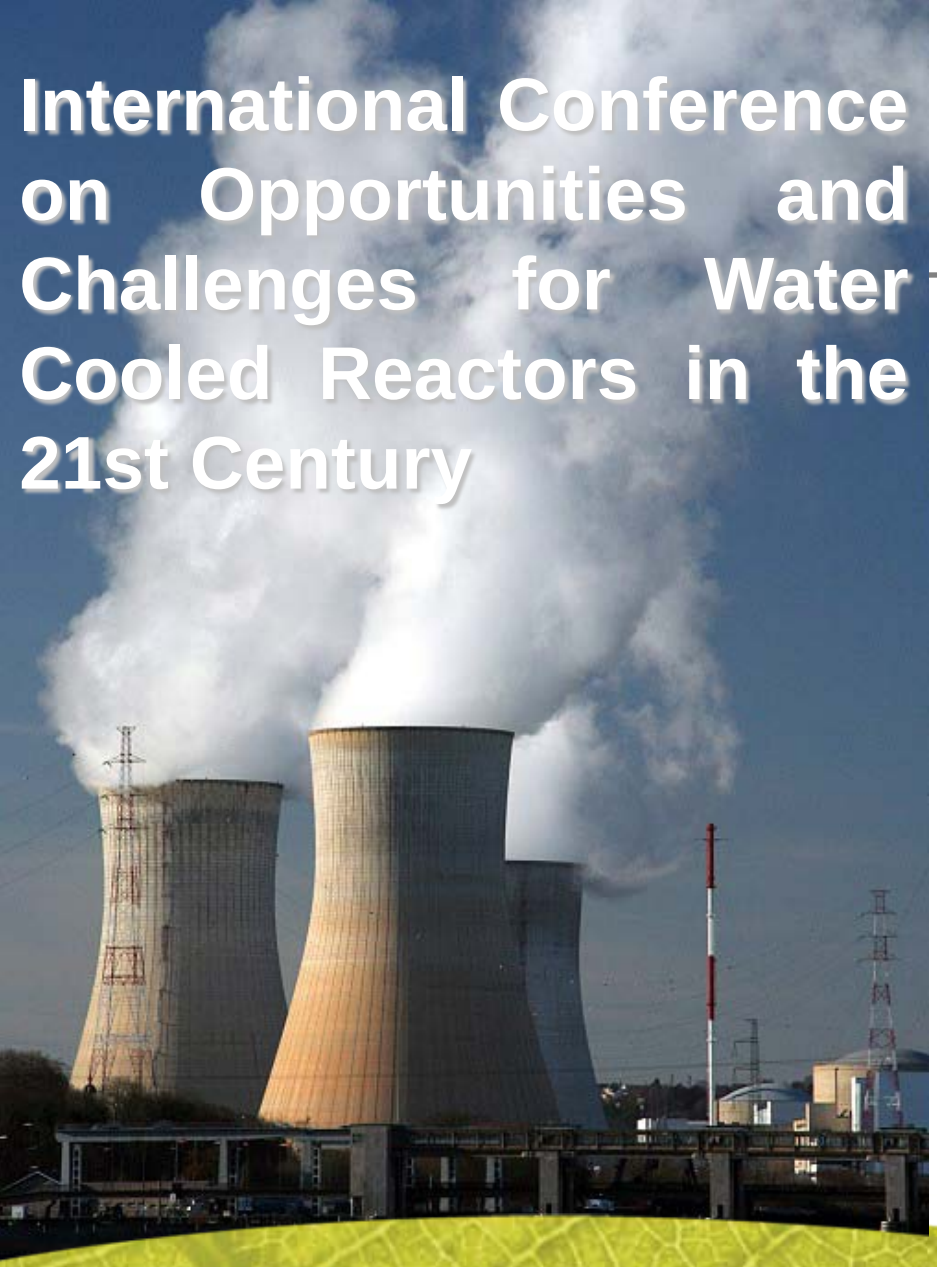

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Long-Term Ageing Management Strategies for Nuclear Power Plants

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Pre-LTO Operator's Ageing Management Practices

Current process and activities that can be credited with managing ageing:

- **Commitments to specific regulations**

  e.g. Reactor Vessel Material Surveillance Program, Environmental Qualification

- **Codes, Standards, Best Practices**

  e.g. In-Service Inspection (ASME Section XI)

- **Operating Experience**

  e.g. Alloy 600 PWSCC

Pre-LTO Operator's Ageing Management Practices

Achievements:

- Has served nuclear power industry well since start-ups and will continue to do so

Limitations:

- Does not meet current ageing management standards for long-term operation specified for License Renewal and Periodic Safety Reviews
- Gaps exist in the ageing management of some important systems, structures, and components (missing programs, SSC's subject to ageing and not covered, out-dated techniques used etc.)

Long-Term Ageing Management Strategies

To confirm existing management is sufficient and/or identify Gaps, several methodologies have been developed:

- **Experienced-based methodologies**
- **Regulatory-based methodologies**
- **Economic-based methodologies**

Experience-Based Ageing Management

Method used since the birth of the nuclear industry which relies on:

- **Preventive Maintenance and Corrective Action Process**

  Regulated from the 1990s onward by the Maintenance Rule in the US

- **Information Sharing**

  Informal or formal through owner's groups, industry message boards, BWR Vessel Inspection Program (VIP), PWR Materials Reliability Program

Experience-Based Ageing Management

Limitations:

- **Example of the Alloy 600 PWSCC Issue**

  This approach can lead the industry to be in a reactive mode instead of adopting a comprehensive and systematic approach and develop inspection and mitigation plans to control events.

- **Not to be used as a single strategy but as a step in more global approaches**

  Not sufficient to meet the LTO challenges.

Regulatory-Based Ageing Management

Rules-driven Practices and recent Plant Life Extension or License Renewal Requirements:

- **Rules Driven Practices**

  Early years of the nuclear industry, the law imposes the use of Codes and Standards (Construction Codes – In-service Codes). Based on operational experience, additional regulations were introduced, e.g. Environmental Qualification after Three-Mile Island.

Limitations:

Becomes less effective as plants get older…

Regulatory-Based Ageing Management

To answer the challenges of Long Term Operation, more recent regulations have been developed:

- **License Renewal Rule + Maintenance Rule**
- **Periodic Safety Review and AIEA Guidelines**

Regulatory-Based Ageing Management

US Regulations:

- **Maintenance Rule [10 CFR 50.65]**

Monitor the performance or condition of certain systems, structures, and components (SSCs), against licensee-established goals, to provide reasonable assurance that those SSCs are capable of fulfilling their intended functions.

- **License Renewal Rule [10 CFR 54]**

Demonstrate you can effectively manage the ageing of certain (SSCs) so that their safety functions will continue to be performed during the period of extended operation.

Regulatory-Based Ageing Management

License Renewal Rule focuses on the following three areas:

(1) Integrated plant assessment to evaluate the ageing management of passive, long lived systems, structures and components to ensure that they can support continued safe plant operation beyond the 40 year term of the original operating license and remain within the safety requirements;

(2) Assessment of Time Limited Ageing Analyses TLAA (e.g. fatigue, neutron embrittlement, environmental qualification analysis) to address the additional 20 years of operation;

(3) Environmental impact assessment of the additional 20 years of operation

Regulatory-Based Ageing Management

- **License Renewal Rule**
  - Safety Related SSCs
  - Non-Safety SSCs which could impact safety related SSCs
  - Equipment used for regulated events (e.g. station blackout)
  - Requires Ageing Management Review for long-lived, passive components
  - Includes ageing management programs
- **Maintenance Rule**
  - Safety Related SSCs
  - Non-Safety SSCs which could impact safety related SSCs
  - Equipment used in Emergency Operating Procedures
  - Equipment whose failure could cause a scram
  - Requires monitoring the performance or condition of SSCs (active & passive)

Regulatory-Based Ageing Management

- **License Renewal Rule**
  - Ageing Management Programs look at components, environments and degradation mechanisms
- **Maintenance Rule**
  - Licensee establishes performance goals consistent with safety
  - If SSC performance or condition does not meet the goal, corrective action is required
  - Performance often measured at the system level, for example the Emergency Diesel Generator and Not the components of the EDG

Regulatory-Based Ageing Management

There are two basic technical activities performed for ageing management

- Perform an Integrated Plant Assessment (Scoping/Screening and Ageing Management Reviews)
- Evaluate Time-Limited Ageing Analyses (TLAAs)

Regulatory-Based Ageing Management

Ageing management process steps include:

- Identify components to be assessed from existing equipment list (SR, NSR supporting SR, regulated events or important to safety classifications)
- Determine component materials of construction
- Identify environments in which these components reside
- Determine the ageing effects for material/environment combinations
- For all components and all ageing effects, confirm that programs exist that manage ageing; or develop new programs or modify existing programs
- Validate results with plant-specific and industry operating experience.

Regulatory-Based Ageing Management

LR Process results: A confirmation of existing programs

- In-Service Inspection (Code-required Inspections)
- Water chemistry monitoring
- Flow-accelerated corrosion monitoring

Gaps leading to modified or new programs

- Underground piping inspections
- Structures and structural components inspections
- Cables and connections inspections

Over half of the US fleet has successfully justified plant operation for 20 additional years following that LR rule

Regulatory-Based Ageing Management

PSR and IAEA Safety Guide No. NS-G-2.10 contains standards

- Section 4.7; Age related degradation mechanisms that could lead to failure of key SSCs should be identified.
- Section 4.16; SSCs important to safety should be assessed against design basis to confirm that ageing has not significantly undermined the design basis assumptions
- Section 4.21; Determine whether ageing is being effectively managed so that required safety functions are maintained and whether an effective ageing management program is in place for future plant operation

Regulatory-Based Ageing Management

LR and PSR-IAEA Processes are compatible, the methodology presented here is a generic methodology, examples are:

- NEK Krsko in Slovenia has implemented ageing management in accordance with PSR commitments (Safety Guide NS-G-2.10 and Safety Reports Series No. 57). This utility made a commitment (with Regulatory body concurrence) that processes implemented under 10 CFR 54 meets the intent of the PSR.
- This process has been also applied in Spain, another European utility (representing seven plants) is presently in the process of implementing the same process on passive components and evaluating methodologies for active components (Exceeds initial operating term in 2015).

Economic-Based Ageing Management

Optimizing the economics of plant-wide ageing management decisions (timing and strategies) to minimize unplanned costs and maximize revenue under budget constraints:

- A Proactive Asset Management (PAM) and evaluation process is performed and consists of: a screening of SSC's, the identification of AM mechanisms and programs, Data collection and definition of desired alternatives (Proactive replacement, spares policy, improved condition monitoring etc.)
- The development of PLIM plans for the important plant components and structures (optimum timing, cost effective condition monitoring, sensitivity).
- The optimization of the PLIM plans at the system or plant level that maximizes the revenue when remaining constrained by a given budget per year.

Economic-Based Ageing Management

Regulatory-based approach can be complemented by a Proactive Asset Management and Plant Life Management Optimization for integrating both the important to safety and important to power production SSCs in one single and comprehensive approach.

Economic-Based Ageing Management can be also applied to specific issues or components, e.g. Alloy 600 Decision Advisor

Questions

Thank You