Koeberg Nuclear Power Station: Plant Life Extension and Ageing Management

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Topics to be covered

- Brief Description
- Global Trends in Nuclear Power
- Periodic Safety Re-Assessment
- Life Extension Modifications
- Ageing Management
- Ageing Management Matrix
- References for identifying Ageing
- Long Term Operation Initiatives
Brief Description (Koeberg)

- 2 x 2775 MW Pressurized Water Nuclear 3 Loop Reactors (PWR)
- Nuclear Steam Supply Systems (NSSS) constructed by Framatome, now AREVA
- ASME III Design
- 2 x 975 MW Electrical with house load consumption 45MW
- Conventional Plant constructed by Alstom
- Original 40 year design assumption

- Original Design assumed a 40 year operational life.

Good operational and maintenance practices has allowed for the assumed life to be extended to 60 years.
The Koeberg Plant Design Consists of 3 main areas to be considered:
- Conventional Plant
- Nuclear Plant
- Emergency Systems

- The used nuclear fuel has to stay on site for 5 to 15 years after shut down.
- The operational life of some parts of the Nuclear plant will therefore be extended to 75 years.

In 2010 Eskom Board approved Business Case for Extending Koeberg Life to 60 years
Global Trends in Nuclear Power

- 225/435 NPPs have been in operation for more than 30 years and 63 for more than 40 years (as of 2014)*

* Source: http://www.iaea.org/pris
Extending plant life is considered in two areas:

1. **Updates to the design**
   - Original Koeberg design was approved by the regulator.
   - Regulator approves all changes to the design.
   - Design has to be updated for extending the life of the plant.
   - Regulator has to approve all Time Limited Ageing Analysis (TLAAs) as part of the design update.

2. **Ageing Management**
   - Regulator has continuous oversight of ageing management processes.
   - Some ageing management processes are approved by the regulator.
   - Plant requires regulatory approval for startup at the beginning of each cycle.
   - This approval includes assurance that ageing has been addressed.
Periodic Safety Re-Assessment

- Koeberg is compared against the EDF reference plant.
- 1<sup>st</sup> Safety Reassessment was performed and implemented.
- 2<sup>nd</sup> Safety Reassessment was performed and is in the process of being implemented.
- External Events Safety Reassessment was performed with implementation starting.
- The resultant modifications are implemented as part of the strategy of continued improvement in safety and to maintain alignment to international standards.

After Fukushima, NNR Instructs External Event PSR
Life Extension Modifications

• Only modifications that result in once off intervention to operate beyond 40 years are considered to be associated with Plant Life Extension.

• Anticipated once off interventions:
  o Steam Generator Replacement (In Progress)
  o Refueling Water Tank Replacement (In Progress)
  o Reactor Vessel Head Replacement
  o Control Rod Drive Mechanisms
  o Switchboards Replacement
  o Condenser Tube Replacement
  o Feed heater Replacement
  o Power Cable Replacement
Ageing Management

- Ageing Management considerations start at design stage – specific intention (40yrs)
- Designer builds in measures to counter known and potential degradation:
  - Material selection
  - Provides maintenance/operations instructions (analysed envelopes)
  - Monitoring suggestions
  - Required Plant Programmes (minimum)
During the life of the plant, operators and utilities:

- Respect the design and operating envelopes
- Perform testing and monitoring
- Identify operational deficiencies (unknown at design)
- Investigate operating experience (OE) - Internal and External
- Adjust design and operating envelopes
- Adjust the monitoring and establish additional ageing management programmes
- Perform plant modification

At about midlife questions start:

⇒ Asset management – Are we going to make it?
⇒ Life extension – Additional requirements to operate beyond the assumed life?
To answer the questions we respond in two ways:

1. **Strategic Objectives as per:**
   - Nuclear Licence
   - Corporate directives & policies
   - International Clubs
   - Nuclear Safety
   - Economics
   - Lifetime (40yrs, plan for 60)
   - Environmental impact
2. Determine Actual Limitations

- Worldwide this is needed for asset management purposes as well as regulator demands

- Two broad approaches have been identified:

**USA**
- Ongoing operational regulator requirements (including maintenance rule)
- **Passive equipment review**

**IAEA/European**
- Comprehensive degradation review (includes active & passive components)
- Regular Periodic Safety Re-Assessments
- Operating Experience
Ageing Management cont..

Time
1984/5

Original Intent

PSR ↓

Now ↓

2025
(40y)

2045
(60y)

Design description
SAR/DSE

AMP
Confirms all degradation catered for

Comparison with actual plant

Operations
Procedures / OTS

→ Ongoing Improvement

Maintenance & Monitoring
Maintenance Bases
ISI / IST

Transients
FAC
BAC
SRSM
Etc.

→ Ongoing Comparisons & Improvement

Aspects linked to:
1. Nuclear Safety
   verified by 10yr SRA
2. Production
   CURA/ NEXCO

→ Need specific intervention

PLEX Business case:
Already Identified replacement of expensive equipment e.g. SG, PTR & RPVH plus others as per Life Of Plant Plans

Can continue without intervention, risk is with Eskom (financial)
Specific Intervention Options

A. US based
   Try to emulate US by adapting Licence Renewal Process
   1. Continue all programmes
   2. Review EPRI IMT & GALL
   3. Compile a LR application
   4. Commit to some replacements and resolutions plus new programmes (e.g. Maintenance Rule)

B. European Based (Recommended)
   Perform Special PSR as per IAEA guidance that covers:
   1. Plant Design
   2. Actual condition of SSCs
   3. Environmental Qualification
   4. Ageing management
   5. Deterministic Safety Analysis
   6. Probabilistic Safety Assessment (PSA)
   7. Hazards
   8. Safety Performance
   9. Operating Experience (OE)
   10. Organisation plus Admin
   11. Procedures
   12. Human factors
   13. Emergency Plan
   14. Radiation Protection

C. Unique
   Develop unique suite of requirements with NNR (can use various inputs e.g. EDF VD series)

Will require special in-depth review and justification plus studies
Ageing Management Matrix

• The Ageing Management Matrix (AMM) contains a list of structures and components (SCs) and the ageing mechanisms applicable to the components.

• The EDF ageing matrix was used to derive the initial Koeberg AMM.

• An assumption was made that for the initial matrix, the ageing concerns of EDF and Koeberg are similar enough to adopt and allow for adaptation to the Koeberg AMM.

• The AMM is continuously updated when new international or internal ageing concerns are identified.

• Where the ageing degradation mechanism is not addressed a gap is identified and tracked until resolution.
Ageing Management Matrix cont..

Ageing Management Programme (AMP)
• Establish if adequate measures are in place to manage the identified ageing
• Determine inspection, monitoring, justification by analysis, maintenance, testing, replace, etc.
• Track "gaps" where ageing is not being sufficiently managed

Disposition (Engineering Position Paper)
• Documents specific ageing and integrity concerns and adopted strategy.
• Identifies intended actions to achieve accepted objective.
• Document items that do not require further evaluation as there are no ageing concerns.

Time Limited Ageing Analysis (TLAA)
• Documents the Assumptions and Subsequent Calculations to conclude on Integrity.

Nuclear Technical Plan (NTP)
• Specifies the Replacement and Refurbishment Projects.
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<th>Organization</th>
<th>Details</th>
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| EDF          | - Koeberg reference plant  
              - Alignment with EDF Ageing Matrix |
| IAEA         | - Industry Links and proven practices  
              - IGALL used for validation of AMM and AMPs |
| FROG         | - OEM (Hosted by Framatome, now AREVA)  
              - All AREVA constructed plants participate |
| PWROG        | - Technology Reference  
              - Most utilities operating PWRs participate |
| EPRI         | - Science Links  
              - Many utilities across the world contribute |
Long Term Operation (LTO) Initiatives

- **Pre-SALTO Mission 1**
  - 2015
  - LTO Process Consolidation
  - LTO Project Planning
  - Policy Documents

- **Scoping**
  - 2016
  - Pre-SALTO Mission 2

- **Screening**
  - 2017

- **Updating Time Limited Ageing Analyses (TLAAs)**
  - 2018

- **NNR Review**
  - 2019

- **Comment Resolution**
  - 2020

- **End of Current Design Life**
  - 2024

- **Performing Inspections**
  - 2025

- **Upgrading Existing Programmes**
  - 2023

- **Analysis**
  - 2022

- **Follow-Up SALTO Mission**
  - 2021

- **SALTO Mission**
  - 2020

- **Pre-SALTO Mission 2**
  - 2019

- **SALTO Mission**
  - 2018

- **Pre-SALTO Mission 1**
  - 2017

- **Pre-SALTO Mission 2**
  - 2016

- **Pre-SALTO Mission 1**
  - 2015
THANK YOU