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Main corrective measures in an early phase of nuclear power plants' preparation for safe long term operation

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HIGHLIGHTS

- Results of SALTO missions provide the most important issues for safe long term operation (LTO) of nuclear power plants.
- The most important technical corrective measures in an early phase of preparation for safe LTO are described.
- Their satisfactory resolution creates a basis for further activities to demonstrate preparedness for safe LTO.

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ABSTRACT

This paper presents the analysis of main technical deficiencies of nuclear power plants (NPPs) in preparedness for safe long term operation (LTO) and the main corrective measures in an early phase of preparation for safe LTO of NPPs. It focuses on technical aspects connected with management of physical ageing of NPP structures, systems and components (SSCs). It uses as a basis results of IAEA SALTO missions performed between 2005 and 2016 (see also paper NED8805 in Nuclear Engineering and Design in May 2016) and the personal experiences of the authors with preparation of NPPs for safe LTO. This paper does not discuss other important aspects of safe LTO of NPPs, e.g. national nuclear energy policies, compliance of NPPs with the latest international requirements on design, obsolescence, environmental impact and economic aspects of LTO. Chapter 1 provides a brief introduction of the current status of the NPP' fleet in connection with LTO. Chapter 2 provides an overview of SALTO peer review service results with a focus on deficiencies related to physical ageing of safety SSCs and a demonstration that SSCs will perform their safety function during the intended period of LTO. Chapter 3 discusses the main corrective measures which NPPs typically face during the preparation for demonstration of safe LTO. Chapter 4 summarizes the current status of the NPP' fleet in connection with LTO and outlines further steps needed in preparation for safe LTO.

1. Introduction

The world's fleet of nuclear power plants (NPPs) is, on average, more than 30 years old. As of October 2016, out of 450 NPPs in operation, 79 NPPs is in operation longer than 40 years and another 182 NPPs longer than 30 years (https://www.iaea.org/pris).

Even though the design life of a nuclear power plant is typically 30–40 years, it is quite feasible for many NPPs to operate beyond their original design lives, provided that nuclear specialists demonstrate by analysis, testing and ageing management safe operation for intended period of long term operation (LTO). Safety upgrades of the plants also provide increased assurance that the plant will operate safely. In the operation of NPPs, safety should always be the prime consideration. Plant operators and regulators must always ensure that plant safety is maintained and, where possible, enhanced during its operating lifetime.

In the recent decade, the number of countries giving high priority to continuing the operation of NPPs beyond the time frame originally anticipated (typically 30–40 years) has steadily increased. The task of managing plant ageing is assigned in most countries to an engineering discipline called plant life management (PLiM), which has gained increased attention over the past decade. An effective ageing management of systems, structures and components (SSCs) is a key element in PLiM for the safe and reliable long term operation (LTO) of NPPs. PLiM can be defined in one sentence as the integration of ageing and economic planning for the

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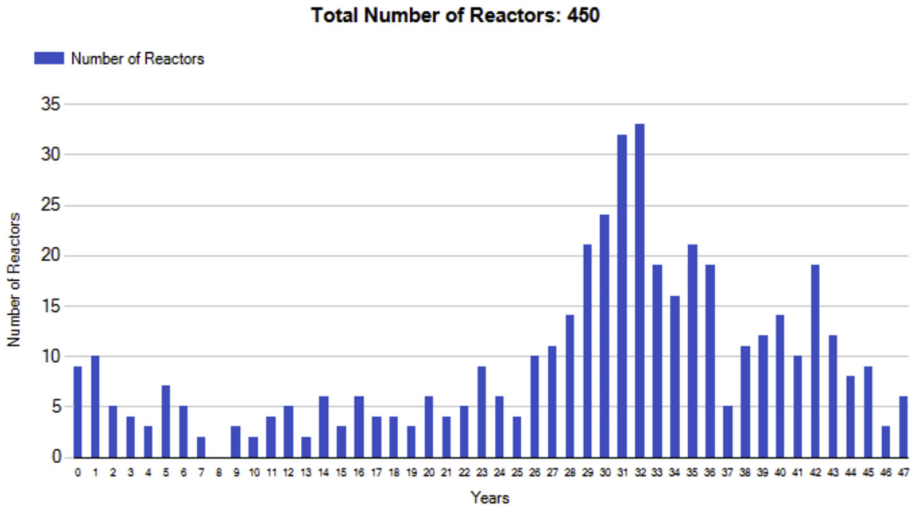

purpose of maintaining a high level of safety and optimizing plant performance by dealing successfully with extended life ageing issues, maintenance prioritization, periodic safety reviews (PSRs), education and training.

To review the preparedness for safe LTO, the IAEA developed a Safety Aspects of Long Term Operation (SALTO) peer review service, the methodology of which is discussed in a paper NED8070 in Nuclear Engineering and Design in September 2014. Chapter 2 provides an overview of the main technical deficiencies of NPPs in preparedness for safe LTO as an outcome of 29 SALTO peer review missions and 4 LTO modules of Operational Safety Review Team (OSART) missions conducted at 22 NPPs in 18 Member States performed in 2005–2016.

Chapter 3 provides a discussion of the main technical corrective measures of NPPs in preparedness for safe LTO which occurred in last decade and their possible solutions.

2. IAEA SALTO peer review results

Recognizing the need to assist its Member States 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 (SALTO) in 2003–2006. The outcome of the programme was consolidated in the publication Safe Long Term Operation of Nuclear Power Plants (Safety Reports Series No. 57, IAEA, Vienna, 2008). General recommendations on methodology, key elements and implementation of effective ageing management programmes (AMPs) for SSCs important to the safety of NPPs are provided in the IAEA Safety Guide entitled Ageing Management for Nuclear Power Plants (IAEA Safety Standards Series No. NS-G-2.12, Vienna, 2009). The recently issued IAEA publication entitled Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL) (Safety Reports Series No. 82, IAEA, Vienna, 2015) provides practical guidance to assist Member States in implementing, maintaining and improving effective AMPs and in the revalidation of time limited ageing analyses.

It was recognized that a SALTO ('Safety Aspects of Long Term Operation') peer review service, using an approach based on the broad experience gained from the Operational Safety Review Team (OSART) service, would be useful to IAEA Member States. The SALTO peer review service is offered by the IAEA, upon request, to all Member States with NPPs in operation. The SALTO review is performed in line with the SALTO Peer Review Guidelines (IAEA Services Series No. 26), published in 2014.

By 2016, 29 SALTO peer review missions had been conducted at 18 NPPs in 15 IAEA Member States. For 4 NPPs in 3 IAEA Member States, an LTO module was reviewed as a part of OSART mission. Many other expert missions based on the SALTO guidelines were also performed. These missions resulted in more than 200 recommendations and suggestions. Their overview is provided in a paper NED8805 in Nuclear Engineering and Design in May 2016.

The nature of these issues covers organization, human resources, managerial topics, deficiencies in documentation and procedures, insufficient data, insufficient programmes to manage physical ageing and obsolescence of SCCs, insufficient demonstration that SSCs will perform their safety function for intended period of LTO etc.

This chapter provides an overview of the most important deficiencies connected with physical ageing of safety SSCs and demonstration that SSCs will perform their safety function during intended period of LTO. These issues can be divided into five categories:

1) Insufficient input data for demonstration of preparedness for safe LTO.
2) Insufficient demonstration that safety SSCs will perform their safety function during the intended period of LTO.
3) Incomplete or missing ageing management programmes (AMPs) and other plant programmes to manage physical ageing of safety SSCs.
4) Incomplete or missing equipment qualification (EQ) programme.
5) Time limited ageing analyses (TLAAs) not demonstrating safe LTO.

The main topics in a category "Insufficient input data for demonstration of preparedness for safe LTO" are:

- Lack of comprehensive and systematic review of modifications against the design basis and the lack of an established design authority function.
- Not accessible or non-existing design basis documentation for SSCs in a scope of LTO.
- Lack of unique IDs (frequently for cables, pipelines, penetrations, I&C components etc.) of SSCS and lack of an SSC master list.
- Missing cable routing.
- Record keeping and collection of data from design, manufacturing, commissioning, operation, maintenance, tests, inspections and monitoring not ensuring the consistency and completeness of data for LTO assessment.