical inspections are required at least every five years. It is also purposeful to report their operability with the same intervals. The report shall present the numbers of faults by fault type from previous reporting periods as well as the current reporting period. The report shall briefly describe the significant maintenance work that has been completed during the reporting period and also the work for which an investment decision has been made but implementation has not begun yet. The licensee shall provide its own assessment on the operability of the SSC. The assessment may be qualitative or, for example, be based on a classification developed by the licensee. The trend of operability shall be examined particularly when maintenance work is not prepared for in the near future. The discovered development and research needs relating to the operability management and maintenance of SSC shall also be recorded in the report. When time-limited qualifications or analyses are related to SSC, their remaining validity shall be reported. If the validity ends in the near future, further actions to renew them and other possible solution models shall be presented. Finally, a summary of the number and condition of spare parts stored at the plant site shall be presented.

The requirement basis for the chapter is the Nuclear Energy Decree (1988/161):

Section 111: *The Radiation and Nuclear Safety Authority (STUK) controls the operation of a nuclear facility to ensure that the operation of the facility is safe and complies with the licence conditions and the approved plans and that the operation also in other respects adheres to the Nuclear Energy Act and to the regulations issued by virtue of the Act. The control of the operation of a nuclear facility also involves the maintenance, repairs, inspections and tests of the nuclear facility systems, structures and components.*

4 International provisions concerning the scope of the Guide

See section 2, Justifications of the requirements.

5 Impacts of the Tepco Fukushima Dai-ichi accident

No impact on the requirements of the Guide.

6 Needs for changes taken into account in the update

The change proposals made in connection with the preparation of the YVL Guide implementation decisions (SYLVI) together with others recorded in STUK's change proposal database have been considered when updating the requirements. Another aim has been to clarify the requirements based on feedback from licensees and further improve the linguistic form.

In addition, the possibilities to reduce the so-called administrative burden have been considered. The administrative burden has been reduced by cutting down on reporting requirements (requirement 905).

Many clarifications of requirements and linguistic improvements have been made in the Guide. Requirement 802 of Guide YVL E.7 “Electrical and I&C equipment of a nuclear facility” has been moved to this Guide as requirement 706a. The requirement concerns the ageing management of cables inside the containment.

A change that is considered significant (requirement 709) is the allowing of corrective maintenance strategy. However, it only lowers the requirement level to the extent that corrective maintenance can be selected as the maintenance strategy for SSC whose failure does not risk nuclear safety. In any case, certain SSC are deliberately used until failure, and when the fault is observed, the SSC are repaired or replaced. In practice, allowing a corrective maintenance strategy means that there are SSC deemed important to safety (because they are safety-classified and Guide YVL A.8 only concerns safety-classified SSC) whose operability does not have an immediate significance in terms of nuclear safety.