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Technological Challenges for Safety - Long Life of Nuclear Installations

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Technological Challenges for Safety – Long Life of Nuclear Installations

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Nuclear Energy School of Management, Trieste 2012

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OBJECTIVE

- Definition of Ageing
- Resulting technological issues
- Identify IAEA work areas in relation to Long Term Operations and Ageing
  - Safety Standards and IAEA activities and services in relation to Ageing Management

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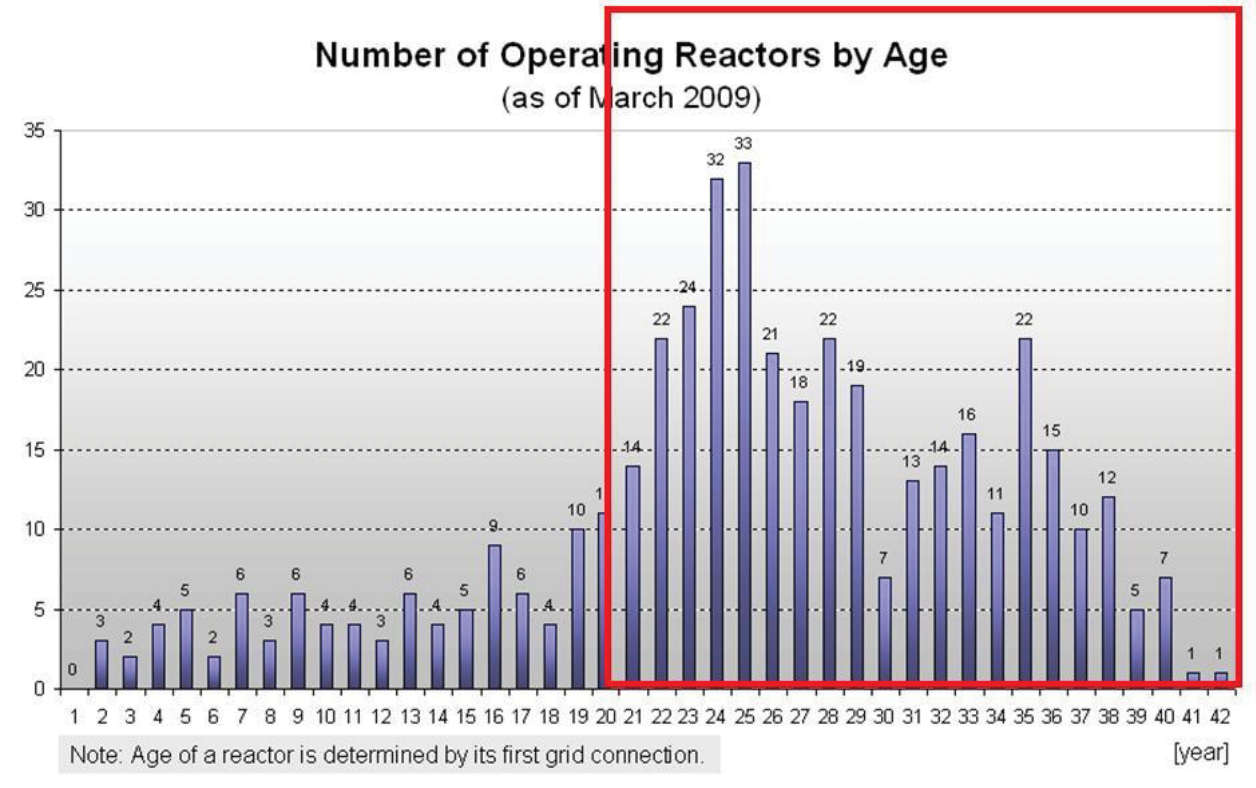
Global Trends in Nuclear Power
- Aging and long-term operation -

Long-term operation and Power uprating

- Long term operation through continuous monitoring, replacement and regulatory review



Age distribution (327/436 over or equal to 20 years)

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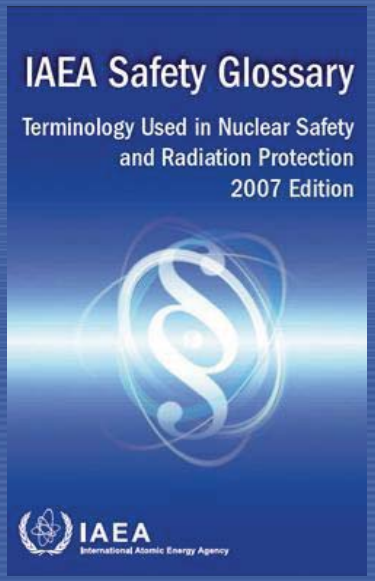
Ageing (IAEA Glossary) (1/2)

- General process in which characteristics of a structure, system or component gradually change with time or use
  - Most commonly used with a connotation of changes that are (or could be) detrimental to protection and safety



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Ageing (IAEA Glossary) (2/2)

- Non-physical ageing: the process of becoming out of date (i.e. obsolete) owing to the evolution of knowledge and technology and associated changes in codes and standards
  - Not always due to changes in the structure, system or component itself. Nevertheless, the effects on protection and safety, and the solutions that need to be adopted, are often very similar to those for physical ageing
- Physical ageing: Ageing of structures, systems and components due to physical, chemical and/or biological processes (ageing mechanisms)

Examples

Non-physical ageing (technological obsolescence)	Physical ageing (material ageing)
• Lack of an effective system (e.g., containment or emergency core cooling system) • Lack of certain safety design features (e.g., diversity, separation or redundancy) • Unavailability of qualified spare parts for old equipment • Outdated procedures or documentation (e.g. do not comply with current regulations)	Ageing effects that could impair the ability of a structure, system or component to function within its acceptance criteria (ageing degradation) • Reduction in diameter due to wear of a rotating shaft • Loss in material toughness due to radiation embrittlement • Thermal ageing, and cracking of a material due to fatigue or stress corrosion cracking

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Physical Ageing

- Programme to monitor and review components and plan for their replacement (e.g. Steam Generators)
- Remanufacture as near as possible to original specification

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Obsolescence

- Programme to monitor and review components and plan for their replacement, based on unavailability of spares etc. e.g. I&C* systems – same function different equipment

1950 - Valves (Vacuum Tubes)
1960 – Transistor (Computer control systems)
1970 – CMOS Logic (Integrated circuits)
1980 – Microprocessors (286, 386, 486, Pentium)
1990 – Digital I&C Protection
2000 – Software – machine code – high level languages
NPP could start with valves and end with microprocessors

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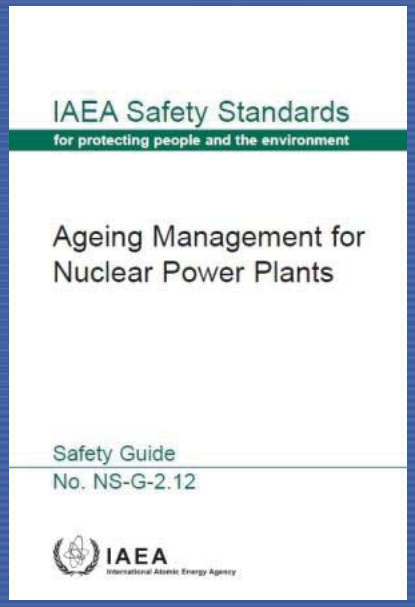
*Instrumentation and Control

Ageing Management (1/2)

- Engineering, operations and maintenance actions to control within acceptable limits the adverse impact of ageing
  - Examples of engineering actions include design, qualification and failure analysis
  - Examples of operations actions include surveillance, carrying out operating procedures within specified limits and performing environmental measurements



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Ageing Management (2/2)

- Life management (or lifetime management) is the integration of ageing management with economic planning
  - Optimize the operation, maintenance and service life of structures, systems and components
  - Maintain an acceptable level of performance and safety
  - Maximize the return on investment over the service life of the facility
- Evaluation of the cumulative effects of both physical ageing and obsolescence on the safety of nuclear power plants is a continuous process and is assessed in a periodic safety review or an equivalent systematic safety reassessment programme

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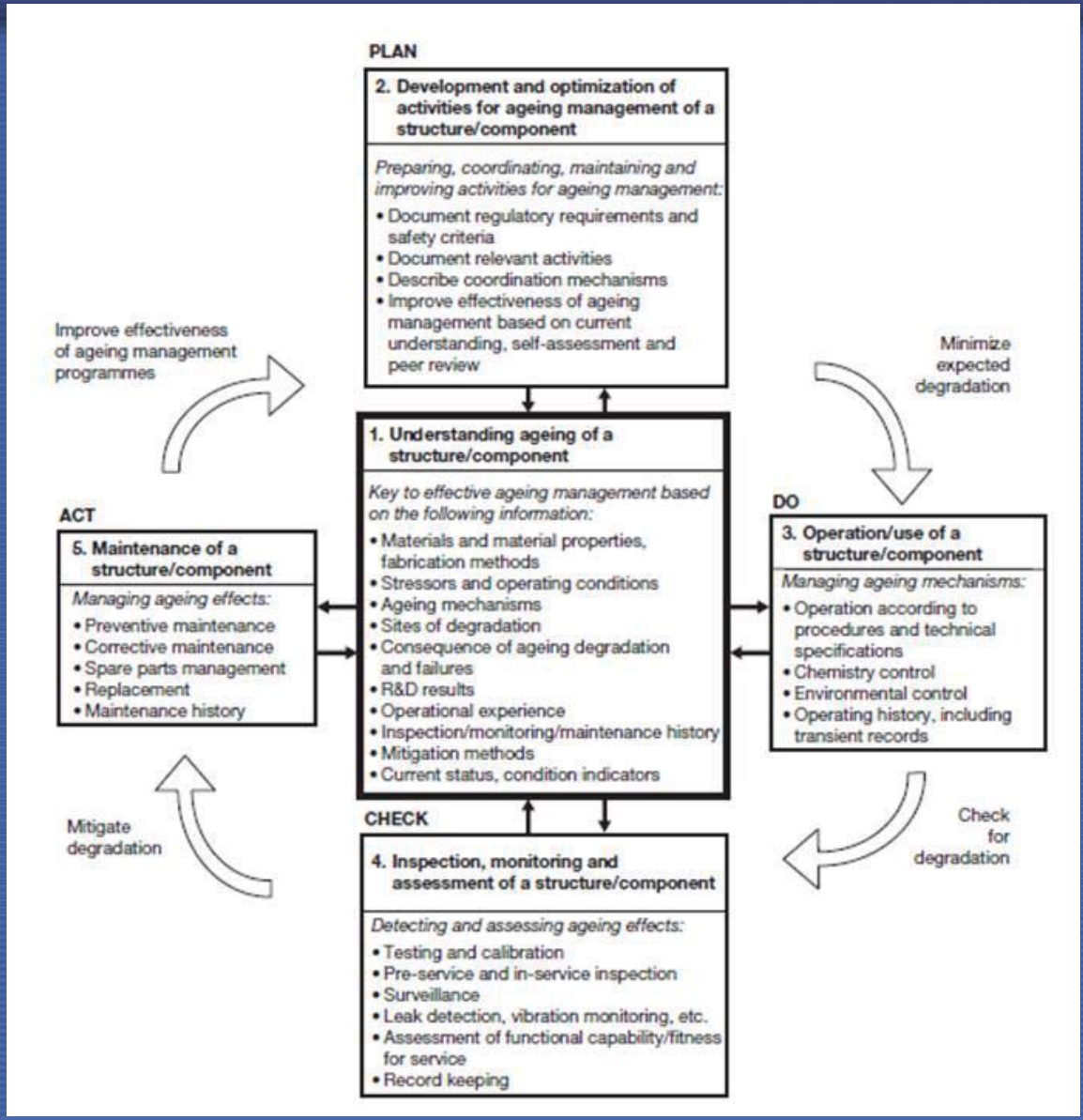
Systematic approach to managing ageing



How is IAEA supporting a safe LTO of NPPs?

1. Establishment of related IAEA Safety Standards

2. Fostering information exchange and establishing databases
   a. Ageing management (AM) and long term operation (LTO) workshops and Programmes
   b. CRP – Coordinated Research Projects

3. Peer review service to assist Member States in application of related Safety Standards

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IAEA Safety Standards: Design and Commissioning/Operation

Article III.A.6 of the IAEA statute:

"The Agency is authorized to establish or adopt … standards of safety for protection of health and minimization of danger to life" in connection with peaceful utilization of nuclear energy

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SSR-2/1 Safety of NPPs: Design

- Requirement 30: Qualification of items important to safety
  - 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
- Requirement 31: Ageing management
  - 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

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SSR-2/2 Safety of NPPs: Commissioning and Operation

- Requirement 14: Ageing management
  - The operating organization shall ensure that an effective ageing management programme is implemented to ensure that required safety functions of systems, structures and components are fulfilled over the entire operating lifetime of the plant
- Requirement 16: Programme for long term operation
  - Where applicable, the operating organization shall establish and implement a comprehensive programme for ensuring the long term safe operation of the plant beyond a time-frame established in the licence conditions, design limits, safety standards and/or regulations

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Fostering information exchange and establishing databases (1/2)

- Programme on Safety Aspects of Long Term Operation of Water Moderated Reactors (SALTO)
  - Established in May 2003 and concluded in 2006
  - Objectives:
    - Assist Member States considering LTO of water moderated reactors in how best to reconcile the related processes and practices
    - Establish a general LTO framework
    - Provide a forum for information exchange

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Fostering information exchange and establishing databases (2/2)

- International Generic Ageing Lessons Learned (IGALL) Programme
  - Established in September 2010, and is scheduled to be completed by 2013
  - Recommendation from Member States to establish an international platform for discussion between regulators and utilities regarding implementation of acceptable Ageing Management Plans
  - Objective: develop a document to provide
    - A guide for ageing mechanisms and effects based on both research results and accumulated operational experience
    - An international agreement on what an acceptable Ageing Management Programme involves for standard plant components, structures, material and environments

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Peer Reviews: SALTO Review Service for NPPs

1. Review of compliance with IAEA standards and international best practices
2. Recommendations for improvement to achieve compliance
3. Opportunity for NPP stuff to discuss their practices with experienced experts
4. Strengthening of public confidence in nuclear power
5. Support in licensing renewal procedure (or extension of operational permission procedure)

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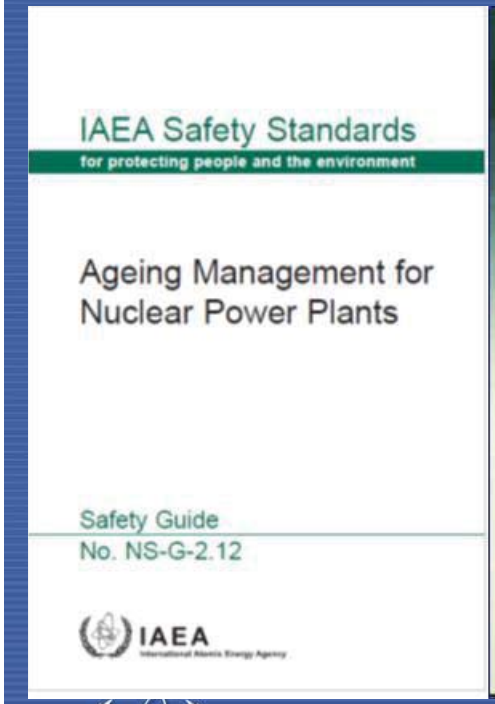
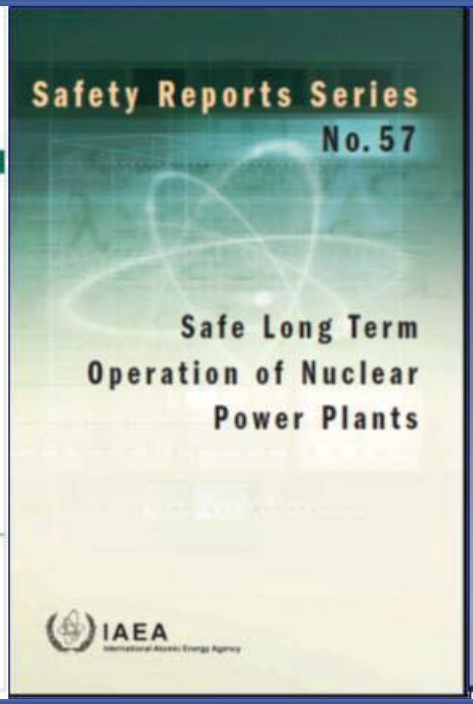
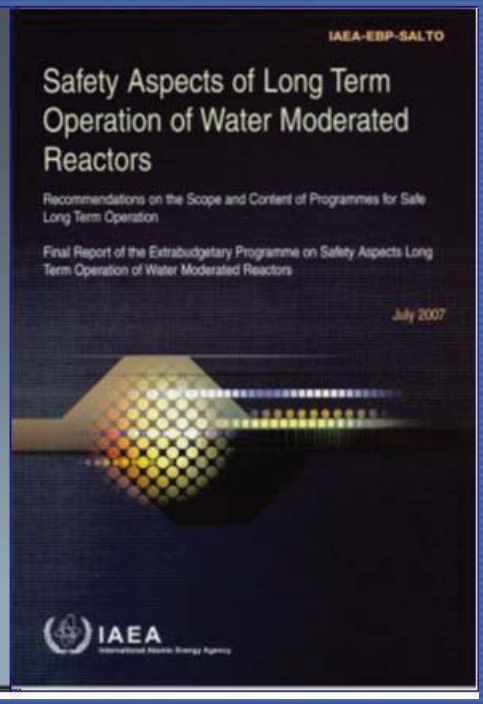
Basic documents used for SALTO Peer Review

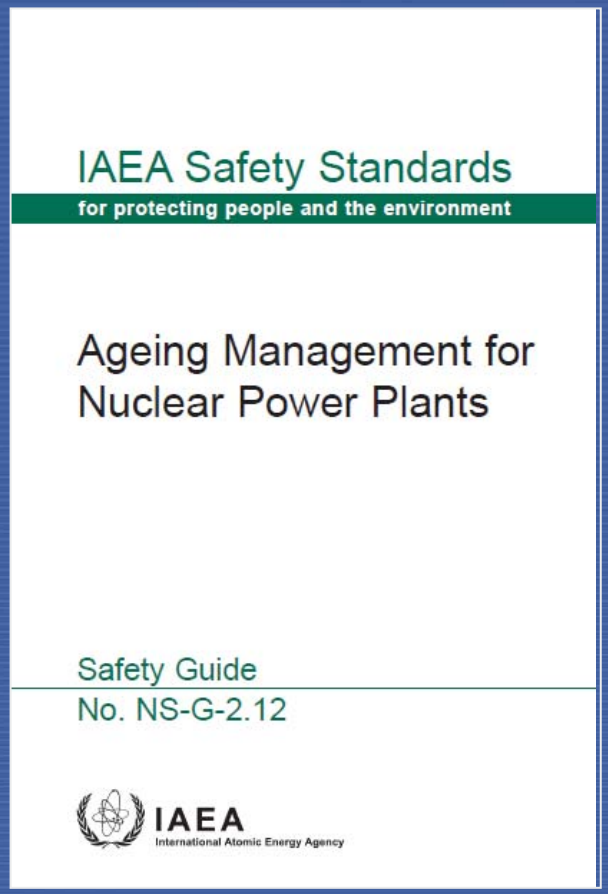
- **Safety Guide : NS-G-2.12, Ageing Management for NPPs (2009)**
- **Safety Report : SRS- 57, Safe Long Term Operation of NPPs (2008)**
- **Safety Series : SS-17, SALTO Guidelines for peer review of LTO (2008)**
- **Safety aspects of long term operation of water moderated reactors (2007)**







Safety Guide on Ageing Management



- **Objective**
  - To provide a set of guidelines and recommendations for managing ageing of Systems Structures and Components (SSCs) important to safety in nuclear power plants.
- **Scope**
  - Structures, Systems and Components in NPPs
  - Mainly focused on physical ageing but also includes management of obsolescence

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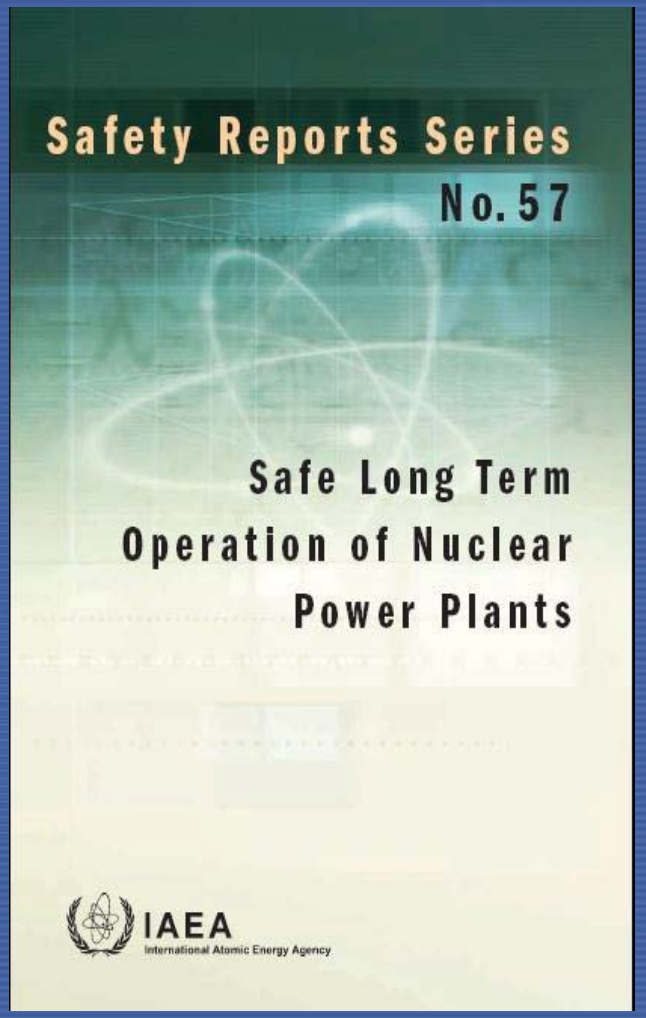
Safety Report No. 57
"Safe Long Term Operation of Nuclear Power Plants"

- Report provides information on key technical considerations and activities to ensure safe LTO of NPPs in accordance with regulatory requirements
- Supports operating organizations in demonstrating the safety of their NPPs during LTO
- Supports regulatory bodies in verifying LTO safety



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SALTO peer review - guideline

- Aims to provide a basic structure and common reference across the various areas covered by a SALTO peer review mission
- Initially developed for SALTO peer review team members, but also provides guidance to a host organization in preparation to a peer review mission

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Standard SALTO Peer Review scope

- **Organization and functions** - Plant policy (LTO, scope of SSCs for LTO), plant implementation programme for LTO
- **Configuration / Modification** management
- **Current safety analysis report** and **PSR (periodic safety review)**
- **Existing plant programmes** relevant to LTO (Maintenance, Equipment Qualification, Surveillance and Monitoring, etc.)
- **Review of ageing management** programmes, scoping and screening of SSCs for LTO

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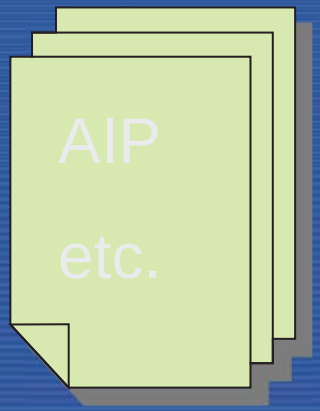
SALTO Peer Review - Methodology

The SALTO peer review team uses four steps to acquire the information needed to develop their recommendations, as set out in the expert's technical notes:

1. Review of written material (Advanced Information Package and NPP documents and procedures)
2. Discussions with counterparts
3. Direct observation of SSC status, environment
4. Discussion of evaluations/tentative conclusions with counterparts



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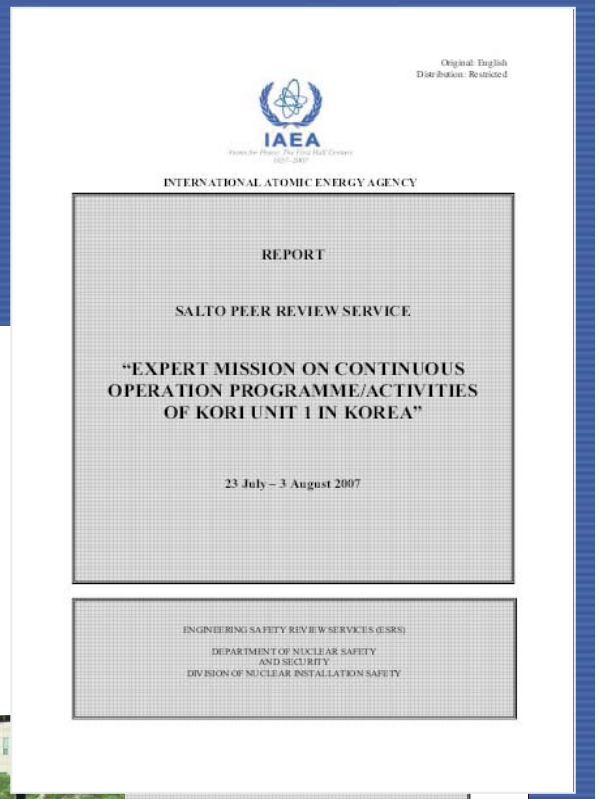
Mission Report Structure

A preliminary report is issued at the end of the mission contains mainly the following chapters:

- Summary information on nuclear power plant
- Objectives and scope
- Conduct of the mission
- Main conclusions and recommendations
  - specific recommendations/suggestions
  - good practices and performance
- Assessment of the safety issues
- Presentation and treatment of the safety issues
- Appendix - Issue Sheets

(basis for follow-up mission)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Distribution: Restricted

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INTERNATIONAL ATOMIC ENERGY AGENCY

REPORT

SALTO PEER REVIEW SERVICE

"EXPERT MISSION ON CONTINUOUS OPERATION PROGRAMME/ACTIVITIES OF KORI UNIT 1 IN KOREA"

23 July – 3 August 2007

ENGINEERING SAFETY REVIEW SERVICES (ESRS)

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
DIVISION OF NUCLEAR INSTALLATION SAFETY

Paks Nuclear Power Plant, Hungary
4 – 7 December 2006

ENGINEERING SAFETY REVIEW SERVICES (ESRS)
ducted under IAEA Technical Cooperation Project ARM/9/014
Strengthening of the Armenian Nuclear Regulatory Authority"

MENT OF TECHNICAL COOPERATION
vision for Europe

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
Division of Nuclear Installation Safety

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SALTO peer review missions performed

- Paks NPP – Limited and full scope (Hungary, 2005 – 2011)
- Karachi NPP – Limited scope (Pakistan, 2007)
- South Ukraine NPP – Limited scope (Ukraine, 2007)
- Kori 1 NPP – Full scope (Republic of Korea, 2007)
- Dukovany NPP – Limited scope (Czech Republic, 2008)
- Borssele NPP - Limited scope (the Netherlands, 2009)
- Kori 1 NPP – Follow-up (Republic of Korea, 2010)
- Koeberg NPP - Limited scope (South Africa, 2011)
- Dukovany NPP – Follow-up (Czech Republic, 2011)
- Borssele NPP – Full scope (the Netherlands, 2012)
- Wolsong 1 NPP – Full scope (Republic of Korea, 2012)
- Tihange 1 NPP – Limited scope (Belgium, 2012)
- Bohunice NPP - OSART module (Slovakia, 2011)
- Muhleberg NPP - OSART module (Switzerland, 2012)

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Planned SALTO missions for 2013

Country	Type/Date	Plant
Hungary	SALTO follow-up April 2013	Paks 1-4
Brazil	SALTO limited scope April 2013	Angra 1
Armenia	SALTO limited scope May 2013	Armenian NPP 2
South Korea	SALTO follow-up November 2013	Wolsong 1
The Netherlands	SALTO follow-up December 2013	Borssele

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Thank you for your attention!

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