Activities for Effective Aging Management and Safe Long-Term Operation Implemented at Fukushima Dai-ichi Nuclear Power Plant

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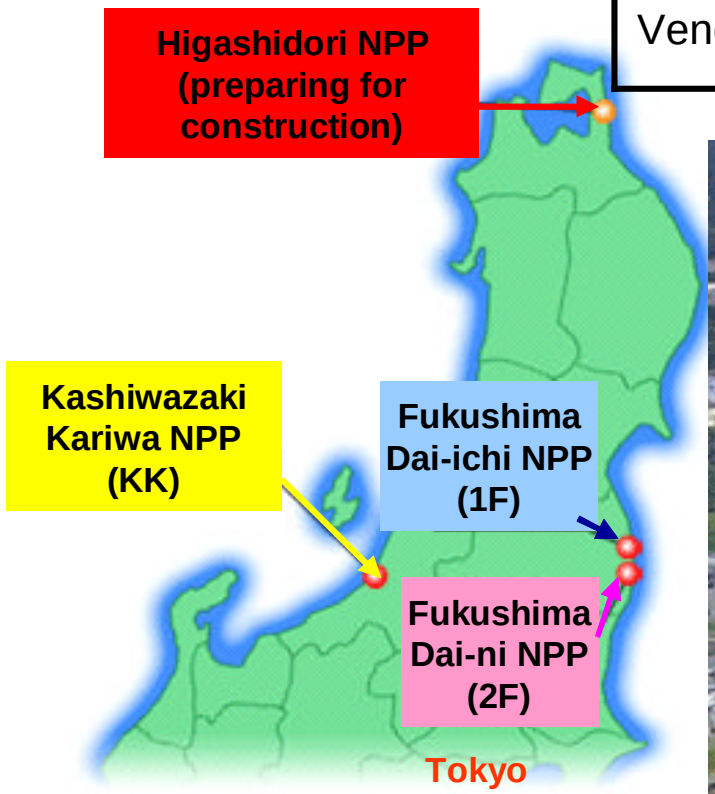
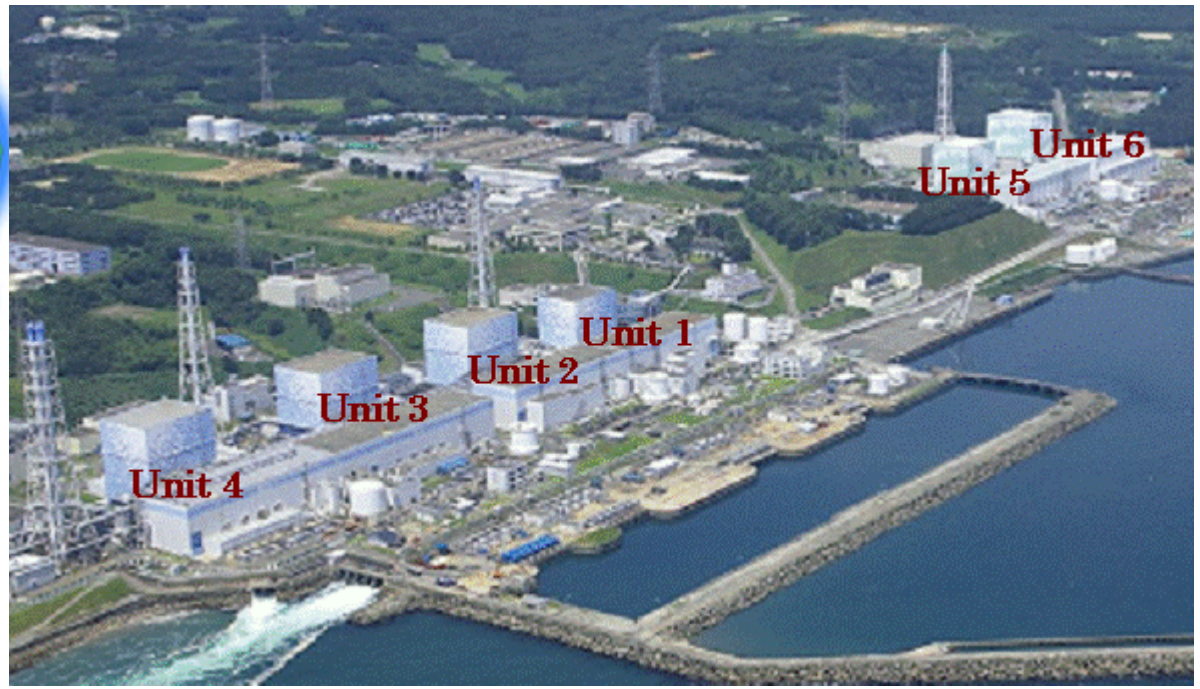
Fukushima Dai-ichi Nuclear Power Plant (1F NPP)

Unit	1	2	3	4	5	6
Output (MWe)	460	784	784	784	784	1100
Turn Over	Mar. 1971	Jul. 1974	Mar. 1976	Oct. 1978	Apr. 1978	Oct. 1979
Vendor	GE	GE+T	Toshiba	Hitachi	Toshiba	GE





Four Different Approaches to Effective Ageing Management at 1F NPP

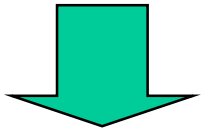
1F NPP is one of the oldest NPP in the world

➡ **Different approaches to effective aging management are being taken:**

1. Improve normal maintenance programmes,
2. Replace or refurbish degraded or obsolescent structures/components (SCs),
3. Perform Ageing Management Reviews before 30 years of operation and every 10 years afterward,
4. Accumulate and use operational experience of similar NPPs in Japan and abroad.

Improvement of Normal Maintenance Programmes

- Most of the current maintenance programmes are time-based maintenance and not really focused on potential ageing degradations and their susceptible locations,
- Information on potential ageing degradations for each S/C is now available in the form of Degradation Mechanism Summary Sheets,
- Other internal/external information can be used to evaluate effectiveness of the maintenance programmes.



Commenced evaluation of effectiveness of the on-going maintenance programmes in 2009

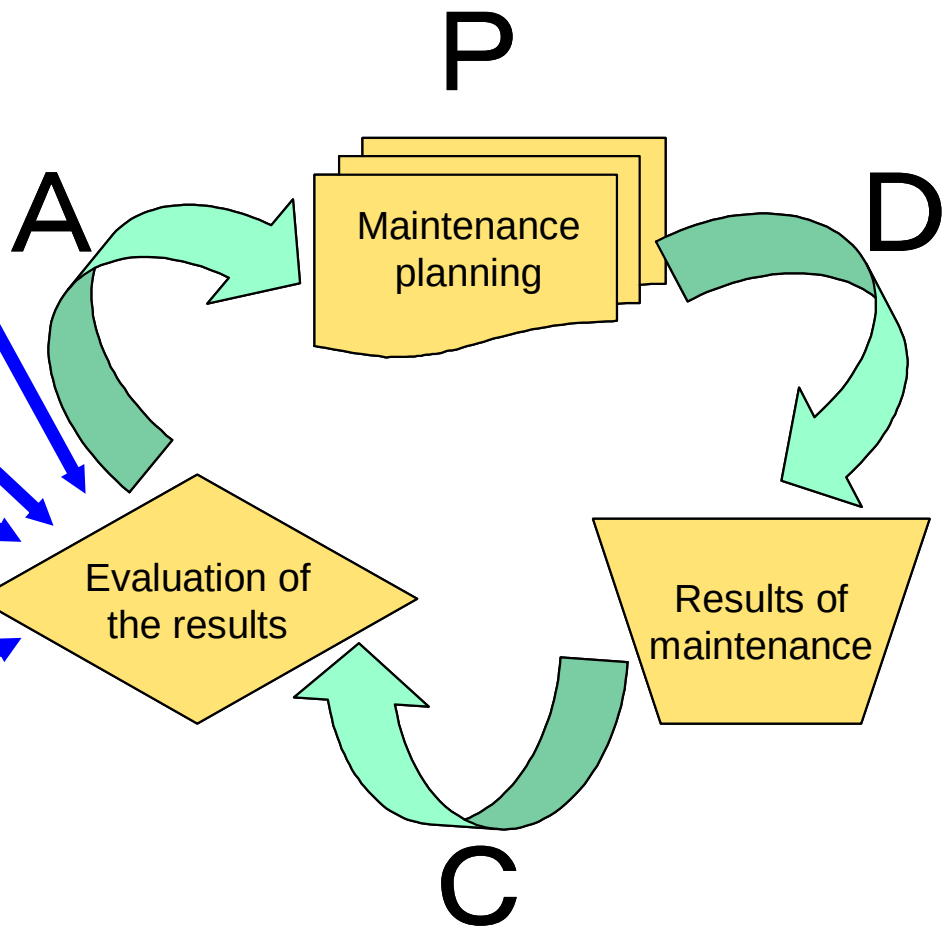
PDCA Cycle to Improve Maintenance Programmes

Performance Criteria
- Number of automatic SCRAM,
- Maintenance preventable function failure
- Unavailable time

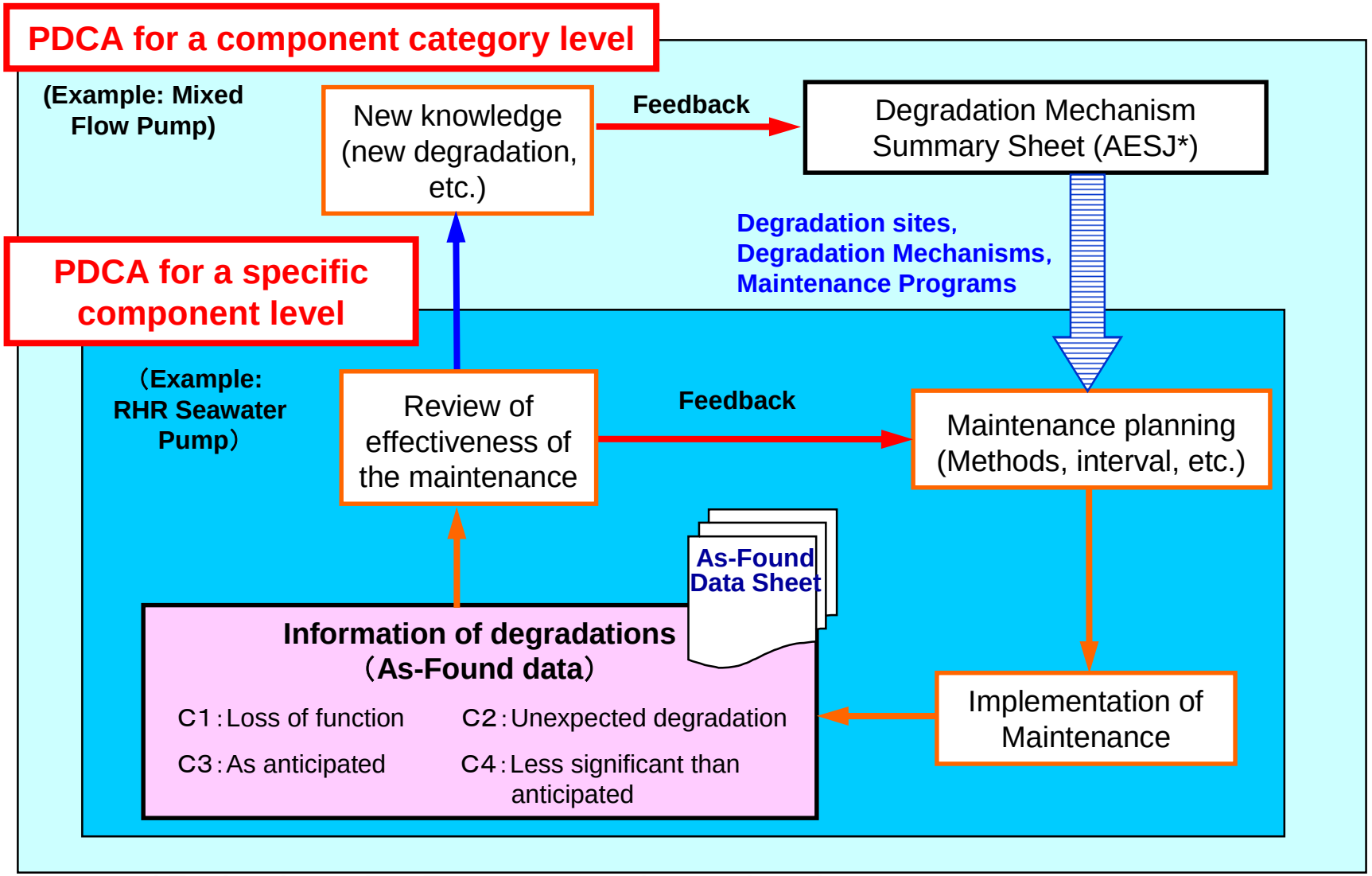
As-Found Data

Evaluation results of past nonconformities

External information
- Results of AMTAs and PSRs;
- Operational experience of other NPPs
- Risk analysis information
- Related R&D results.



PDCA Cycles based on As-Found Data



* AESJ: Atomic Energy Society in Japan

Summary Sheet of Aging Degradation Mechanisms

Experience in Utilities for AM Technical Evaluation in 14 Plants (7 PWRs and 7 BWRs)

- ***SCCs subject to evaluation, importance classification, Class 1～3***
- ***Latest technological knowledge***
  (updated research results, evaluation methods, etc.)
- ***Operational experience***
  (failures and accidents at home and abroad)
- ***Technical Evaluation***
  Extraction of parts and ageing mechanisms t
  Integrity evaluation
  Current maintenance program
  Comprehensive evaluation

Long-term maintenance program
(including R&D subjects)

Ageing mechanisms to be considered in taking AM measures are summarized for 300 components in each PWR and BWR.

e.g. Summary Sheet of Ageing Mechanisms for Turbo Pumps

P01-01 Pump (vertical axial flow turbo pump/seawater/SS)

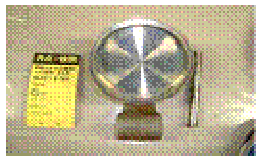
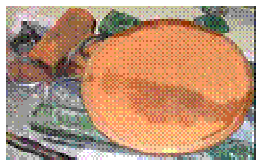
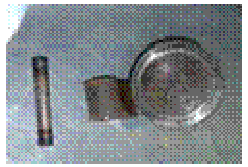
No.	Issues required to achieve intended functions	Part	Material	Ageing phenomena	Remarks
1	Assurance of pump capacity (head)	Main shaft	SS	Wear	
2		Main shaft	SS	Corrosion (pitting, etc.)	
・		・・・	・・・	・・・	・・・
13	Maintenance of boundary	Discharge elbow	Cast iron	Corrosion (pitting, etc.)	
14		Discharge pipe	Cast iron	Corrosion (pitting, etc.)	
・		・・・	・・・	・・・	・・・
23	Support of component	Support plate	SS	（N/A）	
24			SS	（N/A）	
・		・・・	・・・	・・・	・・・

Evaluation of As-Found Data (1)

New System

○Accumulate As-Found Data and reflect them on the evaluation of effective ness of maintenance activities → revise the maintenance plan (change maintenance intervals, etc.)

(Example of valve overhaul maintenance)

As-Found Data		Evaluation of Maintenance Effectiveness		Feedback to the Maintenance Plan
	Drop out of the valve disk due to corrosion	C-1	Loss of function (The component is out of order)	Strengthen the maintenance plan
	Erosion of the valve disk due to chattering	C-2	More significant than expected (Unplanned repair or replacement is necessary)	Consider shortening the maintenance interval
	Minor rust on the valve disk: only polishing the surface	C-3	As anticipated (Only replace consumables)	Continuation of the current maintenance
	In a good condition: no repair action is required	C-4	Less significant than anticipated or no degradation (no repair action is required)	Consider extending the maintenance interval

Evaluation of As-Found Data (2)

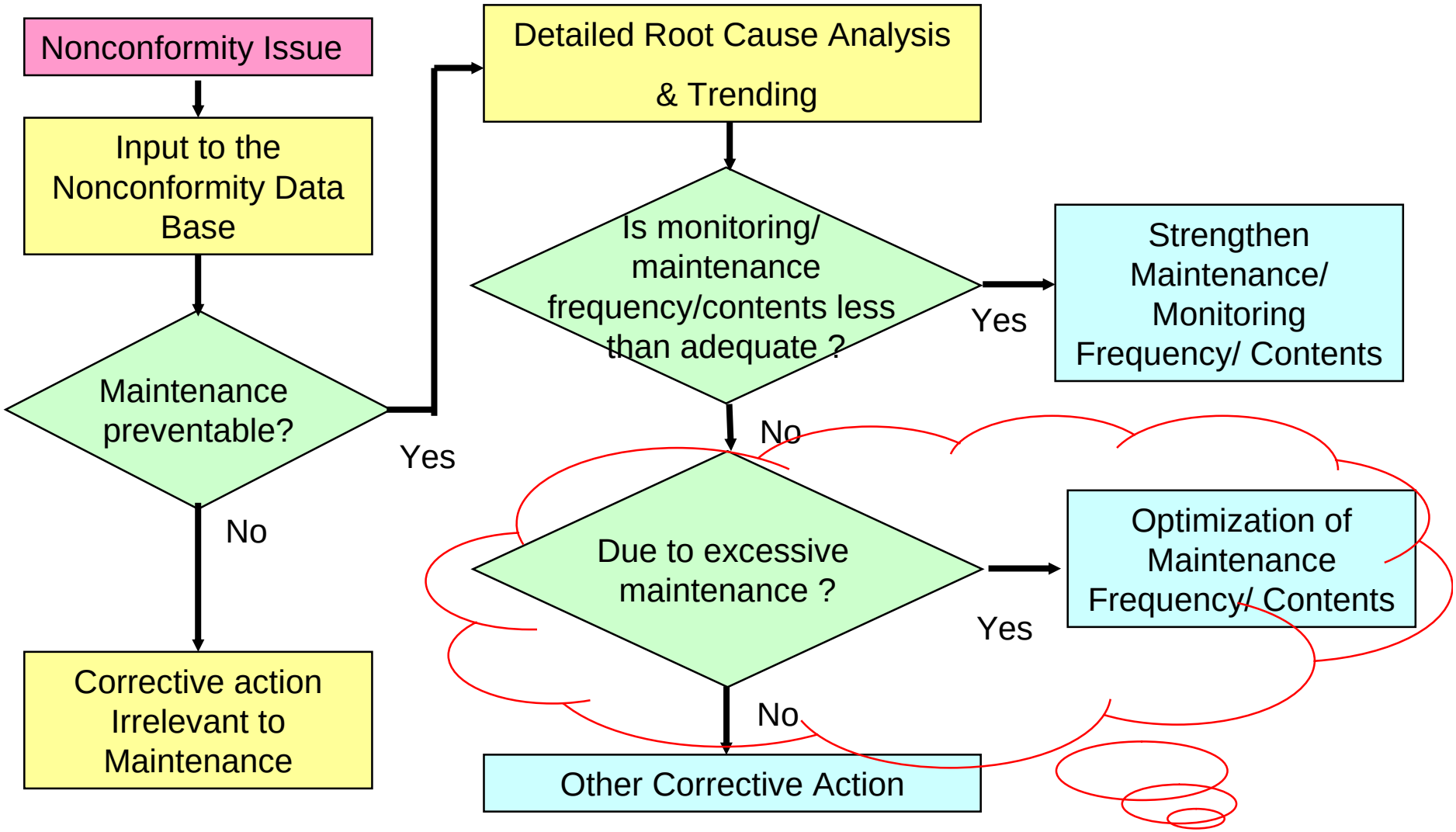
About 4000 As-Found Data have been evaluated.
Less than 5% of them are categorized to C-1 and C-2.

Unit	C-1	C-2	C-3	C-4
1	0 %	2.2 %	52.0 %	45.4 %
2	0.2 %	1.3 %	47.2 %	51.3 %
3	1.3 %	2.7 %	66.7 %	29.3 %
4	0 %	0 %	33.3 %	66.7 %
5	1.0 %	0 %	7.0 %	95.2 %
6	0.1 %	0.7 %	6.0 %	92.3 %
Total	0.1 %	1.3 %	28.2 %	70.3%

Maintenance programmes for these components will be strengthened.

Maintenance programmes for these components will be optimized.

Analysis and Feed-back of Past Nonconformity Issues (Corrective Action Program)



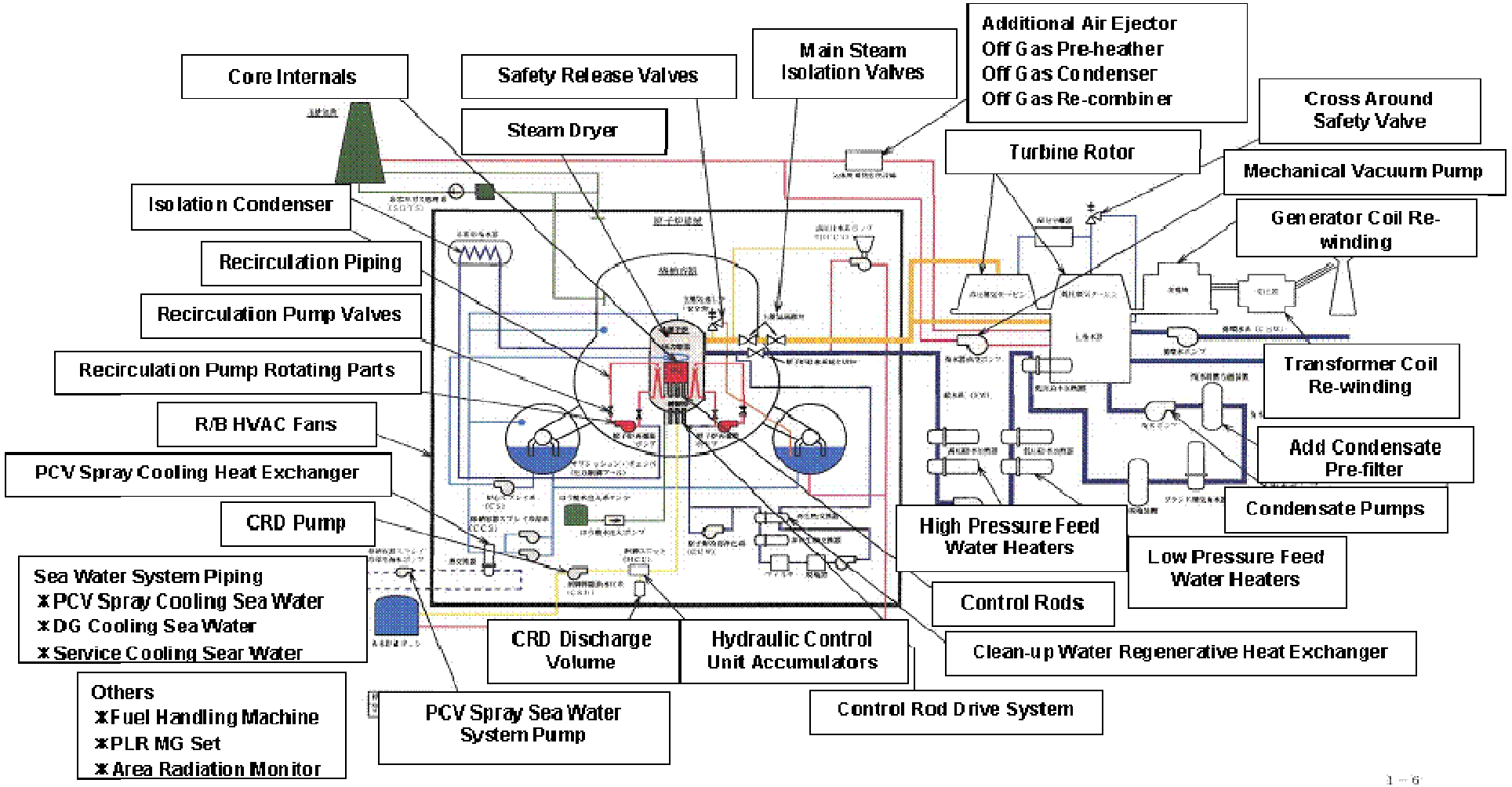
This Step is also important for the 1F NPP.

Efforts to reduce Nonconformity Issues related to Component/Equipment Degradations

All nonconformities related to component/equipment degradation are analyzed and evaluated for improvement of maintenance programmes to reduce these nonconformities.

Group	2008	2009	2010
Reactor	ECCS MOVs	CRD/HCU	Imported components
Turbine	Main turbine	HPCI/RCIC turbines Imported Valves	Imported Valves Sea water piping, flanges
Electric	Wedge of motors	Capacitors Low voltage motors	Capacitors Low voltage motors
I&C	Recorders Temperature elements	TOSDIA controller	High sensitivity off-gas monitors
Rad-waste	RW/B HVAC Ducts	House Boiler	Incinerator

Replacements and Refurbishments of SCs at 1F NPP (Examples of Unit 1)



Replacement Projects of the Core Internals

Unit 1: 2000 -2001

Unit 2: 1998 -1999

Unit 3: 1997 -1998

Unit 4: 2010 -2011

Unit 5: 1999 -2000

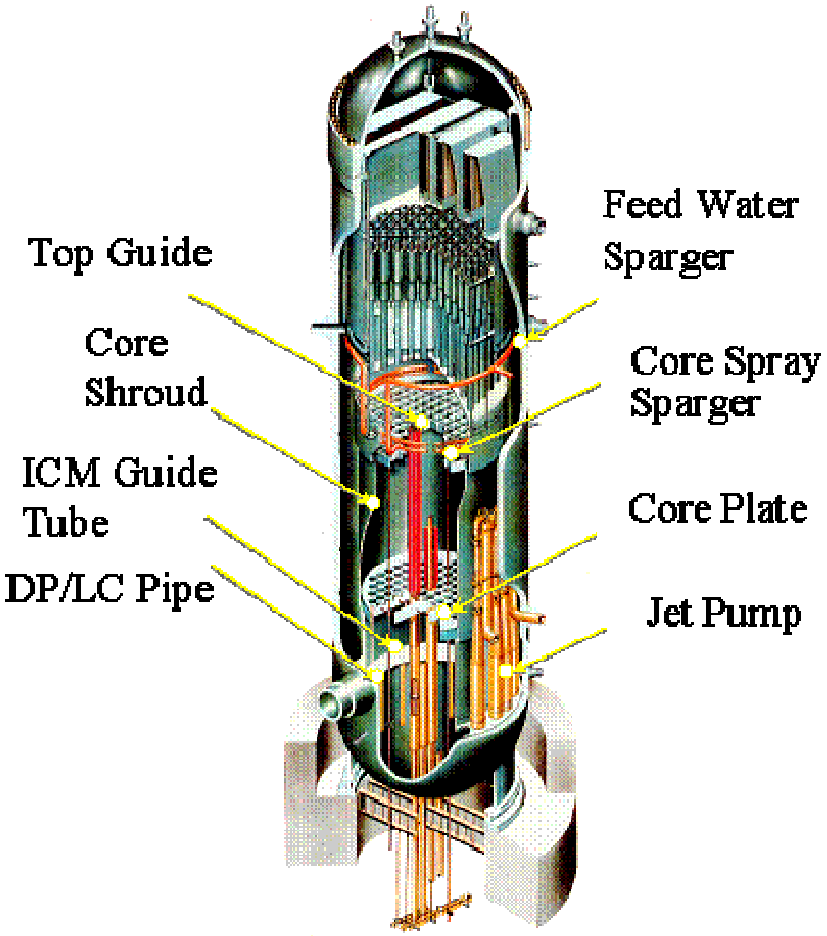
Unit 6: 2011 -2012

- Replaced Components

  Core Shroud and other main components made of 304SS

- New Components

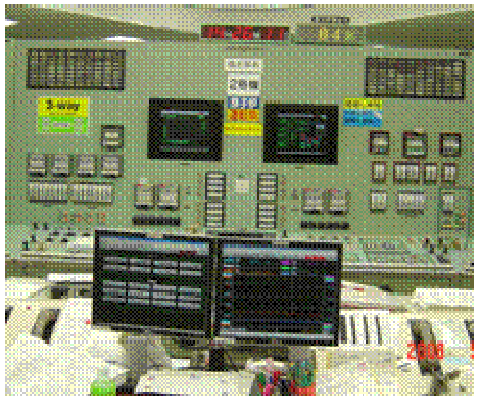
  Material : 316NG
  Forging is adopted for Core Shroud



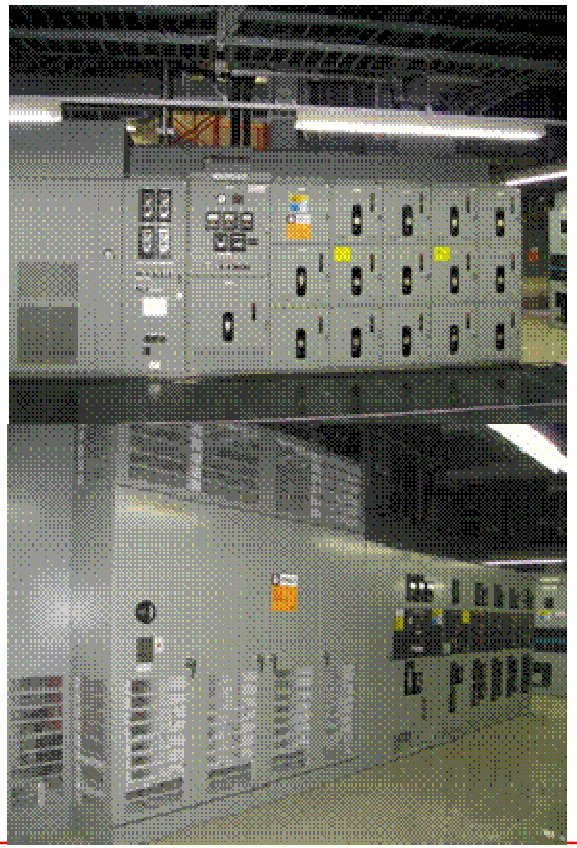
Replacement / Refurbishment of Electric Components and I&C Equipment

- All I&C equipment/components important to safety and plant reliability (process computer, neutron monitoring, etc) are replaced every 15-20 years.
- Electricity power source switch gears are being replaced after 30 years of operation.

New Neutron Monitor Control Board

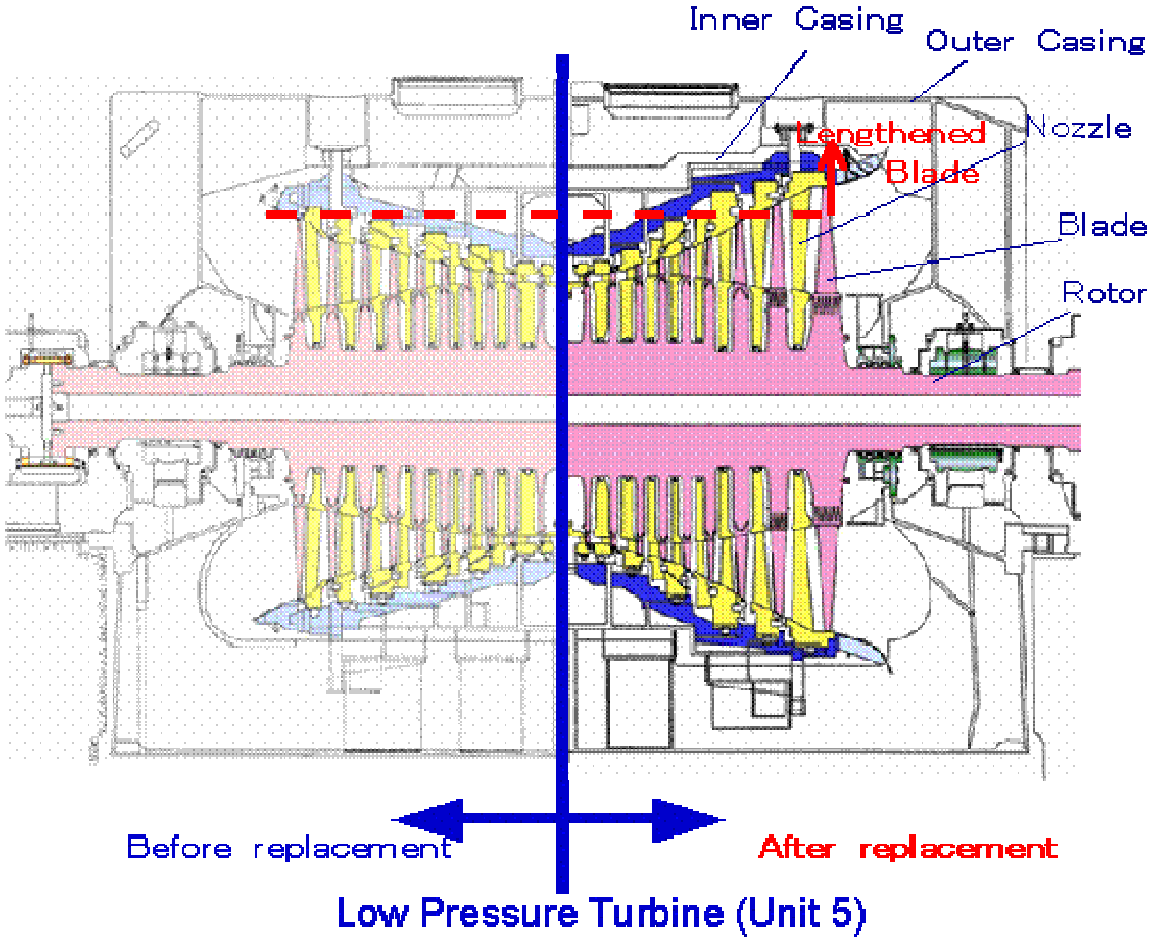


New Process Computer



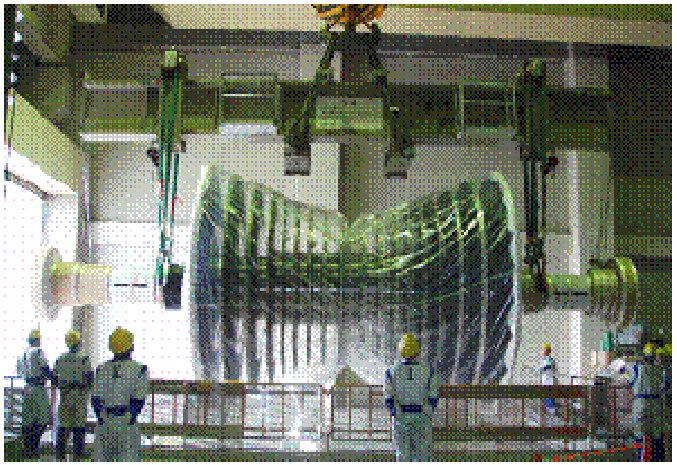
Power Centre

Turbine Rotor Replacement with Higher Efficiency



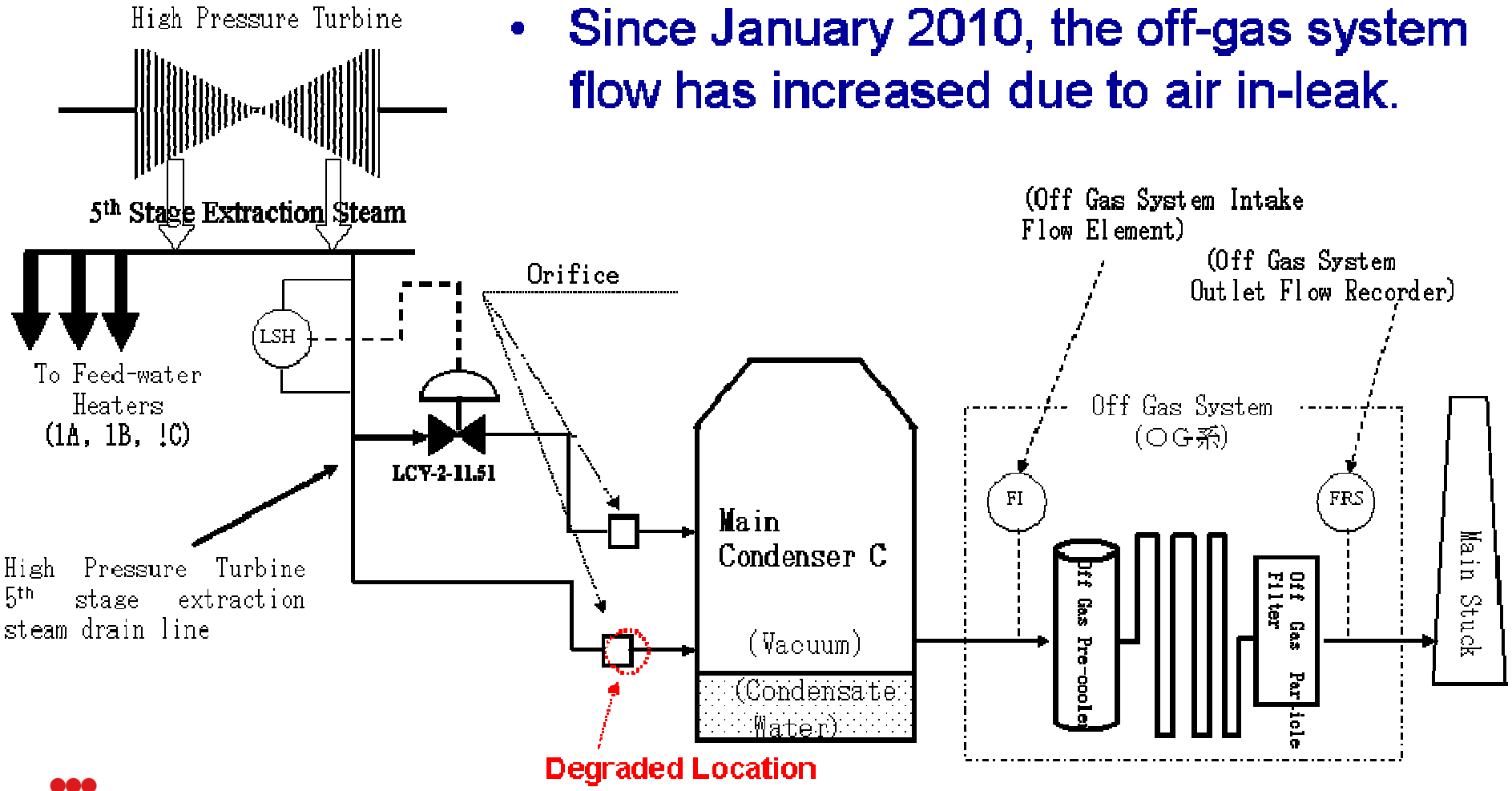
Unit 5 in 2008

Unit 6 in 2006



Lessons Learned from Recent Replacement (1)

- The turbine rotors of Unit 6 were replaced in 2009 with those of higher thermal efficiency.
- **Since January 2010, the off-gas system flow has increased due to air in-leak.**



Lessons Learned from Recent Replacement (2)

Mechanism

Rapid loss of material due to liquid drop impingement. (Material: Low Alloy Steel (Cr-Mo))

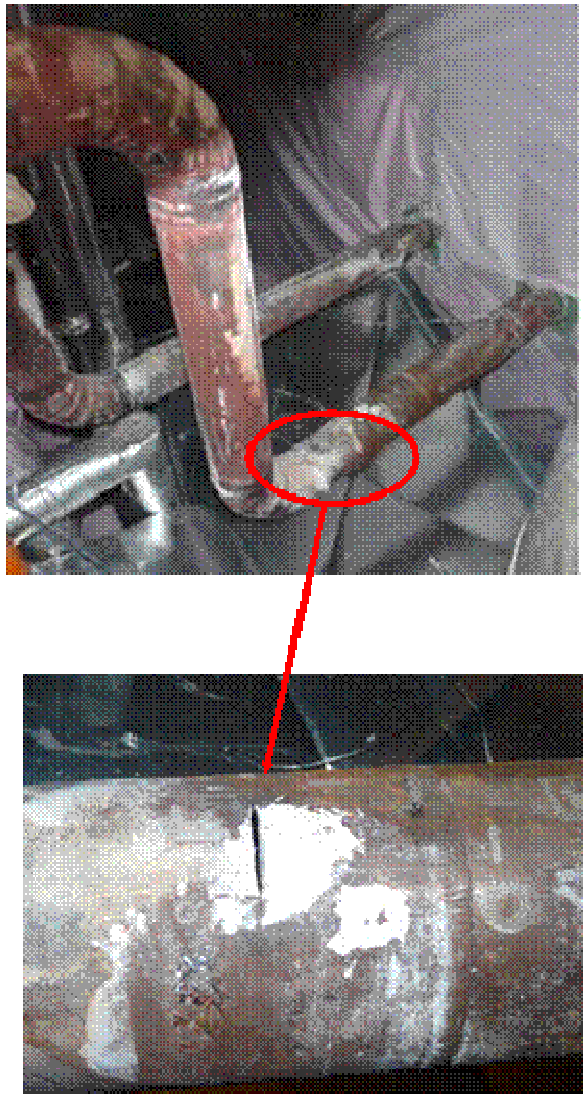
Cause

Increase of drain after the turbine replacement.

Change of operation.

Root Cause

Insufficient review of design changes.



Ageing Management Review (Aging Management Technical Evaluation: AMTA)

Screening of SCs
- Class 1 &2 SCs
- Class 3 components which involve high energy fluid

Grouping of SCs
- Types (pumps, etc.)
- Similarity (structure, material, etc.)

Selection of representative SCs

Ageing degradation study
- Significance of potential ageing degradations
- Identification of susceptible sites (parts) of each SC

Technical evaluation
- Possibility and consequence of the ageing degradations
- SC integrity assessment against ageing

Evaluation of the current maintenance programmes

Evaluation of the previous long term maintenance plans/implementation

Seismic analysis of ageing SCs

for beyond 40 years

Actions for next 10 years
- Updated long-term maintenance plans (part of Tec. Spec.), New R&D programs

Topics and Long-term Maintenance Plans for 1F-1 after 40 years of operation (Examples)

1. Upgrade the technical evaluations based on the latest knowledge.
   - Seismic evaluation of ageing components
   - Neutron irradiation embrittlement prediction
   - Thermal fatigue
2. Reflection of recent ageing problems
   - HVAC duct corrosion
   - Fatigue of the RCIC check valve
3. Additional long-term maintenance plans (example)
   - Inspection programme for the off gas system components against SCC
   - Inspection programme for the buried piping

Challenges related to Ageing (1)
(Stress Corrosion Cracking)

1. Measures for all three factors are being taken.

Material

- SS 304 pipes susceptible to SCC have been replaced
- Alloy 182 weld lines will be eliminated as much as possible. (exception: core shroud support, etc.)

Stress

- Induction Heat Stress Improvement for the recirculation piping.
- Water Jet Peening, other surface treatment for the core internals and RPV nozzles.

Environment

- Hydrogen Water Chemistry

2. Main objectives of the coming core internals replacement project is to replace components made of SS 304 and accumulate knowledge on SCC of Alloy 182.

Challenges related to Ageing (2)
(Cable Ageing, Ageing of Capacitors)

Cable Ageing

- Difficult to replace because of large quantity (1000-2000 km in total).
- Cables with short lives have been replaced.
- Replace plans will be set up based on the results of the national R&D projects and SCAP.

Ageing of Capacitors

- Most susceptible I&C equipment to heat and radiation.
- Difficult to locate where they are used.
- A detailed list of capacitors are being established and their maintenance/replacement plan will be established.

International cooperation/ use of operational experience of similar NPPs in Japan and abroad

- EPRI instruction for establishing reliability centered maintenance (RCM) and condition based maintenance (CBM) programmes.
- Mutual information exchange and cooperation
  - Tokai-2 in Japan
  - Santa Maria de Garona in Spain
- Information exchanges with foreign NPPs on specific topics
  - Laguna Verde in Mexico (Jet Pump Problem, SCC issues, Radiation Dose Reduction)
  - Beznau NPP in Switzerland (Equipment Qualification)

Conclusions

- The 1F NPP are setting-up actions which enable the NPP to improve maintenance programmes and to systematically and effectively manage aging degradations of SSCs.
- It is expected that aging management of SSCs at the plant would be considerably improved through these programs.
- To fully accomplish the objective of the new strategy and activities, it must be a crucial factor to strengthen engineering capability of the plant staff members and to have a suitable organizational structure in the maintenance department.

Thank you very much for your attention.

Any questions?