Ageing Management for the Full Life Cycle of NPPs

DOU, Yikang
SNERDI

3rd WNA Regional Workshop on Technical and Regulatory Issues Facing Nuclear Power Plants – Leveraging Global Experience
May 15-16, 2018, Shanghai, China
This document is the property of and contains proprietary information owned by SPIC and/or its related proprietor. You agree to treat this document in strict accordance with the terms and conditions of the agreement under which it was provided to you. No disclosure or copy of this document is permitted without the prior written permission of SPIC.
Contents

I. A glance of China nuclear power plants

II. Safety aspects of NPPs’ full life cycle of AM

III. SNPTC’s practice
1 A glance of China nuclear power plants

- Up till now, the mainland of China has 38 NPP units in operation and 18 units under construction.
- All NPP units, either in operation or under construction, are in sea coast, the most developed area and relatively remote from coal mine areas.
- Nuclear power is approximately 3% of the total energy power.
- Chinese Government promised in 2015 in Paris Agreement on Climate Change that by the year 2030, the percentage of non-fossil energy in China should reach as high as 20%.

Conclusion: Nuclear power is an irreplaceable choice to reduce greenhouse gas and to realize clean energy, however, we need strengthening the cost-benefit of NP.
## A glance of China nuclear power plants - a list of operating NPPs

<table>
<thead>
<tr>
<th>NPP</th>
<th>Owner</th>
<th>Type</th>
<th>Power(MWe)</th>
<th>FCD (1st unit)</th>
<th>Date of connecting to grid (1st unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qinshan 1</td>
<td>CNNC</td>
<td>PWR</td>
<td>310</td>
<td>1985-03-20</td>
<td>1991-12-15</td>
</tr>
<tr>
<td>Daya Bay</td>
<td>CGN</td>
<td>PWR</td>
<td>2x984</td>
<td>1987-08-07</td>
<td>1993-08-31</td>
</tr>
<tr>
<td>Qinshan 2</td>
<td>CNNC</td>
<td>PWR</td>
<td>2x650+2x660</td>
<td>1996-06-02</td>
<td>2002-02-06</td>
</tr>
<tr>
<td>Ling’ao</td>
<td>CGN</td>
<td>PWR</td>
<td>2x990+2x1086</td>
<td>1997-05-15</td>
<td>2002-02-26</td>
</tr>
<tr>
<td>Qinshan 3</td>
<td>CNNC</td>
<td>CANDU</td>
<td>2x728</td>
<td>1998-06-08</td>
<td>2002-11-19</td>
</tr>
<tr>
<td>Tianwan</td>
<td>CNNC</td>
<td>WWER</td>
<td>2x1060+1x1126</td>
<td>1999-10-20</td>
<td>2006-05-12</td>
</tr>
<tr>
<td>Ningde</td>
<td>CGN</td>
<td>PWR</td>
<td>4x1086</td>
<td>2008-02-18</td>
<td>2012-12-28</td>
</tr>
<tr>
<td>Hongyanhe</td>
<td>CGN/SPIC</td>
<td>PWR</td>
<td>4x1119</td>
<td>2007-08-18</td>
<td>2013-02-17</td>
</tr>
<tr>
<td>Yangjiang</td>
<td>CGN</td>
<td>PWR</td>
<td>4x1086</td>
<td>2008-12-16</td>
<td>2013-12-31</td>
</tr>
<tr>
<td>Fuqing</td>
<td>CNNC</td>
<td>PWR</td>
<td>4x1089</td>
<td>2008-11-21</td>
<td>2014-08-20</td>
</tr>
<tr>
<td>Fangjiashan</td>
<td>CNNC</td>
<td>PWR</td>
<td>2x1089</td>
<td>2008-12-26</td>
<td>2014-11-04</td>
</tr>
<tr>
<td>Fangchenggang</td>
<td>CGN</td>
<td>PWR</td>
<td>2x1086</td>
<td>2010-07-30</td>
<td>2015-10-25</td>
</tr>
<tr>
<td>Changjiang</td>
<td>CNNC</td>
<td>PWR</td>
<td>2x650</td>
<td>2010-04-25</td>
<td>2015-11-07</td>
</tr>
</tbody>
</table>

**Total:** 36933/38
<table>
<thead>
<tr>
<th>NPP</th>
<th>Owner</th>
<th>Type</th>
<th>Power (MWe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hongyanhe</td>
<td>CGN/SPIC</td>
<td>PWR</td>
<td>2x1119</td>
</tr>
<tr>
<td>Fuqing</td>
<td>CNNC</td>
<td>PWR (Hualong 1)</td>
<td>2x1089</td>
</tr>
<tr>
<td>Yangjiang</td>
<td>CGN</td>
<td>PWR</td>
<td>2x1086</td>
</tr>
<tr>
<td>Sanmen</td>
<td>CNNC</td>
<td>PWR (AP1000)</td>
<td>2x1250</td>
</tr>
<tr>
<td>Haiyang</td>
<td>SPIC</td>
<td>PWR (AP1000)</td>
<td>2x1250</td>
</tr>
<tr>
<td>Taishan</td>
<td>CGN</td>
<td>PWR (EPR)</td>
<td>2x1750</td>
</tr>
<tr>
<td>Fangchenggang</td>
<td>CGN</td>
<td>PWR (Hualong 1)</td>
<td>2x1080</td>
</tr>
<tr>
<td>Shidaowan</td>
<td>CHNG</td>
<td>HTR-PM</td>
<td>1x200</td>
</tr>
<tr>
<td>Tianwan</td>
<td>CNNC</td>
<td>WWER, PWR</td>
<td>1x1126, 2x1089</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>20752/18</strong></td>
</tr>
</tbody>
</table>
Contents

I. A glance of China nuclear power plants

II. Safety aspects of NPPs’ full life cycle of AM

III SNPTC’s practice
2 Safety aspects of NPPs’ full life cycle of AM

- In 2009 IAEA published a guidelines on “Ageing Management for Nuclear Power Plants” (NS-G-2.12), introducing concept of proactive AM.

- AM is not only required for operating stage, but also required for full life cycle stages of NPPs, including design, fabrication, construction, commissioning and decommissioning.

- In 2012, NNSA published safety guideline Ageing management for NPPs (HAD 103/12) based on the IAEA guideline NS-G2.12.
2 Safety aspects of NPPs’ full life cycle of AM

Reliability starts from design and is maintained throughout the full life cycle of NPP

Design

Construc
tion

operating

AMP (traditional understanding)

Operating within design life

OLE

Decommissioning plan

Decommissioning

PLEX Plan

Resource allocation: Screening; ageing mechanisms; ageing detection; ageing mitigation; ageing assessment; data collection and record keeping; impact of significant modification......

Maintaining availability of SSCs for decommissioning activities through AMP

EQ program; identifying ageing deg.; exp. Feedback; materials; monitoring; facilit. O&M; Ageing issues for FSAR

Data by vendors; exp. Feedback; baseline data; testing sampling; hot spots ident.; vib. monitoring

Resource allocation: Screening; ageing mechanisms; ageing detection; ageing mitigation; ageing assessment; data collection and record keeping; impact of significant modification......

Maintaining availability of SSCs for decommissioning activities through AMP

Reliability starts from design and is maintained throughout the full life cycle of NPP

PSAR

FSAR

PSR-1

PSR-2

......

PSR-n+1

PSR-n+m +D

app

app

©SPIC 2018. All rights reserved.
## 2 Safety aspects of NPPs’ full life cycle of AM

<table>
<thead>
<tr>
<th>Stage</th>
<th>Needs</th>
<th>Activities arouse from needs</th>
<th>Related technical support</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td><strong>EQ programme</strong></td>
<td>1) Design basis conditions for normal operation and DBA; 2) EQ requirements and document package</td>
<td>EQ activities based on design requirements to demonstrate qualification of all safety related equipment</td>
</tr>
<tr>
<td><strong>Identify and evaluate potential ageing mechanisms</strong></td>
<td><strong>Experience feedback</strong></td>
<td>A series of ageing mechanisms analysis reports as part of design documents</td>
<td>Analysis of potential ageing mechanisms based on material properties, environment conditions and loadings</td>
</tr>
<tr>
<td><strong>Online monitoring</strong></td>
<td><strong>Facilitate of inspection and maintenance</strong></td>
<td>To sensible ageing mechanisms, online monitoring should be considered in design</td>
<td>Establishment of various monitoring systems</td>
</tr>
<tr>
<td><strong>As a special topic for Final Safety Analysis Report (FSAR)</strong></td>
<td><strong>Explain AMP policies, EQ requirements, condition monitoring measures to safety regulatory during design stage</strong></td>
<td>Demonstration of accessibility and capability of maintenance</td>
<td>A series of additional technical support documents for FSAR</td>
</tr>
</tbody>
</table>
EQ Activities throughout whole life of NPPs

Design input
- Identifying PIEs
- Environmental conditions
- Safety functions
- Equip. list

EQ Implementation
- EQ Requirements and criteria, methodologies
- Programmes and procedures, QA...
- Identifying resources
- EQ implementation by test, analysis or the combination.
- Documentation

Maintaining EQ
- Control of maintenance
- Control of change
- Environment monitoring
- Degradation and failure analysis
- Experience feedback

Design and Construction stage

Operation stage

Feedback
2. Safety aspects of NPPs’ full life cycle of AM

Equipment Qualification Flowchart

- Project Requirements
- Regulatory/Licensing Requirements
- Quality Assurance Requirements
- Design Requirements
- Performance Specifications
- Acceptance Criteria
- Qualification Methodology
- Qualification Plan/Procedure
- Implementation of Qualification Plan / Procedure
- Topical Report EQ Methodology
- Qualification Documentation
- Equipment Qualification Verification and Maintenance
- Procurement Storage and Handling
- Installation and Operation
- Develop Surveillance and Maintenance Program
- Implementation of surveillance and Maintenance Program

Nuclear Power Plant Scope
## 2 Safety aspects of NPPs’ full life cycle of AM

<table>
<thead>
<tr>
<th>Stage</th>
<th>Needs</th>
<th>Activities arise from needs</th>
<th>Related technical support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabrication/Manufacture</td>
<td>Ageing effects being sufficiently taken into account in fabrication</td>
<td>1) Conveying ageing related factors to suppliers by purchaser; 2) In fabrication, ageing effects and related mitigation measures being sufficiently taken into account; 3) Designers may provide technical support regarding ageing analysis</td>
<td>Experiments on material properties; simulation of fabrication process; defect assessment; tolerance analysis; ageing mitigation measures</td>
</tr>
<tr>
<td></td>
<td>Baseline data collection and documentation</td>
<td>1) Baseline data being well kept and submitted to purchaser; 2) baseline data list and record keeping requirements provided by designer</td>
<td>Baseline specifications; database technique</td>
</tr>
<tr>
<td></td>
<td>Sufficient specimen used for ageing monitoring and evaluation based on design specifications</td>
<td>Surveillance and monitoring requirements given in design specifications by designer and followed by suppliers</td>
<td>Specimen program and utilization plans, such as RPV surveillance program</td>
</tr>
</tbody>
</table>
## 2 Safety aspects of NPPs’ full life cycle of AM

<table>
<thead>
<tr>
<th>Stage</th>
<th>Needs</th>
<th>Activities arouse from needs</th>
<th>Related technical support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioning</td>
<td>Systematic program as guideline for measuring and record keeping for ageing management related baseline data</td>
<td>In commissioning program, ageing management related data measuring and record keeping requirements should be brought into and implemented</td>
<td>Specific data needed, methodology on measurement and record keeping, acceptance criteria</td>
</tr>
<tr>
<td></td>
<td>Special attention for identification of temperature and irradiation hot spots and for measurement of vibration on piping and rotating components</td>
<td>Systematic investigation on hot spots; vibration measurement for safety related piping and rotating components; advanced record keeping systems</td>
<td>Identification of vibration limits; establishment of baseline for trend analysis</td>
</tr>
<tr>
<td></td>
<td>Baseline data are properly collected under critical conditions which are in conformance with design requirements. Installed equipment is in conformance with its EQ requirements.</td>
<td>Technical support materials be ready by operator for safety review; site reconfirmation being carried out during commissioning</td>
<td>For qualified equipment, carrying out walk down on site to reconfirm during commissioning</td>
</tr>
</tbody>
</table>
## 2  Safety aspects of NPPs’ full life cycle of AM

<table>
<thead>
<tr>
<th>Stage</th>
<th>Needs</th>
<th>Activities arouse from needs</th>
<th>Related technical support</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall AMP</td>
<td><strong>Needs</strong></td>
<td>Determination of AMP policies and resource allocation for related activities</td>
<td><strong>Related technical support</strong> <strong>SSC screening; ageing mechanism analysis;</strong></td>
</tr>
<tr>
<td>For any significant changes, ageing effects should be evaluated</td>
<td><strong>Needs</strong></td>
<td>Ageing effects to safety should be demonstrated for significant changes</td>
<td><strong>It should be demonstrated by TLAA that under new conditions of the changes, ageing effects has no significant impact to safety.</strong></td>
</tr>
<tr>
<td>For any new discovered ageing mechanisms, assessment should be performed in time</td>
<td><strong>Needs</strong></td>
<td>Ageing mechanism analysis based on current knowledge and experience feedback</td>
<td><strong>Analyze that the effects to safety by the new ageing mechanisms can be effectively controlled</strong></td>
</tr>
<tr>
<td>Pre-arranged plan being prepared based on experience feedback on significant ageing</td>
<td><strong>Needs</strong></td>
<td>Establishment and implementation of component or topic specific AMPs</td>
<td><strong>The AMPs should include ageing mechanism analysis, ageing evaluation, inspection, mitigation, etc.</strong></td>
</tr>
<tr>
<td>Spare parts management</td>
<td><strong>Needs</strong></td>
<td>Availability of spare parts and stock reservation method</td>
<td><strong>Demonstrate the availability of replacement parts</strong></td>
</tr>
</tbody>
</table>
## Significant ageing mechanisms - Reactor Pressure Vessel

<table>
<thead>
<tr>
<th>Degradation Locations</th>
<th>Corrosion</th>
<th>Fatigue</th>
<th>Irradiation</th>
<th>Fretting and Wear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core beltline region</td>
<td></td>
<td>environment fatigue</td>
<td>neutron irradiation</td>
<td></td>
</tr>
<tr>
<td>Stud bolts</td>
<td>boric acid corrosion</td>
<td>mechanical and thermal fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nozzle corner</td>
<td></td>
<td>mechanical and thermal fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRDM penetration</td>
<td>PWSCC</td>
<td>mechanical and thermal fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out surface of head</td>
<td>boric acid corrosion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottom head</td>
<td></td>
<td></td>
<td></td>
<td>wear induced by loose parts</td>
</tr>
</tbody>
</table>
## 2 Safety aspects of NPPs’ full life cycle of AM

### Significant ageing mechanisms - Steam Generator

<table>
<thead>
<tr>
<th>Degradation Sites</th>
<th>Erosion-Corrosion</th>
<th>Fatigue</th>
<th>Irradiation</th>
<th>Fretting and Wear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube to tubesheet crevices</td>
<td>ODSCC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube to support plate crevices</td>
<td>ODSCC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sludge pile</td>
<td>ODSCC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free span region of tubes</td>
<td>ODSCC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact region between tubes and anti-vibration bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact region between tubes and loose parts</td>
<td></td>
<td></td>
<td></td>
<td>fretting-wear</td>
</tr>
<tr>
<td>Feedwater nozzle, nozzle to piping welds</td>
<td>erosion-corrosion</td>
<td>high and low cycle fatigue</td>
<td></td>
<td>fretting-wear</td>
</tr>
<tr>
<td>Shell girth welds</td>
<td>SCC</td>
<td>Corrosion-fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedwater nozzle bore, blend radius, shell inside surface beneath the nozzle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J-tubes and feedring</td>
<td>erosion-corrosion</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2 Safety aspects of NPPs’ full life cycle of AM

RPV

SG

1. 主蒸汽出口管嘴
2. 二次侧入孔
3. 次级分离器甲板*
4. 次级分离器*
5. 初级分离器*
6. 水位管嘴（环向共25个）
7. 汽鼓
8. 初级分离器甲板*
9. 锥体
10. 应急给水管嘴（3英寸）
11. 孔（100mm）
12. 套筒（用于支承结构和包
13. 检查孔（75mm，3个）
14. 胶木机
15. 下简体
16. 备用支承附件（4个）
17. U形管（3530根）
18. 倒向支承附件（8个）
19. 孔（150mm，2个）
20. 孔（100mm，3个）
21. 给水管嘴
22. 撒管嘴（14个）
23. 一次侧隔板
24. 管板
25. 一次侧进口管嘴（2个）
26. 一次侧出口管嘴
27. 一次侧封头
28. 一次侧人孔（2个）
29. 工艺接头
30. 基座支承
*为蒸汽发生器内部部件，即非压力边界部件
### Significant ageing mechanisms - Reactor Internals

<table>
<thead>
<tr>
<th>Degradation Sites</th>
<th>Erosion-Corrosion</th>
<th>Fatigue</th>
<th>Irradiation</th>
<th>Fretting and Wear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core barrel</td>
<td></td>
<td>thermal stress, FIV</td>
<td>neutron irradiation</td>
<td></td>
</tr>
<tr>
<td>Formers and baffles</td>
<td></td>
<td>Thermal stress</td>
<td>irradiation swelling</td>
<td></td>
</tr>
<tr>
<td>Bottom-mounted instrumentation</td>
<td></td>
<td>FIV</td>
<td></td>
<td>fretting wear</td>
</tr>
<tr>
<td>Guide tube assembly</td>
<td></td>
<td>FIV</td>
<td></td>
<td>fretting wear</td>
</tr>
<tr>
<td>Radial keys</td>
<td></td>
<td>FIV</td>
<td></td>
<td>fretting wear</td>
</tr>
<tr>
<td>Instrumentation sleeve, control rod guide tube</td>
<td></td>
<td>FIV</td>
<td></td>
<td>wear</td>
</tr>
<tr>
<td>Irradiation surveillance capsule</td>
<td></td>
<td>FIV</td>
<td>neutron irradiation</td>
<td>fretting wear</td>
</tr>
<tr>
<td>Connections (bolts, pins)</td>
<td>IGSCC, IASCC</td>
<td>FIV</td>
<td>irradiation creep and swelling</td>
<td></td>
</tr>
<tr>
<td>Compressed elastic ring</td>
<td></td>
<td>Axial forces</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Significant ageing mechanisms - other primary loop components

<table>
<thead>
<tr>
<th>Component</th>
<th>Erosion-Corrosion</th>
<th>Fatigue</th>
<th>Embrittlement</th>
<th>Fretting and Wear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressurizer (spray nozzle)</td>
<td></td>
<td>thermal fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCP (rotating parts)</td>
<td></td>
<td>vibration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charging pump (rotating parts)</td>
<td></td>
<td>vibration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressurizer safety valve</td>
<td></td>
<td>thermal stratification</td>
<td>thermal ageing of CF8M material</td>
<td>mechanical vibration</td>
</tr>
<tr>
<td>Electric gate-valve</td>
<td></td>
<td>thermal stratification</td>
<td>thermal ageing of CF8M material</td>
<td>mechanical vibration</td>
</tr>
<tr>
<td>Main piping</td>
<td></td>
<td>thermal/ mechanical fatigue</td>
<td>thermal ageing</td>
<td></td>
</tr>
<tr>
<td>Surge line of pressurizer</td>
<td></td>
<td>thermal/ mechanical fatigue</td>
<td></td>
<td>Vibration</td>
</tr>
<tr>
<td>Class 1E Cable</td>
<td>oxidation and chemical corrosion</td>
<td></td>
<td>thermal ageing/ irradiation embrittlement</td>
<td>vibration</td>
</tr>
<tr>
<td>transformer</td>
<td></td>
<td>cyclic operation</td>
<td>thermal ageing</td>
<td></td>
</tr>
</tbody>
</table>
### Significant ageing mechanisms - Containment and structures

<table>
<thead>
<tr>
<th>Structures</th>
<th>Corrosion</th>
<th>Fatigue</th>
<th>Embrittlement</th>
<th>Concrete degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>acidic or alkaline corrosion</td>
<td>fatigue</td>
<td></td>
<td>Leaching and efflorescence</td>
</tr>
<tr>
<td>Reinforced concrete</td>
<td>General corrosion or pitting of reinforced steel</td>
<td>Temperature increase near reactor cavity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-stressing system</td>
<td>Denting, stress corrosion or hydrogen embrittlement</td>
<td></td>
<td>Loss of prestressing</td>
<td></td>
</tr>
<tr>
<td>Steel lining</td>
<td>Corrosion induced by anti-rust failure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 2 Safety aspects of NPPs’ full life cycle of AM

<table>
<thead>
<tr>
<th>Stage</th>
<th>Needs</th>
<th>Activities arouse from needs</th>
<th>Related technical support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decommissioning</td>
<td>Decommissioning activities should be carried out through effective ageing management</td>
<td><strong>SSCs important to decommissioning should be maintained their availability and functionality through effective ageing management</strong></td>
<td><strong>Analyze functionality of aged SSCs which are important to decommissioning</strong></td>
</tr>
</tbody>
</table>
The targets of NPP PLiM lie in:

- Maintaining high safety level
- Optimizing SSCs’ operation, maintenance and service life
- Maintaining acceptable SSCs’ performance status
- Obtaining as much as possible the return on investment beyond NPP lifetime
- Establish basis for LTO of NPP
2 Safety aspects of NPPs’ full life cycle of AM – PLiM: economic considerations

Ageing Management:
- More focus on safety
- Limited to safety related SSCs

PLiM:
- Economic, more from whole plant
- 2\textsuperscript{nd} Loop SSCs included
- Asset Management
- Knowledge Management
2 Safety aspects of NPPs’ full life cycle of AM

- Challenges on Management
  - Although ultimate responsibilities belong to utilities, how to distribute them to related parties?
I. A glance of China nuclear power plants

II. Safety aspects of NPPs’ full life cycle of AM

III SNPTC’s practice
Establishment of SNEQC in collaborated by SPERI, SNERDI, SNPEC, SNPAS etc. to meet the needs of EQ for CAP series NPPs
3 SNPTC’s Practice

SNEQC – Seismic/vibration shake tables

2.5m*2.5m 3 axis 6 freedom Seismic table

1.5m*1.5m high frequency shake table

1 m*1 m 3 axis 6 freedom Seismic table
3  SNPTC’s Practice

SNEQC – LOCA facilities

Fig. 1-LOCA facilities

Fig. 2-LOCA facilities (large cabin)

<table>
<thead>
<tr>
<th>LOCA simulating facilities</th>
<th>L: 24 m**3</th>
<th>M: 14.7 m**3</th>
<th>S: 7.1 m**3</th>
</tr>
</thead>
</table>

Maximum Temperature rate more than 130°C/s
3 SNPTC’s Practice

Electric Penetration Assembly (EPA) EQ implementation

- EQ program review (2013.4.27)
- EMC (2013.12)
- Electric shortcut test (2014.3)
- Seismic test (2014.4)
- LOCA test (2015.1)
- Completion of EQ reports (2015.3)

©SPIC 2018. All rights reserved.
3 SNPTC’s Practice

R&D on EQ fundamental aspects implemented by SNERDI

The activation energy measurement for non-metallic material

The Seismic margin test for electric-magnet valve
3 SNPTC’s Practice

IAEA CRP on cable ageing study
Benchmark, Condition Monitoring

- Thermal ageing
- Radiation ageing
- Thermal-Radiation interaction

Implemented by SNERDI

Thermal (AMS and others)

Irradiation Cell (AECL)

Irradiation Thermobox (UJV)
3 SNPTC’s Practice – Overall AMP

AMP organization and Responsibilities

Previous PSR

Overall AMP

Review of existing programs and procedures

Topical AMPs

Equipment specific AMPs

Equipment Screening

AMP Database

- Degradation mechanisms
- Ageing detection
- Ageing mitigation
- Ageing assessment
- AMP procedures

AMP for T1

Topic for FAC
- Investigation
- Detection
- Mitigation
- Assessment

AMP for T2

Topic for Dead Line
- Investigation
- Detection
- Mitigation
- Assessment
- AMP procedures

AMP for Tm

Topic of obsolescence

AMP for RPV

AMP for SG

AMP for En

Implemented by SNERDI

Next PSR

OLE
3 SNPTC’s Practice – RPV AMP

- main targets:
  - Ageing Mechanism Analysis
  - AMP development
  - Structure of AM Data Base
  - RPV life assessment considering PTS condition

Implemented by SNERDI
3 SNPTC’s Practice – RI AMP

Reactor Internals AMPs development for PWRs of Qinshan NPP

Qinshan-I 1 x 320 MWe PWR unit

Qinshan-II 4 x 650 MWe PWR units

Entrusted by CNNO, SNERDI carried out AMP development for Qinshan-I and Qinshan-II (2013~2015)
3 SNPTC’s Practice – RI AMP

Reactor Internals AMPs development for PWRs of Qinshan NPP

➤ Evaluation on RI ageing mechanisms
  ● Fatigue
  ● Irradiation embrittlement
  ● Wear
  ● Stress relaxation
  ● Stress corrosion cracking (SCC)
  ● Irradiation-assisted stress corrosion cracking (IASCC)
  ● Void swelling
  ● Thermal ageing embrittlement

Implemented by SNERDI

©SPIC 2018. All rights reserved.
3 SNPTC’s Practice – AMP for Piping Systems

PWR Primary Boundary Piping System AM Research for Qinshan NPP -- Qinshan-I and Qinshan –II, carried out by SNERDI

Main tasks:
- Ageing Mechanism Analysis
- Aging Condition Assessment Guide Line
- Structure of AM Data Base
- Aging Condition Evaluation and Remaining Life Evaluation
- Primary Boundary Piping System AMP -- General
- Primary Boundary Piping System AMP – Unit Specific
- Technical Guideline for Primary Boundary Piping System AM Evaluation
3  SNPTC’s Practice – AMP for Piping Systems

PWR Primary Boundary Piping System AM Research for Qinshan NPP

- Examples of Ageing Analysis
  - Thermal Stratification
  - Crack Growth
  - Fatigue

Implemented by SNERDI
Daya Bay NPP Ex-Vessel Neutron Dosimetry

- The Ex-Vessel Neutron Dosimetry (EVND) was installed in one of units of Daya Bay NPP in October 19th 2013.
- Data from EVND provide best estimation of RPV neutron exposure together with data from RPV surveillance capsules and calculated neutron fluence, which can be used in following aspects:
  - Assess the neutron embrittlement of RPV
  - Monitor the change of neutron fluence rate and spectrum after modification of core design and reactor internals
  - Provide data for RPV aging management and life extension of NPP

Crew of EVND installation in Daya Bay NPP

Implemented by SNPSC
Life management for conventional island

Equipment Supervision

- Pfm. tests
- Monitoring on vib., stress and pfm.
- Metal supervision and failure analysis
- Life mgm.

Sys. upgrading
Eq. upgrading
Maint. support

R&D topical projects

Overall Target: Digital plant, good economy, high reliability, good safety performance and well under control

Implemented by SPERI
3 SNPTC’s Practice – OLE for Qinshan-1

Implemented by SNERDI

- 2013.7 OLE Program proposal submission
- 2014.1 Program proposal acceptance
- 2014.9 Program group establishment
- 2014.12 Scoping and screening
- 2015.12 IPA and environmental impact evaluation
- 2016.12 OLE application submission
- 2016.6 FSAR and TLAA
- 2017 NNSSA review
- 2017 ~ 2022 Promise execution
- 2021.12 OLE permission

R18 (2018.4 ~ 2019.4)

R19, R20
Summaries

- Activities on ageing management cover the full life cycle of NPPs, including stages of design, manufacture, construction, commissioning, operation, as well as decommissioning.

- Although the ultimate responsibilities belong to utilities, the responsibilities should be distributed to all related parties to make sure ageing management being implemented and the related records being well kept.

- SNPTC carried out ageing management activities and provided comprehensive services in all life cycle stages of NPPs.
Thank you for your attention