

IAEA ACTIVITIES TO SUPPORT SAFE LONG TERM OPERATION OF NUCLEAR POWER PLANTS

This paper presents main IAEA activities for safe long term operation (LTO). It includes establishment of IAEA Safety Standards and other LTO related documents, fostering information exchange and establishing databases including IGALL (International Generic Lessons Learned) Programme and provision of SALTO (Safety Aspects of Long Term Operation) peer review service. This paper provides introduction on new IAEA Safety Standards related to LTO, an overview of IGALL programme results and plans and provides insights into IAEA SALTO peer review service objectives, scope, methodology and results.

INTRODUCTION

301 out of 450 nuclear power plants (NPPs) worldwide have been in operation for more than 30 years and 98 for more than 40 years (as of May 2018). In view of these facts, many countries are giving a high priority to continuing the operation of NPPs beyond the time frame originally anticipated (e.g. 30 or 40 years).

Long term operation (LTO) of a nuclear power plant may be defined as operation beyond an established time frame set forth by, for example, licence term, design, standards, licence and/or regulations, which has been justified by safety assessment, with consideration given to life limiting processes and characteristics of systems, structures and components (SSCs). Proper and safe LTO is based on the experience and practices in areas such as ageing management programmes (AMPs), other plant programmes relevant for LTO, time limited ageing analyses (TLAAs) and plant license renewal. Other activities, including periodic safety review, current licensing basis and plant modifications, are also relevant to LTO. Effective AMPs are key elements in the safe and reliable operation of NPPs during the time frame originally planned for operation and for the period of LTO.

LTO is justified by a safety assessment that considers life limiting processes and characteristics of structures, systems and components.

In order to assist Member States in effectively managing the effects of ageing and preparation for safe LTO, the IAEA has developed related safety standards and guidance publications.

The IAEA Safety Aspects of Long Term Operation (SALTO) peer review service was introduced to support Member States in their activities for safe LTO. Findings, conclusions and recommendations resulting from the SALTO peer review service are intended to assist national decision makers who have the sole responsibility for the regulation and the safe LTO of their NPPs. Different components of SALTO peer review service have already been provided to 23 Member States operating 252 NPPs.

IAEA supports safe LTO of NPPs in three basic areas:

1. Establishment of IAEA Safety Standards and other LTO related documents;
2. Fostering information exchange and establishing databases;
3. Provision of SALTO peer review service.

ESTABLISHMENT OF IAEA SAFETY STANDARDS AND OTHER LTO RELATED DOCUMENTS

Recognizing the differing levels of development in its Member States, and the need for comprehensive information about international good practices to assist regulatory bodies and operating organizations in dealing with the unique challenges associated with LTO, the IAEA conducted the Extrabudgetary Programme on Safety Aspects of Long Term Operation of Water Moderated Reactors in 2003–2006. Final Report of the Programme 'Safety Aspects of Long Term Operation of Water Moderated Reactors, Recommendations on the Scope and Content of Programmes for Safe Long Term Operation' [1] was published in July 2007.



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This document was used as a basis for a Safety Report No. 57 'Safe Long Term Operation of Nuclear Power Plants' [2] which was published in 2008. This Safety Report was also used as the basis of IAEA SALTO peer review service.

Safety Guide NS-G-2.12 'Ageing Management for Nuclear Power Plants' [3] was published in 2009. This Safety Guide deals with the establishment, implementation and improvement of AMPs for SSCs important to safety in NPPs. It mainly focuses on managing the physical ageing of SSCs important to safety but also provides recommendations on safety aspects of managing obsolescence and on the application of ageing management for LTO.

The requirements for the design and operation of NPPs are established in the Specific Safety Requirements publications SSR 2/1 (Rev.1) on Safety of Nuclear Power Plants: Design [4] and SSR 2/2 (Rev.1) on Safety of Nuclear Power Plants: Commissioning and Operation [5], both published in 2016. SSR 2/2 contains also Requirement 16: Programme for long term operation which is the IAEA highest level basis for recommended activities for safe LTO.

The latest published document in the area of LTO is a Safety Report No.

82 'Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL)' [6] (also called 'IGALL Safety Report') which was published in 2015. In April 2017, the IAEA endorsed a new Safety Guide DS485 [7] on 'Ageing Management and Development of a Programme for Long Term Operation for Nuclear Power Plants' which will be published as SSG-48 in 2018. This Safety Guide supplements and provides recommendations on meeting the requirements related to ageing management and LTO that are established in SSR-2/1 (Rev.1) [4] and SSR-2/2 (Rev.1) [5]. It provides guidance for operating organizations on implementing and improving ageing management, obsolescence management and on developing a programme for safe LTO for NPPs. It may also be used by the regulatory body in preparing regulatory requirements, codes and standards, and in verifying effective ageing management, obsolescence management and preparation for safe LTO of NPPs.

The recommendations provided in this Safety Guide are applicable for NPPs throughout their entire lifetime (including their decommissioning), taking into account the different reactor designs existing worldwide. This Safety Guide focuses mainly on managing the physical ageing of SSCs within the scope of ageing management ('in-scope SSCs'). It also provides recommendations on safety aspects of managing technological obsolescence and recommendations on the programme for safe LTO of NPPs for its ageing management related activities.

FOSTERING INFORMATION EXCHANGE AND ESTABLISHING DATABASES (IGALL PROGRAMME)

The IAEA conducts each year numerous workshops, seminars, expert missions and working groups in the area of LTO and ageing management to support NPPs, technical support organizations and regulatory authorities in their LTO activities.

Coordinated Research Projects are also way to enhance information exchange of research and development results between Member States. The Extrabudgetary Programme on International Generic Ageing Lessons Learned (IGALL Programme) with current active contribution of more than 200 experts from 30 Member States was commenced in 2010. The aim of the IGALL Programme is to develop and maintain documents and a database to provide a technical basis and practical guidance on managing ageing of mechanical, electrical and instrumentation and control components and civil structures important to safety of NPPs.

The IGALL Programme Phase 1 was successfully completed in September 2013. The IGALL Safety Report [6] and a Technical Document on 'Approaches to Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL) Programme Final Report' [8] were published. The IGALL Safety Report, as a main IGALL Programme deliverable, contains three major parts, an Ageing Management Review (AMR) which summarizes information on AMR and provides a roadmap to the AMR tables, AMPs presenting basic concepts of AMPs and describing the 9 generic attributes of an effective AMP and TLAs providing a collection of typical TLAs.

The IGALL Phase 2 (2014-2015) dealt with enhancement of AMPs and TLAs for CANDU mechanical components, WWER mechanical components and electrical and I&C components. Technological obsolescence programme was also developed.

The IGALL Phase 3 (2016-2017) focused on preparation of a new IGALL Safety Report edition, update of all AMPs and TLAs, particularly operating experience feedback, feedback from research and development and references. AMR tables were also significantly updated and improved.

The IGALL Phase 4 (2018-2019) main objectives are further enhancement of AMPs, TLAs and AMR, development of integrated AMP, development of guidance for regulators to review



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NPPs' preparedness for safe LTO, collection of experiences in ageing management during delayed construction periods, prolonged outages, extended shutdown and post final shutdown periods and development and implementation of workshop/ training for 'junior' experts on IGALL use

The IGALL programme results are publicly available in 'IGALL database' on the IAEA web site. The current 'IGALL database' consists of more than 2600 line items in the AMR table, 92 AMPs, 26 TLAs and Technological Obsolescence Programme.

The IGALL Safety Report represents a common internationally agreed basis on what constitutes acceptable AMPs, as well as a knowledge base on ageing management for design of new plants, design reviews, safety reviews (such as periodic safety review), etc., and serves as a roadmap to available information on ageing management.

The IAEA IGALL Programme assures that information contained in the IGALL Safety Report will be kept updated and creates an international network for continuous discussion and devel-

opment of AMPs and TLAs as recommended tools to manage ageing.

SALTO PEER REVIEW SERVICE

Objective of SALTO peer review service

The IAEA SALTO programme provides advice and assistance to Member States embarking on LTO in enhancing the safety of NPPs. Careful design and high quality of construction are prerequisites for a safe nuclear power plant. However, a plant's safety depends ultimately on the ability and conscientiousness of the operating personnel and on the plant programmes, processes and working methods. This applies also to all LTO related activities. A SALTO peer review service reviews a facility's LTO related activities and programmes against IAEA Safety Standards and proven good international practices.

The SALTO peer review is a comprehensive safety review directly addressing strategy and key elements for safe LTO of NPPs. The key objectives of the



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SALTO peer review are to provide:

- The host organization (operating organizations, technical support organizations, regulators) with an objective assessment of the status of the preparedness for LTO with respect to international nuclear safety standards;
- The host organization with recommendations and suggestions for improvement in areas where performance falls short of international best practices;
- Key staff at the host organization with an opportunity to discuss their practices with experts who have experience with related practices in the same field;
- Member States with information regarding good practices identified in the course of the review;
- Reviewers and observers from Member States and the IAEA staff with opportunities to broaden their experience and knowledge of their own field.

The SALTO peer review is designed to assist operating organizations in adopting a proper approach to LTO including implementing appropriate activities to ensure that plant safety will be maintained during the LTO period. The SALTO peer review can also support regulators in establishing or improving regulatory and licensing strategies for LTO of NPPs.

SALTO peer reviews are available to all Member States with NPPs considering LTO. Many Member States have participated in the programme by hosting one or more SALTO missions or by making experts available to participate in missions. Follow-up missions are a standard part of the SALTO programme and are conducted between 18 to 24 months following the SALTO mission.

Conduct of SALTO peer review service

The SALTO review is performed in line with the SALTO Guidelines, Service

Series 26, published in 2014 [9]. SALTO teams consist of senior expert reviewers from NPPs, technical support organizations and regulatory authorities in the various disciplines relevant to the mission. During technical discussions between reviewers and plant staff, the plant's LTO and AMPs are examined in detail and their performance checked; strengths are identified and listed as good practices, and weaknesses are listed as recommendations or suggestions. The terms 'recommendation', 'suggestion' and 'good practice' are defined in the SALTO Peer Review Guidelines [9]. The criteria used by the teams as they formulate their conclusions are based on IAEA Safety Standards, e.g. [4-7] among others, and, therefore, may be more stringent than national requirements. SALTO reviews are not regulatory inspections, nor design reviews. Rather, SALTO reviews consider the effectiveness of AMPs and LTO preparation activities, and are more oriented to programme,



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process and management issues than to hardware. The performance or outcome of the various programmes is given particular attention. SALTO teams neither assess the adequacy of plant design nor compare or rank the safety performance of different plants.

SALTO peer review service consists of the following elements:

- Workshop/seminar on IAEA safety standards and SALTO review method;
- Pre-SALTO mission (2 years or more before entering LTO, more than once if required);
- SALTO mission (less than 2 years before entering LTO);
- Follow-up SALTO mission (1.5 to 2 years after SALTO mission).

Pre-SALTO mission reviews existing plant programmes and LTO plans at an early stage of their preparation prior to the complete implementation of the LTO activities. Pre-SALTO mission should be conducted well in advance of entering the LTO period to facilitate completion of necessary activities. This mission should review the completeness of the plant intended activities for preparation for safe LTO and the compliance of those activities with the IAEA standards and recommendations.

The SALTO mission reviews the status of the LTO activities close to their completion or when completed, and prior to entering the LTO period.

The length of SALTO missions is based on the mission scope and is normally from seven to ten working days.

The review addresses the following areas:

- Organization and functions, current licensing basis (CLB), configuration/modification management;
- Scoping and screening and plant programmes relevant to LTO;
- AMR, review of AMPs and revalidation of TLAs for mechanical components;
- AMR, review of AMPs and revalidation of TLAs for electrical and I&C components;
- AMR, review of AMPs and revalidation of TLAs for civil structures;
- Human resources, competence and knowledge management for LTO.

The SALTO peer review is conducted by a team of international experts with experience applicable to the areas of review. The typical team composition includes a majority of external experts (experienced experts



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from utilities, regulatory authorities or support organizations) and IAEA staff members (including the team leader and the deputy team leader if applicable).

The SALTO peer review team uses four steps to acquire the information needed to develop their recommendations and suggestions:

- Review of written material and databases;
- Discussion and interviews;
- Direct observation of performance, status and activities;
- Discussion of evaluations and tentative conclusions within the team and with counterparts.

The SALTO mission report contains issues with recommendations and suggestions. The report is submitted through official channels to the Member State and is usually publicly available unless agreed otherwise.

To check the progress in implementing recommendations and suggestions to resolve issues, a follow-up SALTO mission is conducted.

SALTO peer review service history

As a pilot, the SALTO peer review was performed for Hungarian regulatory authority and Paks NPP in Hungary starting in 2005. It consisted of series of limited-scope SALTO missions, Pre-SALTO mission, SALTO mission and SALTO follow-up mission. Based on this experience, a first edition of SALTO Guidelines was published in 2008.

A large amount of experience was collected and SALTO peer review service was changed and improved significantly. Experience gained out of these missions and repeated requests of NPPs to add a new review area of 'Human resources, competency and knowledge management for LTO' led to revision of SALTO Guidelines in 2013. The scope, time schedule, terminology, reporting and procedures for SALTO peer review services were also standardized in this document. New SALTO Guidelines [9] were published in January 2014 and have been used already in a draft version since 2013.

During the period 2005 - June 2018, 26 Pre-SALTO and SALTO missions reviewed plants in 14 Member States including Argentina, Armenia, Belgium, Brazil, Bulgaria, China, the Czech Republic, Hungary, Korea, Mexico, the Netherlands, South Africa, Sweden and Ukraine. Several Member States are planning to invite SALTO missions in future (e.g. Pakistan, Romania, Slovakia, Spain).

9 Follow-up SALTO missions were performed in the same time. Numerous expert missions and support missions based on SALTO methodology were also performed for NPPs and regulators. SALTO workshops were introduced in 2012 as a preparatory phase for SALTO missions and were conducted, e.g. in Finland, France, Iran, Japan, Slovenia, UK.

Growing importance of LTO activities and these workshops/seminars resulted in an increased understanding of the SALTO peer review service and in an increased number of SALTO missions' requests.

SALTO Peer Review Service Results

Many of the challenges faced by those responsible for ensuring the safe operation of NPPs are common throughout the world. The results of a SALTO peer review service are, therefore, of interest and possible application to many NPPs and not solely to the plant in which they were originally identified.

Issues derived from 22 SALTO missions conducted during the period of 2005 to June 2015 were analyzed by the IAEA in 2015. Results are published on IAEA web site in working material 'SALTO missions highlights 2005-2015'. This document includes also results of



6 Follow-up SALTO missions conducted in the same period.

Currently, the IAEA prepares similar analysis of SALTO missions conducted during the period of July 2015 to June 2018.

Calendar of performed and planned SALTO missions is publicly available on IAEA web site. It includes an executive summary of each Pre-SALTO, SALTO and Follow-up SALTO.

In 2017, the IAEA also developed SALMIR database which contains complete results of all SALTO missions conducted since 2005. Database is updated and is available on IAEA IG-ALL restricted web site.

CONCLUSION

IAEA activities for safe LTO include establishment of IAEA Safety Standards and other LTO related documents, fostering information exchange and establishing databases including IGALL programme and provision of SALTO peer review service.

The IAEA endorsed a new Safety Guide SSG-48 [7] on 'Ageing Management and Development of a Programme for Long Term Operation for Nuclear Power Plants' which provides guidance for ageing management, obsolescence management and preparation for safe long term operation of nuclear power plants.

The IGALL Programme represents well-established international network for continuous discussion and development of AMPs and TLAs as recommended tools to manage ageing.

SALTO peer review service has been established as effective tool to review the compliance with IAEA standards,

to provide opportunity for NPP staff to discuss their practices with experienced experts, to strengthen the public confidence to NPP and to support in licensing renewal procedure (or extension of operational permission procedure).

The most important issues for safe LTO of NPPs identified by SALTO missions are connected with unclear definition of LTO plant policy, poorly established configuration/modification management, lack of access to design basis, incomplete scoping and screening of SSCs for LTO, poor interaction of plant programmes with AM, AMPs not ad-

ressing all generic attributes of effective AMP, insufficient environmental qualification programme including revalidation of qualified life time, inconsistency of databases, inadequate AMP of reactor containment and insufficient human resources for LTO activities.

The IAEA is encouraging Member States to invite SALTO peer review service. This peer review for reviewing ageing management and other activities relevant to LTO can be carried out at any time during the lifetime of a NPP but is strongly recommended prior to entering LTO period.■

- [1] INTERNATIONAL ATOMIC ENERGY AGENCY 2007, Final Report of the Programme on Safety Aspects of Long Term Operation of Water Moderated Reactors, Vienna: IAEA.
- [2] INTERNATIONAL ATOMIC ENERGY AGENCY 2008, Safe long term operation of nuclear power plants, Safety Report Series No. 57, Vienna: IAEA.
- [3] INTERNATIONAL ATOMIC ENERGY AGENCY 2009, Ageing Management for Nuclear Power Plants, Safety Standards Series, Safety Guide No. NS-G-2.12, Vienna: IAEA.
- [4] INTERNATIONAL ATOMIC ENERGY AGENCY 2016, Safety of Nuclear Power Plants: Design, Specific Safety Requirements No. SSR-2/1 (Rev.1), Vienna: IAEA.
- [5] INTERNATIONAL ATOMIC ENERGY AGENCY 2016, Safety of Nuclear Power Plants: Commissioning and Operation, Specific Safety Requirements No. SSR-2/2 (Rev.1), Vienna: IAEA.
- [6] INTERNATIONAL ATOMIC ENERGY AGENCY 2015, Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IG-ALL), Safety Report Series No. 82, Vienna: IAEA.
- [7] INTERNATIONAL ATOMIC ENERGY AGENCY 2018, Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants, Specific Safety Guide No. SSG-48 (DS485), Vienna: IAEA.
- [8] INTERNATIONAL ATOMIC ENERGY AGENCY 2014, Approaches to Ageing Management in Member States: International Generic Ageing Lessons Learned (IGALL) Final Report, TECDOC 1736, Vienna: IAEA.
- [9] INTERNATIONAL ATOMIC ENERGY AGENCY 2014, SALTO Peer Review Guidelines, Guidelines for Peer Review of Safety Aspects of Long Term Operation of Nuclear Power Plants, IAEA Services Series No. 26, Vienna: IAEA.