Ageing Management and Long Term Operation of NPP Borssele

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Topics

• Facts about NPP Borssele
• Current status of LTO: license
• Major upgrades
  • Safety upgrades from PSRs
  • Other important upgrades
• Ageing Management review in last PSR
• LTO activities
Facts about NPP Borssele

• 2-loop PWR designed and built by Siemens Kraftwerk Union (German company, now part of AREVA-NP)
• Construction started in 1969
• Commercial operation since 1973
• Gross capacity 515 MWe (1365 MWth): October/November 2006 uprating 482 to 515 MWe by replacing turbine rotors and water separators
• Design operating life: 40 years (2013)
• 1 year cycle
• Mean load factor until now: 0.82, last years above 0.94
  Tendency towards shorter outages (< 2 weeks)
Current status of LTO: license aspects

- 1973: NPP Borssele in commercial operation: operating license without an end date
- 1994: political agreement closing NPP Borssele in 2003
- 1994-2006: lawsuits and political discussions about closing date of NPP Borssele, no end of license date (politics: 2013?, EPZ: why?)
- 16 June 2006: The Borssele Agreement:
  ✓ NPP may operate until 2034 (60 years of operation)
  ✓ NPP should be among the 25% safest Western water cooled NPPs
  ✓ Immediate dismantling after closure
  ✓ Shareholders will invest 250M€ in renewable energy projects
  ✓ The government will invest another 250M€ in renewable energy projects
- From 30 to 40 to 60 years perspective in only a few years time!
- PSR regime: every ten years a Periodic Safety Review: no specific regulator policy on LTO
1. First ‘PSR’: Safety evaluation performed during 1982 – 1985 based on Post-TMI (Harrisburg) discussions

   Backfitting Note Dutch Nuclear Regulatory Body (KFD):
   ⇒ PSR regulation (reviewing against state of the art)


Safety upgrades 1982-1985

Major:
Implementation of 2-train autonomous (10h) bunkered make-up and decay heat removal system

Other upgrade examples first ‘PSR’:
• Automatic test facility reactor protection system
• Modernization fire detection system
• Implementation accident and post-accident instrumentation
• Introduction of Westinghouse symptom based emergency procedures
• Installation active H2-recombiner
Major safety upgrades implemented in 1997:
New emergency diesels in a new separated building
Major safety upgrades implemented in 1997:

- Replacing the primary safety valves by Sebim tandem relief valves directly mounted on pressurizer dome (feed & bleed during severe situations)
Major safety upgrades implemented in 1997: A new control room
Other safety upgrades implemented in 1997:

- Additional bunkered building accommodating the reactor protection system
- New batteries with increased capacity
- Deep well system for long term cooling
- Seismic supports
- Leak before Break: new steam- and feedwater piping
- H₂-mitigation: passive cathodic recombiners
- Containment pressure relief system (filtered venting)
- Back-up control room and simulator
Major upgrades because of material degradation:

- Erosion-corrosion in steam-water systems in early years: several replacements and repair actions:
  - Heat exchangers
  - Valves
  - Some turbine blades
  - Piping

- In 1982 a big improvement was made by replacing the Cu-Ni condenser by a Ti condenser, the chemistry could be changed from phosphate chemistry to AVT chemistry: wastage of steam generator tubes stopped changed
Other upgrades because of material degradation

- Embrittlement of wires (spreader cabinet): in 1997 about 7700 wires were replaced: ‘the red wire project’

- RPV-internals: replacement of several Inconel X-750 baffle-former bolts due to cracking (IGSCC)
Major upgrades in outage 2006

• Replacement of generator stator due to damage as a result of short circuits in the external grid

• New turbine rotors with higher efficiency and a new water separator:
  → 35 MWe Power Uprate
A changing view on Ageing Management (1995….)

- International awareness of the importance of good ageing management at NPPs
- IAEA guidelines on ageing management
- NPP Borssele: a new license after the 1997 back-fitting project with a requirement on ageing management demanded by the regulator
- Specific attention on ageing and ageing management in the PSR

😊 AM is not a new thing! The way how to do it is new.
Activities in AM after 1998

- AM studies:
  - report on ageing issues
  - interviews with experienced engineers
- implementation of ageing management team
- program for AM experience feedback
- development of AM database (experience feedback database)
- active involvement in several international projects/groups on AM (IAEA, VGB, OECD..)
- PSR (1993-2003) with special project on AM
- AMAT review 2003
AM experience feedback system

Operational processes:
- Procescontrol
- Chemistry

In-Service Inspection

Periodic Testing

Surveillance

Maintenance

Aging Knowledge

Aging Evaluation

External Knowledge and Experience
Specific project for review of AM:

- Screening for long living passive SSC (systems, structures or components) important to safety
- Ageing Management Review of long living passive SSC (RPV, primary piping, containment, SG’s, buildings…)
- Comparing AM at KCB to latest IAEA guidelines and best practices
Results SSC studies

• Most SSC in good condition: operation until 2013 is no problem
• Some issues:
  ➢ More study on irradiated assisted ageing for RPV internals
  ➢ Some repair actions on important buildings (coating outside)
  ➢ Some further repair on underground cooling water piping
Objective to make an independent review of:

- The ageing management system
- The assessment of the ageing status of SSC important to safety (done for the PSR)

Results:

- according to AMAT team the SSC are, in general, in good condition and NPP Borssele has established a working Ageing Management System
- recommendations and suggestions for further improvement of the existing ageing management
- Identification of some good practices (e.g. the used AM database)
LTO-activities

- Feasibility study on ageing management investments for 60 years
  - Safety and economics (PLIM)
  - Physical ageing and technological ageing (obsolescence)
  - All SSC involved
  - No detailed assessments: a general engineering view to determine financial consequences of LTO
  - Performed by AREVA in strong cooperation with EPZ-specialists
General results of study

- No replacements of major primary circuit components necessary since e.g.
  - Sufficient safety margins regarding RPV embrittlement
  - Appropriate SG tube behaviour without PWSCC
- Civil structures are well maintained and repair programs have been performed
- Some components need extra spares: e.g.
  - Heater rods pressurizer
  - CRDM’s
- Some BOP heat exchangers need to be replaced
- Major replacements of I&C necessary due to obsolescence
- Scope of investments no threat for economical LTO!
Urgent LTO-activities on safety

• Update of Ageing Management Review
  Reviewing potential ageing issues relating to 60 years of operation (next PSR and partly in progress)

• Update/renewal of Time Limited Ageing Analyses (TLAA’s)
TLAA’s: main topics

- RPV embrittlement, current TLAA comprises 40 years of operation
  - New surveillance program starting next outage
  - State of the art: both old (Charpy-V/RT_NDT) and new concept (fracture toughness/Master Curve)
  - Two new sets of irradiated capsules + new set of unirradiated specimens
- Fatigue assessments of components important to safety, current TLAA’s comprise 40 years
  - Implementing new monitoring systems to determine realistic P,T transients
  - New state of the art fatigue assessments
- Environmental Qualification of E&I components
  - Database with residual lifetime calculations of comp’s
  - Implementing monitoring systems for monitoring environmental loads
Thank you for your attention!