Maintenance Measures Related to Plant Life Management Taken by Japanese PWRs

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Nuclear Power Plants in Japan (as of October 15, 2007)

- **PWR In operation**: 23 units, 19.4 GWe
- **BWR In operation**: 32 units, 30.2 GWe
- **Under construction**: 2 units, 2.3 GWe
- **Planned**: 11 units, 14.9 GWe

**Locations**:
- **Hokkaido EP Co./Tomari**
- **Tohoku EP Co./Onagawa**
- **Tokyo EP Co./Fukushima No.1**
- **Tokyo EP Co./Fukushima No.2**
- **JAP Co./Tokai No.2**
- **Shikoku EP Co./Ikata**
- **Hokuriku EP Co./Shika**
- **Tokyo EP Co./Kashiwazaki Kariwa**
- **JAP Co./Tsuruga**
- **Kansai EP Co./Mihama**
- **Kansai EP Co./Ohi**
- **Kansai EP Co./Takahama**
- **Chugoku EP Co./Shimane**
- **Chugoku EP Co./Kaminoseki**
- **Kyushu EP Co./Genkai**
- **Kyushu EP Co./Sendai**
- **EPDC Co./Ohma**
- **Chubu EP Co./Hamaoka**

**Operated over 30 years**:
- 24 units as of 2007
- 34 units as of 2012
- 34 units as of 2017
Time Frame of PLM-related Activities

PLM Technical Evaluations by Utilities
(Regulatory requirements)

Flow of PLM Technical Evaluation

A. Select components/structures
B. Select ageing phenomena and parts
C. Integrity evaluation assuming 60 year operation
D. Establish 10-year long-term maintenance program
Utilities’ PLM-related R&D Efforts

R&D in initial stages (FY1976～1984)
Cause investigation and development of inspection/repair technologies to address ageing phenomena in SSC (e.g.)
Trial and error

R&D for plant service life extension (FY1985～1995)
Systematic R&D for plant SSC
Aiming at systematic R&D

PLM-related R&D (since FY1996)
Identifying technical issues through PLM technical evaluations
Identifying requirements through technical evaluations

Inspection/monitoring and repair/replacement technologies
Development of inspection/monitoring technologies
Development of repair/replacement technologies as well as inspection/monitoring technologies
Development of preventive maintenance, technologies, stress relief, water chemistry improvement, etc.

Ageing evaluation technologies
Assessing integrity by clarifying ageing phenomena
• Determining the timing of maintenance

Future Target: Cooperation with Japanese and overseas organizations from long-term viewpoint

Completion of R&D roadmap

Improvement by clarifying degradation mechanism
• Development of high SCC resistant material
• Modification of design (structure/environment)
A Coordinating Committee on Ageing Management was established with members from industries, utilities, research organization and regulatory authorities.
R&D Efforts inside Industry

Industry

➢ Electric utilities
➢ Japanese/overseas vendors

Comprehensive technologies applicable to actual units

Collecting information and investigating trends of Japanese and overseas plants

➢ JANTI

Research Institutes
➢ CRIEPI
➢ INSS
➢ Research institutes of equipment manufacturers
➢ Research institutes of inspection companies
➢ Overseas research institutes etc.

Basic research on the subjects such as clarification of ageing mechanisms besides practical techniques
Industrial Efforts to Promote PLM-related R&D Activities

Technology information coordination committee

PLM research promotion council board
【Policies regarding research promotion】
[Secretariat: JANTI (FEPCO)]

PLM research administrative review meeting
【Discussing research strategies】
[Secretariat: CRIEPI]

Evaluation results
Providing future directions

10 Sub Group (SG): Examination team
【Individual Issues.】

Chairman and deputy chairman of promotion council board participate in the committee.

Collaboration

<The Federation of Electric Power Companies of Japan>

Nuclear energy development committee

Nuclear energy development committee Comprehensive task force

Equipment maintenance committee

<Electric power companies, manufacturers and organizations that are involved in the support system>
Nine electric power companies, JAPC, Electric Power Development CO., CRIEPI and JANTI
<table>
<thead>
<tr>
<th>Major technical theme</th>
<th>R&amp;D subject</th>
<th>Task</th>
<th>Necessity of solving the issue, policy toward solution</th>
<th>Concrete contents of study</th>
<th>Expected results and benefits for operating plants</th>
<th>Term</th>
<th>Priority</th>
<th>Related research</th>
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<tbody>
<tr>
<td>Irradiation embrittlement</td>
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<td>Database development</td>
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<td>Development of evaluation techniques</td>
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<td>Codifying process</td>
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When preparing an actual worksheet, columns were added or deleted according to the characteristics of each ageing phenomenon.
Actual Image of Technological Map Format

<table>
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<tr>
<th>検査機関</th>
<th>試験機器</th>
<th>検査項目</th>
<th>検査結果</th>
<th>検査対象</th>
<th>検査方法</th>
<th>検査試料</th>
<th>検査機性</th>
<th>検査管理</th>
<th>検査日</th>
<th>検査者</th>
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*SAMPLE*

PLM研究ゼミナールSG会サブグループ議題☆(案)

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<thead>
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<th>宮崎大学</th>
<th>高校</th>
<th>中学</th>
<th>小学校</th>
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<th>探求</th>
<th>基準</th>
<th>目標</th>
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*SAMPLE*
## PWSCC-related R&D Activities

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<td>R/V Head Nozzle</td>
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<td>BMI Nozzle</td>
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### Research regarding Alloy 600 in Japan
- **Ageing Evaluation (constant load testing, crack propagation)**
- **Detection Accuracy**
- **The Application of Peening**
- **Alloy 690 long-term integrity**
- **Water chemistry improvement**

### Countermeasures in Japan
- **Replacement (Alloy 600 SG and R/V head)**
- **Preventive Maintenance (Alloy 600 peening)**

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**Countermeasures in Japan**
- Replacement (Alloy 600 SG and R/V head)
- Preventive Maintenance (Alloy 600 peening)
Revision of national standards

Test specimen reconstruction technologies (Charpy specimens)

Revised equation to predict embrittlement

1. Introduction of refined equation to predict embrittlement (in particular, identification of embrittlement trends in high irradiation regions)
2. Review and reevaluation of PTS conditions
3. Introduction of probabilistic fracture mechanics

Future R&D programs
Development of PLM Technical Information base

Continuous improvement of maintenance programs is essential.

- Review of standards
- Field engineers
- Evaluation of effectiveness of maintenance programs (Maintenance management index, PLM technical evaluation, etc.)
- Inspection/repair
- Planning maintenance

Electric power companies [Common base]

- Steering Committee: determining policies regarding development/maintenance of information base
- Candidate for an organization operating the base data and meetings: JANTI
- Accumulation of failure/degradation data
- Electrical experts meeting: Evaluations according to components and technical fields
- Third-party review, Information from external organizations Cooperation, Support
- Technical base
  - Operational standards
  - Maintenance/management rules for technical base

External experts

- Academic world
- Codes/standards
- Plant vendors
- Equipment manufacturers
- Monitoring system supplier
- CRIEPI
- Overseas organizations (INPO, WANO, EPRI, etc.)
- Interface with external experts

- Analysis of system functions for each reactor type
- Standards for maintenance importance evaluation
- Failure mode analysis for each component
- Standard template for each component (Maintenance items, frequencies)

* Revising data such as ageing characteristics data and maintenance template by developing the technical base.
* Implementing PLM evaluations based on common technical base for maintenance management
* Developing technical base so that industry, government and academia can effectively utilize individual utilities’ operation and maintenance data for improved nuclear safety.

The 9th PLM Investigation Committee meeting (October 30, 2006)
Conclusion

① Present status of PLM-related R&D activities in Japan
The Japanese industry, government and academia are working together toward the development of PLM R&D roadmap as an increasing number of NPPs mark the 30th year of operation.

② Japanese nuclear industry’s efforts
A new organization for the development of the roadmap has been organized with participation by all the Japanese electric power companies and manufacturers, which results in common policies for future PLM research activities.

③ Remaining issues to be addressed
Cooperation with international organizations is essential for effective and reasonable promotion of R&D activities as the demand for nuclear energy is increasing and nuclear power plants worldwide are ageing.