

IAEA Technical Meeting related to iGALL Database May 18 2009

***Ageing Management and Safe Long Term Operation
in Light Water Reactors
- Safety Regulation and Knowledgebase Activities in Japan -***

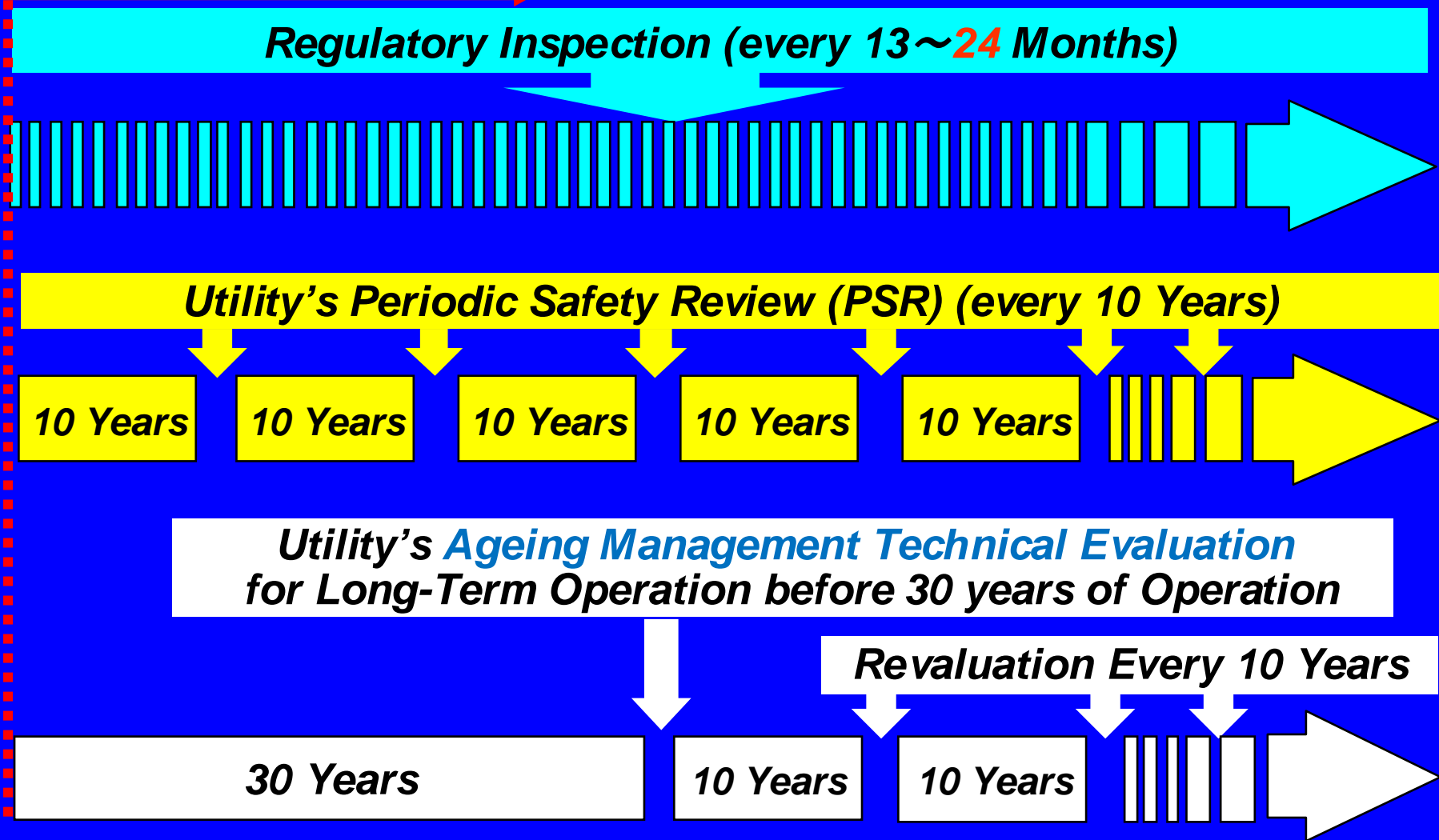
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1. Background of Ageing Management for Nuclear Power Plants in Japan

Current Regulatory Inspection, Periodic Safety Review and Ageing Management Technical Evaluation in Japan

Start of Commercial Operation



2. Current Ageing Management

2.1 Ageing Management Technical Evaluation by Utilities

Ageing Management Technical Evaluation on the 3rd and following PSR

- ***Review on Operational Experiences and Ageing Degradation in SSC***
- ***Reflect Latest Database and Technological Knowledge***
- ***Assumption of Service for 60 years***
- ***Prepare Long-Term Maintenance Programs***

Ageing Management Technical Evaluation by Utilities

1. Classification of SSCs and Ageing Phenomena

1.1 Categorizing, Classifying and Grouping of SSCs

1.2 Clarification of Ageing Phenomena

2. Technical Evaluation of Ageing Management

2.1 Technical Evaluation of Integrity of SSCs

- Evaluation by actual inspection and monitoring of data
- Analyses and calculation on the assumption of long-term operation

2.2 Review of Current Maintenance Program (CMMP)

Preservation review of CMMP adequacy against ageing degradation of SSCs on the assumption of long-term operation

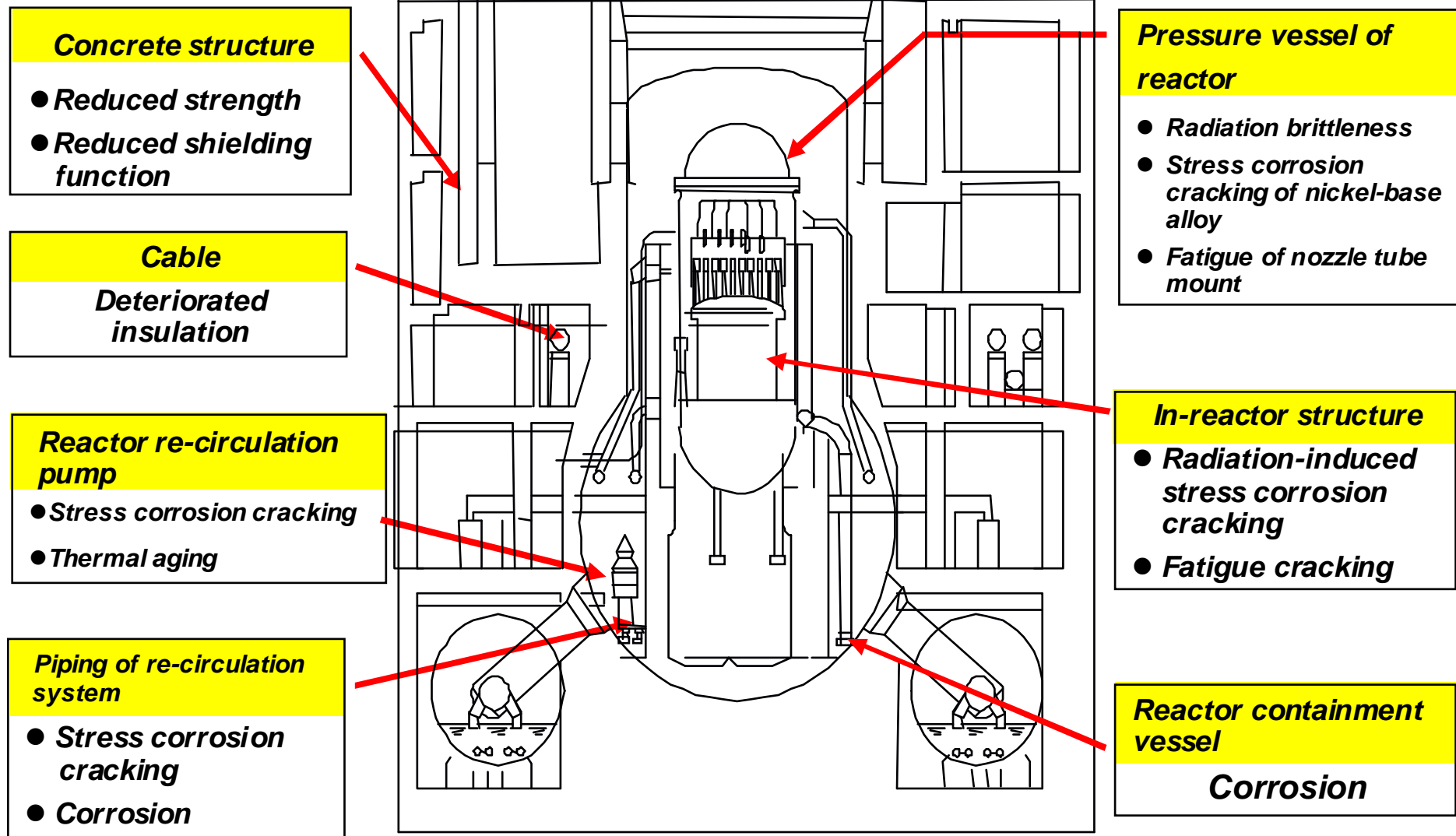
3. Long-term Maintenance Program

3.1 Confirmation of CMMP to be continued adequately

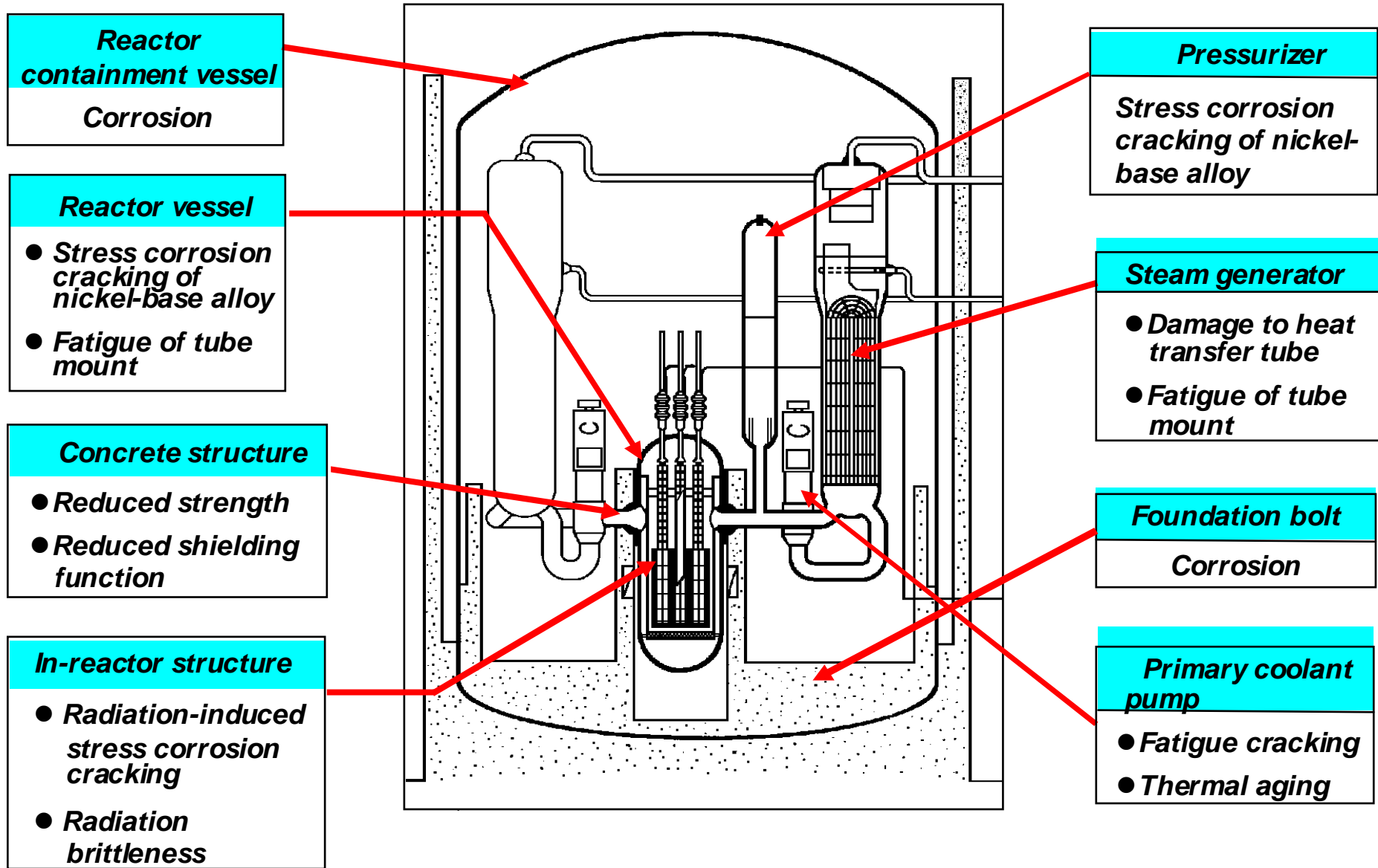
3.2 Clarification of additional maintenance program to CMMP and establishment of long-term maintenance program

3.3 Clarification of Research and Development tasks

Ageing Degradation of Major Components in BWR



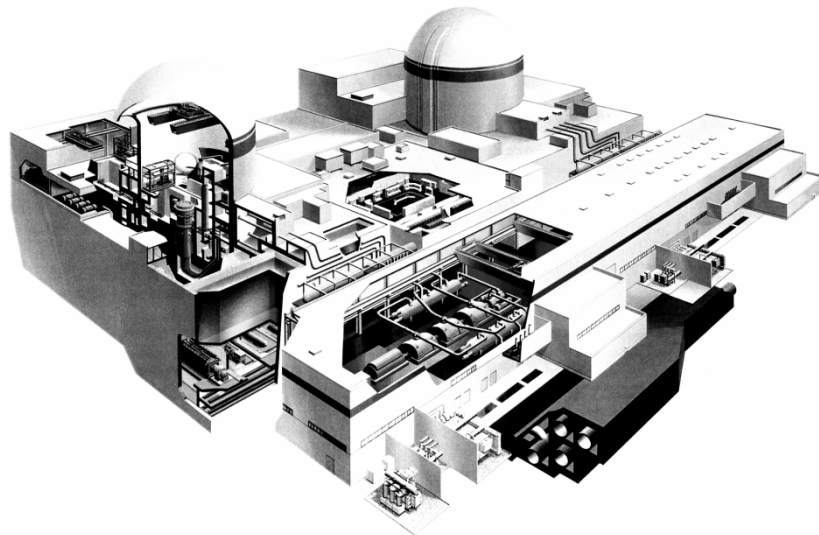
Ageing Degradation of Major Components in PWR



Systems, Structures and Components for AMTE in PWR

Selection of SSCs for Evaluation

Facilities and structures with the safety functions specified in “Guidelines to examination of importance classification of safety functions of the light water reactor facility for the power generation” (Decision of the Nuclear Safety Commission on August 30, 1990)^{*1} are selected for evaluation.



	Category of subjects of evaluation	Example
1	Pump	Primary coolant pump
2	Heat exchanger	Steam generator
3	Pump motor	Sea water pump motor
4	Vessel	Reactor vessel
5	Piping	Primary coolant pipe
6	Valve	Steam adjusting valve
7	In-reactor structure	Core indication structure
8	Cable	Power cable
9	Electric facility	Generator
10	Turbine	High pressure turbine
11	Concrete and steel-reinforced structures	External shielding wall
12	Measurement and control Facility	Temporary coolant pressure gauge measuring and control unit
13	Air-conditioning facility	CV circulation fan
14	Mechanical facility	Fuel handling unit
15	Electric facility	Emergency DG
16	Other facilities	Liquid waste evaporator

***1... Fuel assemblies are not included for AMTE**

Extraction of Important Ageing Mechanisms

● indicates an ageing mechanism that is determined to be important measures for extended operating life

△, ▲ indicates an ageing mechanism that is determined not to be important measures for extended operating life

Ageing mechanisms assumed on the Takahama No.1 unit filling and high pressure injection pumps

Item required for achievement of function	Site	Consumables Regularly Replaced components	Material	Aging change event							Remarks
				Reduced wall thickness		Cracking		Material quality change		Others	
				Wear	Corrosion	Fatigue cracking	Stress corrosion cracking	Thermal aging	Deterioration		
Maintenance of pump capacity and head	Main shaft		Stainless steel	▲		●*1 △*2					*1: Fretting fatigue cracking *2: High cycle fatigue cracking
	Vane wheel		Stainless cast steel		△*3						*3: Cavitation
	Casing ring		Stainless steel	▲							
	Bearing box		Cast iron		▲						
	Bearing (sliding)		Carbon steel White metal	▲							
	Gasket	◎	—								
	Shaft joint		Low alloy steel								
	Speed increasing gear		Low alloy steel	●							
	Bearing of speed increasing gear (sliding)		White metal	▲							
Casing of speed increasing gear		Cast iron		▲							
Maintenance of boundary	Casing		Low alloy steel								
	Casing cover		Low alloy steel								
	Casing bolt		Low alloy steel		△						
	Mechanical seal	◎	—								
	Gasket	◎	—								
	O-ring	◎	—								
	Casing drain tube		Stainless steel								
	Balancing tube		Stainless steel								
Mechanical seal cooler		Stainless steel									
Support of components	Base plate		Carbon steel		▲						
	Mounting bolt		Carbon steel		▲						
	Foundation bolt		Carbon steel		●						

[Speed increasing gear] Although wearing of gear is prevented with lubrication oil at inside of the unit, wearing is possible when it is operated for a long time, Accordingly, evaluation is required on aging change.

[Corrosion of speed increasing gear casing] Inside of the unit is exposed to atmosphere of lubrication oil. It is possible to say that no technical problem will occur by the operating condition and comparison with material testing data.

- : Aging change event evaluated as important for extended operating life (specific)
- △: Aging change event evaluated as insignificant for extended operating life (common)
- ▲: Aging change event evaluated as insignificant for extended operating life (specific)

2. Current Ageing Management

2.2 Review Processes of Ageing Management Technical Evaluation by NISA and JNES

Maintenance and Ageing Management Activities from Plant Commissioning

Determine maintenance type, inspection/test items and interval based on *Maintenance Program* using *SSC parts-level Summary Sheet of Ageing Mechanisms*

Cross Table for Ageing Mechanism and Maintenance Actions in specific component and areas compiled by Utilities Group



XX pump		Federation of Electric Power Companies				
Component function	Location	Material	Aging effect	Consumables	Included in PLM?	Recommended maintenance task
Ensure capacity / head	Shaft	Stainless steel	Wear	—	○	PT, VT
			Corrosion (pitting, etc)		○	PT, VT
			High cycle fatigue crack		○	PT, VT
	Intermediate shaft joint	stainless	Corrosion (pitting, etc)	—	○	PT, VT
			Corrosion (pitting, etc)		○	PT, VT
Maintain boundary	Gland packing	—	Property change	○	—	Replacement

Incorporation

Summary Sheet of Ageing Mechanisms defined by AESJ¹⁾

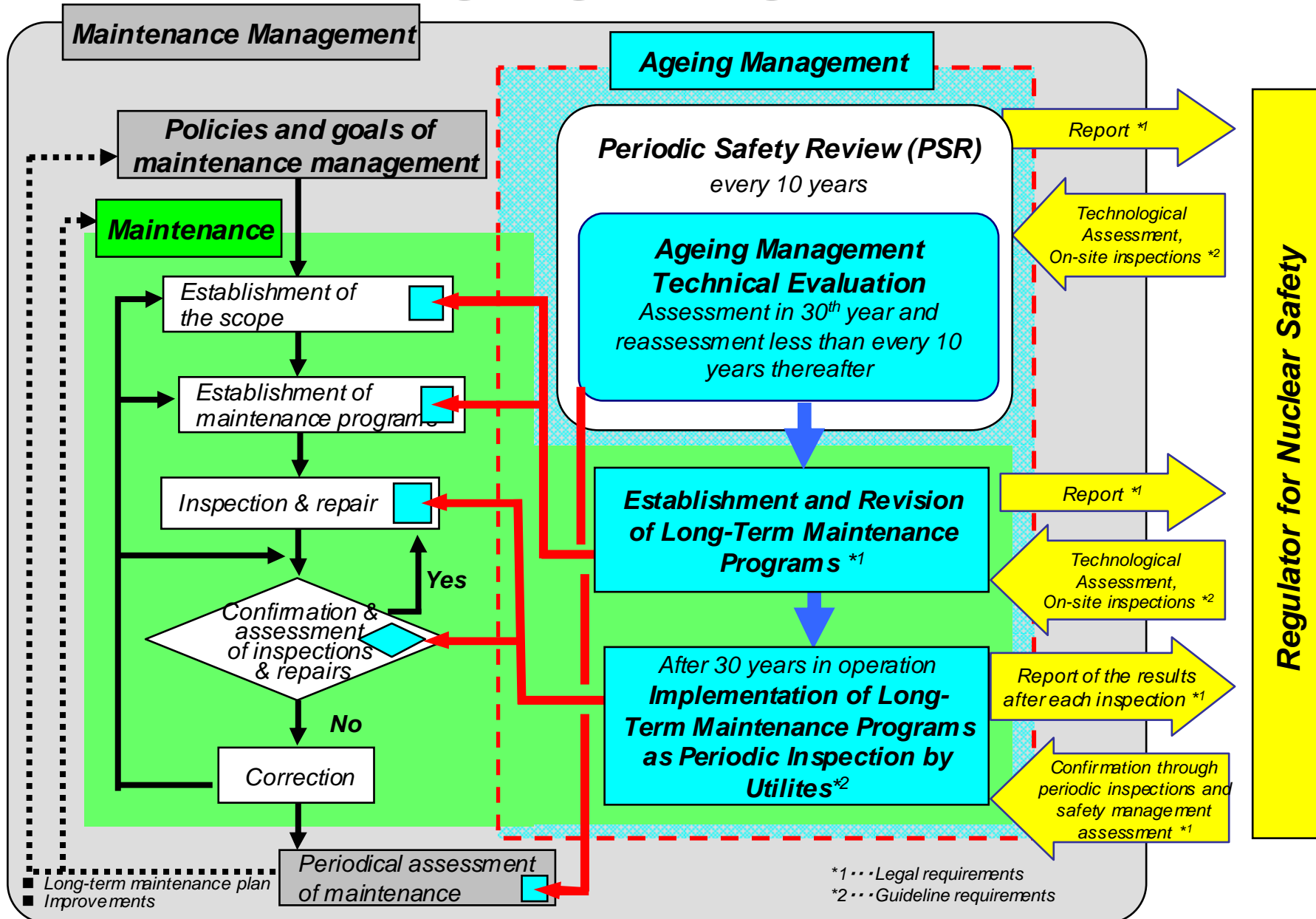
Complied through the experience of AMTE in 14 plants in Japan (7 PWRs and 7 BWRs)

1) AESJ: Atomic Energy Society of Japan

Maintenance Action Plan in Each Plant

Develop inspection plan based on evaluation results

Current Safety Regulation for Maintenance and Ageing Management



Regulatory Guidelines, Standard Review Plan and Review Manuals for Ageing Management and Technical Evaluation



- Ageing Management
Implementation Guideline**
- Scope of the Guideline
 - Implementation, Reevaluation and Revision of the Ageing Management Technical Evaluation (AMTE)
 - Establishment, Reevaluation and Revision of Long-Term Maintenance Program (LTMP)
 - Verification Processes of AMTE and LTMP by the Regulatory Authority
 - Publication of the results of the Review by the Regulatory Authority and Other Matters
 - Application of this Guideline
 - Actions for Progress

- Standard Review Plan for
Ageing Management
Technical Evaluation**
- Purpose
 - Objectives
 - Detailed Review Procedures of AMTE
 - NISA: Review and Site Audit, Report to AMTE-WG
 - JNES: Report Detailed Review Results on the Technical Evaluation
 - Points of View and Criteria for Reviews
 - Confirmations for Periodical Safety Review

- Age-related Technical
Evaluation Review Manual**
- Neutron Irradiation Embrittlement or Reactor Pressure Vessel
 - Stress Corrosion Cracking (SCC)
 - Fatigue
 - Thinning of Piping
 - Insulation Degradation of Electrical Cables of Instruments and Control Facilities
 - Strength and Shielding Capability Degradation of Concrete
 - Seismic Safety Evaluation
 - View point and Understanding of Approaches to Prevention for Organization Culture Degradation

Review Processes of AMTE (Ageing Management Technical Evaluation) by NISA&JNES



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HAMAOKA-1 1F-FUKUSHIMA-3

***Ageing Management
Technical Evaluation
Report by Utilities***



***Working Group on Ageing Management in
NISA discusses review processes of AMTE***



***AMTE Audit in site by NISA &
JNES***

3. Progress Aging Management Activities under the New Regulatory Inspection System in Japan

- Regulatory requirements for enhancing
ageing management activities -***

“Summary Sheet of Ageing Mechanisms” by Standard Committee in Atomic Energy Society of Japan

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
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)

N o.	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 boundary of	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)	
.	

Ageing Management Actions according to Plant Operational Years

1. Ageing management from the early stage of NPP operation

Effective ageing management can be continually performed since the early stage of operation in accordance with the maintenance program established utilizing the [degradation mechanism identification table \(JEAC 4209-2007\)](#), which incorporates all the contents of the summary sheet of ageing Mechanisms.

2. Ageing management every 10 years within the framework of PSR

The ageing phenomena for which mid-term trend monitoring is effective shall be subject to the investigation.

3. Ageing management before the operation for 30 years and following every 10 years

Among the ageing phenomena to be focused from the AM viewpoint, those for which the AM Technical Evaluation should be performed shall be identified and specified.

4. Knowledge-base Activities for Ageing Management for Safe Long Term Operation of LWRs

Technical Information Basis for Ageing Management

Ageing Management

- Ensuring the safety and reliability of NPPs
- Implementation of effective safety regulations
- Establishment of maintenance technologies
- Formulation of evaluation standards and methods
- Accumulation and utilization of knowledge and data

Development of Technical Information Basis

Reflection of necessity, importance, and urgency of R&D

2. Research and Development

- ① Inspection and monitoring technologies
- ② Preventive maintenance, and repair technologies
- ③ Evaluation technology for materials degradation

1. Technical Information

- ① Umbrella aging information
- ② Plant operation experiences
- ③ Scientific information, etc.

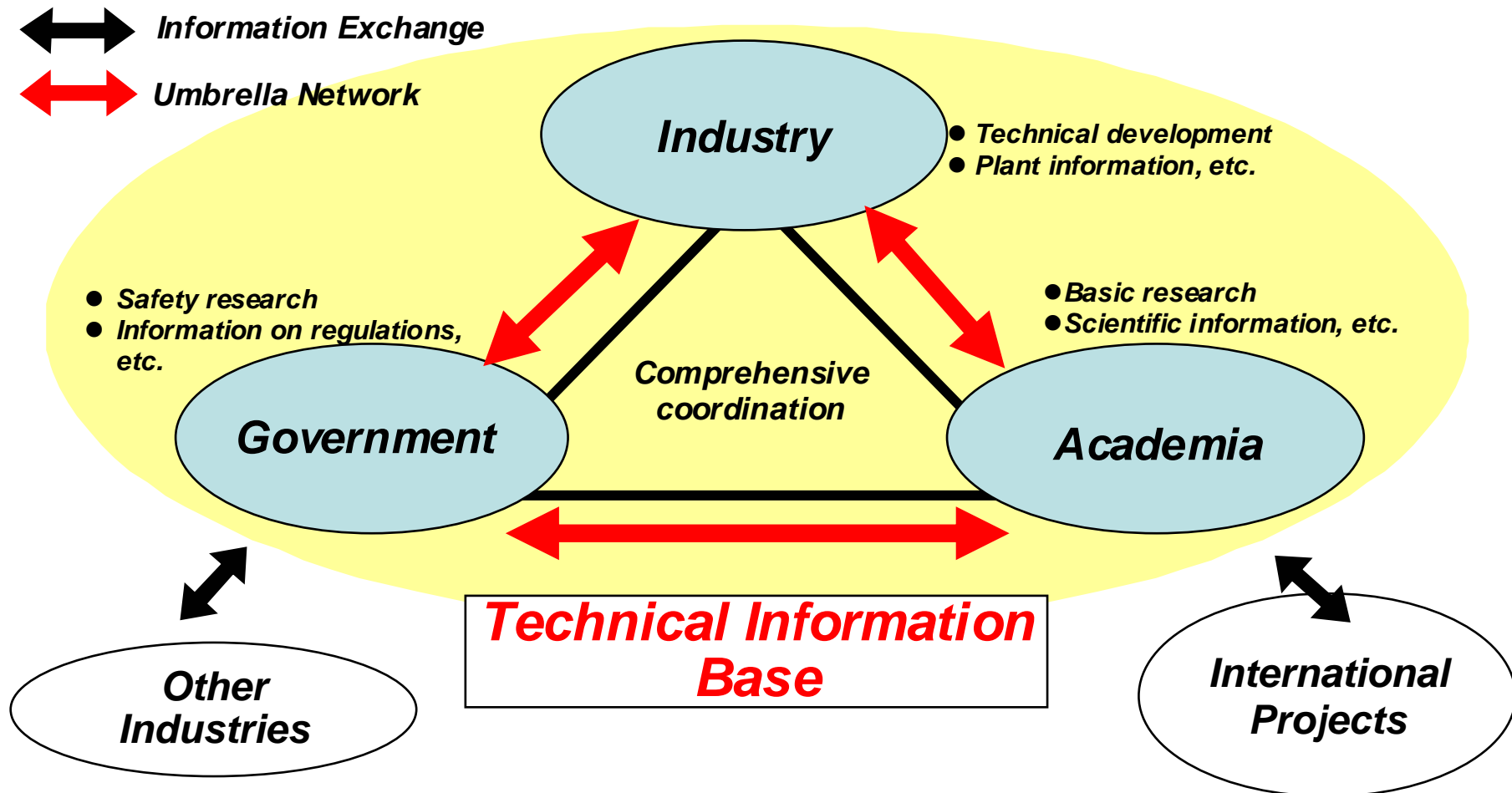
Reflection of Investigation and R&D results

<http://www.agingdb.jp/>

Synthetic Technical Information Basis

Sharing and utilization by industry, government and academia

A Coordinating Committee on Ageing Management was established with members from industries, utilities, research organization and regulatory authorities.



Major Roles of Industries, Government and Academia for Ageing Management

Academia

- Responsibility to contribute to safety research activities
 - to accumulate and expand fundamental knowledge
 - to keep human resources through the safety research

Government

- Responsibility to establish and improve safety regulations
 - by conducting safety researches,
 - by keeping infrastructure
- Responsibility to promote nuclear energy for national energy security

Industries

- Primary responsibility to keep safe operation of power plants
 - research and development, and development of the infrastructure for safety and public interests

Academic Societies

- To develop, review strategy maps periodically and build a consensus with experts from industries, government and academia
 - by identifying important issues to be solved
 - by discussing roles of stakeholders for rational and efficient implementation of research
- To develop and improve codes and standards based on safety research outcome

Strategy Maps 2008 for Ageing Management

Maps for Technical Issues

4. Systematic Maintenance			
3. Establishment of Information Basis			
2. Establishment of Codes and Standards			
1. Safety Research to Solve Ageing Issues			
Ageing phenomenon	Current Status	40 th to 50 th year	Long-life, next-generation reactor
<i>Irradiation embrittlement</i>	* Counter measures are being taken by rule of thumb based on plant data.	* Predication methods and monitoring technology will be upgraded.	* Advanced designs will be developed based on past operating experience.
<i>Stress corrosion cracking</i>	* Counter measures suited to materials in use are being taken. * Database is being constructed.	* Use of SCC-resistant materials will be ensured. * Database will be constructed.	* Simulation methods will be established. * ISI technology will be upgraded.
<i>Fatigue</i>	* Counter measures suited to materials in use or environment are being taken, and database is being constructed.	* Counter measures suited to materials in use or environment will be taken, and database will be constructed.	* Counter measures suited to materials in use or environment will be taken, and database will be constructed.
<i>Wall thinning</i>	* Counter measures suited to materials in use are being taken, and database is being constructed.	* Mechanism-based predication methods will be established. * Risk-based maintenance methods will be established.	* Monitoring technology will be upgraded.
<i>Deteriorated cable insulation</i>	* Counter measures suited to materials in use are being taken. * Database is being constructed.	Deterioration diagnosis technology will be upgraded.	* Monitoring technology will be upgraded.
<i>Decreased strength of concrete</i>	Intensive study is being made on scarcely known fields.	The reliability of integrity evaluation methods will be improved or enhanced. CCV integrity evaluation methods will be established.	* Past records of performance will be reflected in the maintenance technology and durability designs for new plants. * Recycling methods will be established for replaced structures and materials.

Strategy Maps 2008 for Ageing Management Roadmaps for Stress Corrosion Cracking

6. Repair & Replacement Technologies

5. Monitoring Technologies on SCC

4. Inspection Technologies on SCC

3. Integrity Evaluation : NiSCC

2. Integrity Evaluation : IGSCC

1. Integrity Evaluation : IASCC

Fiscal Year	Phase I (until 40 year operation of early stage NPPs)					Phase II (until 50 year operation)						Phase III (until 60 year operation)
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015~2019	2020~2029
Preparation and refinement of initiation data and crack growth data on IASCC	IASCC initiation test methods											
	Extended IASCC crack initiation data and its refinement											
						Extended IASCC crack growth data and its refinement						
						Correlation between laboratory data and field events						
						Obtaining of crack growth data for ex-plant materials						
Preparation of infrastructure for IASCC research Preparation and refinement of initiation data and crack growth data on IASCC						In-core IASCC Initiation and growth evaluation						
						Refurbishment of laboratory facility including JMTR						
Confirmation of the data and evaluation technology, and preparation of regulatory criteria	IASCC evaluation technology confirmation					Understanding and modeling of IASCC crack						
Understanding of IASCC mechanism	Study of accelerated irradiation validity											
						Understanding and modeling of IASCC crack initiation and growth mechanism						Study of IASCC mechanism at high fluence region
Simulation technology of IASCC initiation and propagation						Development of simulation technology of IASCC initiation and growth						

Strategy Maps 2008 for Ageing Management Roadmap of Research and of Code Development for IASCC

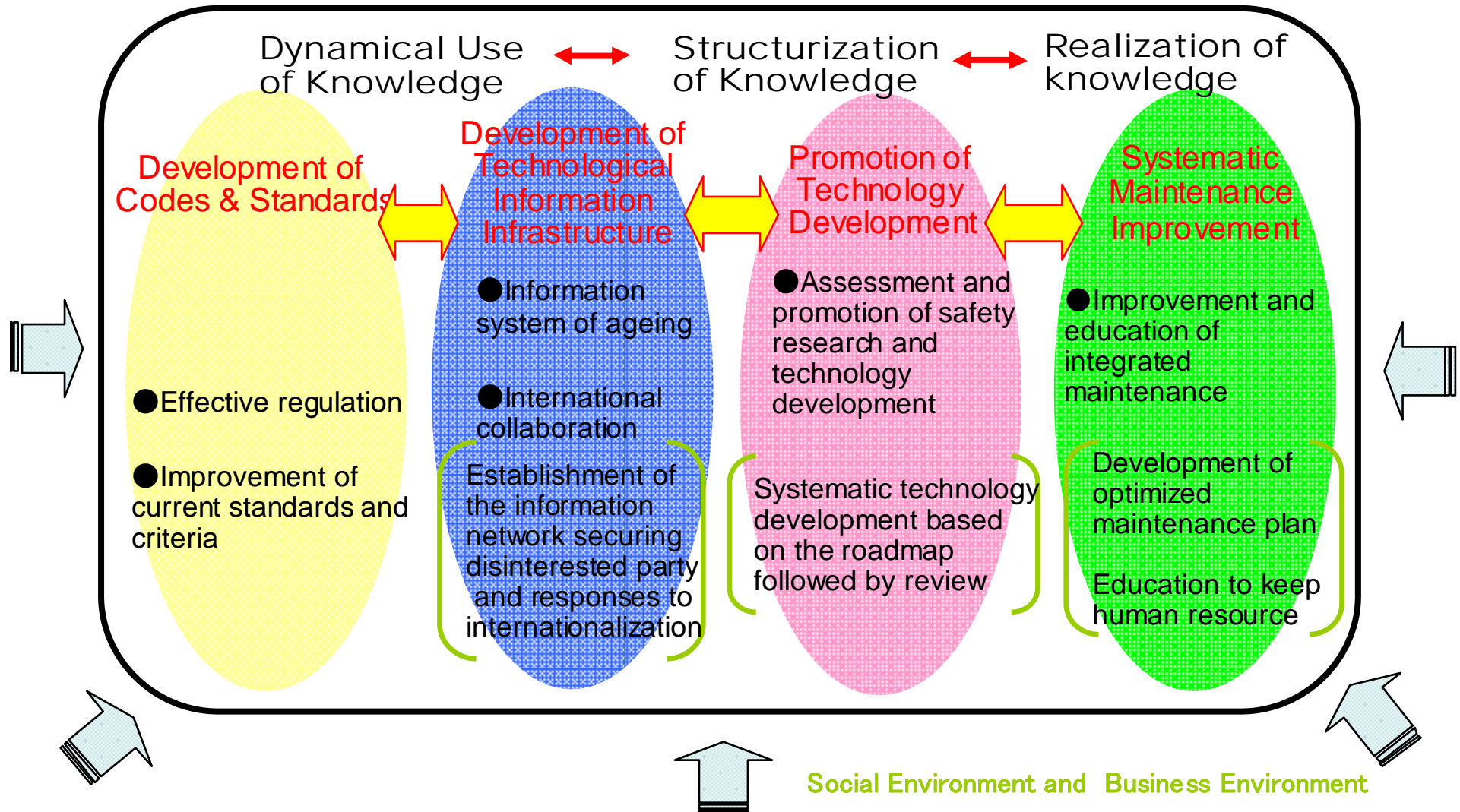
	Phase I (until 40 year operation of early stage NPPs)					Phase II (until 50 year operation)						Phase III (until 60 year operation)	
Fiscal Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015~2019	2020~2029	
Preparation and refinement of initiation data and crack growth data on IASCC	IASCC initiation test methods												Stake holder's Roles for AM Industry Government Academia Academic Societies
	Extended IASCC crack initiation data and its refinement												
	Extended IASCC crack growth data and its refinement												
	Correlation between laboratory data and field events												
	Obtaining of crack growth data for ex-plant materials												
Preparation of infrastructure for IASCC research Preparation and refinement of initiation data and crack growth data on IASCC	Refurbishment of laboratory facility including JMTR					In-core IASCC Initiation and growth evaluation							
	IASCC evaluation technology confirmation			Understanding and modeling of IASCC crack									
Confirmation of the data and evaluation technology, and preparation of regulatory criteria	Study of accelerated irradiation validity					Study of IASCC mechanism at high fluence region							
	Understanding and modeling of IASCC crack initiation and growth mechanism					Study of IASCC mechanism at high fluence region							
Understanding of IASCC mechanism	Development of simulation technology of IASCC initiation and growth					Development of simulation technology of IASCC initiation and growth							
	Development of simulation technology of IASCC initiation and growth					Development of simulation technology of IASCC initiation and growth							
Simulation technology of IASCC initiation and propagation	Establishment of CS for fitness-for-service					Establishment of CS for fitness-for-service							
	IASCC integrity evaluation guide					Coding of IASCC initiation and growth simulation							
	IASCC integrity evaluation guide					SCC long term integrity evaluation guide							
	IASCC integrity evaluation guide					SCC long term integrity evaluation guide							
Establishment of code and standards, and regulatory criteria	Establishment of CS for fitness-for-service					Establishment of CS for fitness-for-service							
	IASCC integrity evaluation guide					Coding of IASCC initiation and growth simulation							
	IASCC integrity evaluation guide					SCC long term integrity evaluation guide							
	IASCC integrity evaluation guide					SCC long term integrity evaluation guide							

Recent Progress of Research Coordination and Safety Research Projects in Japan

- ***A Coordinating Committee on Ageing Management was established with members from industries, utilities, research organization and regulatory authorities.***
- ***Research Projects on Fundamentals of Ageing Management funded by NISA started from 2006 in 4 districts in Japan.***
- ***Organized R&D projects by Utilities have started.***

Basic Structure of the Strategy Maps

Academic Meaning of the Strategy Maps



Summary : Infrastructure for Ageing Management

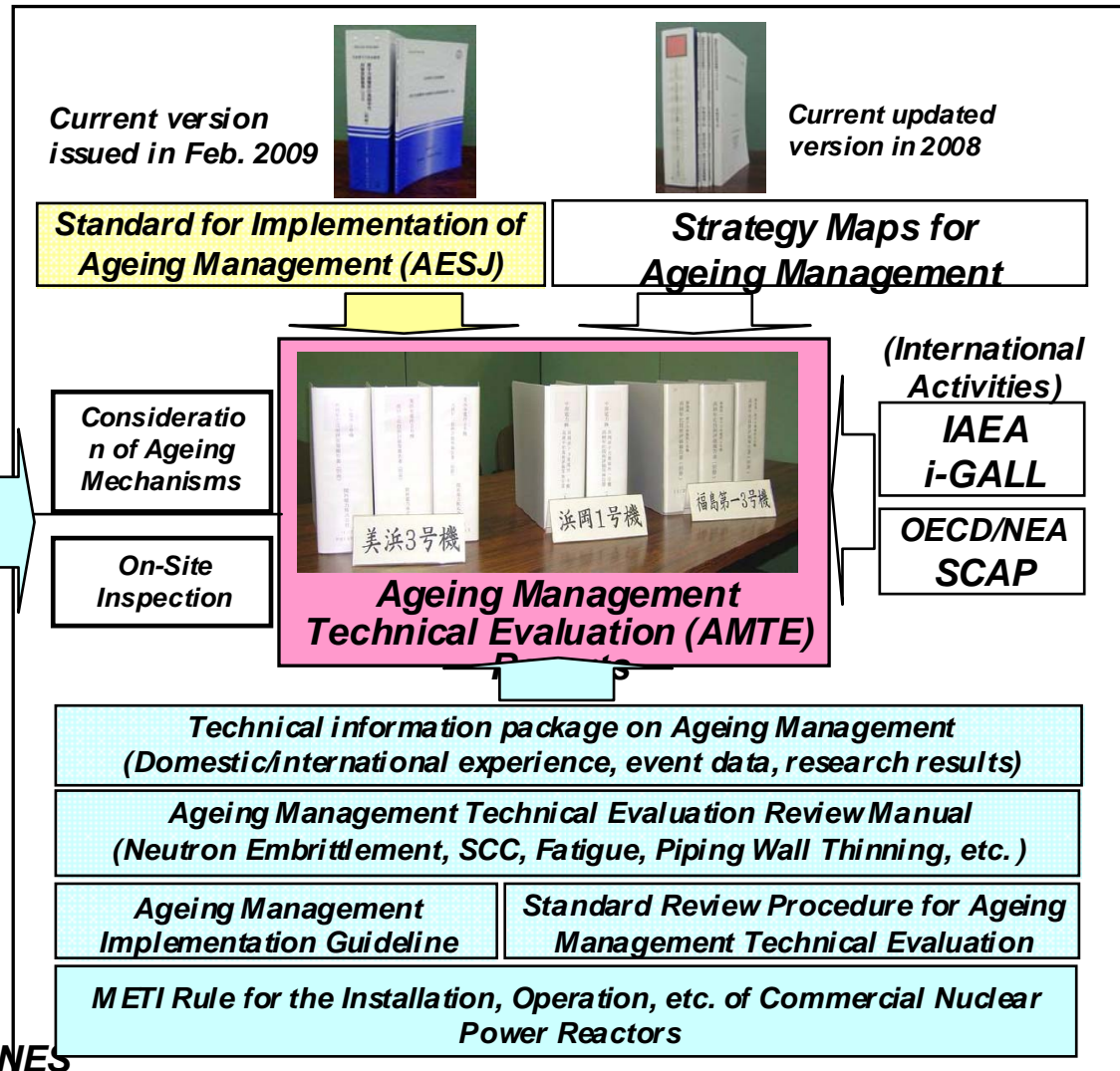
1. **Basic Policy on Aged Nuclear Power Plants (August ,1996)**
2. **Enhancement of Ageing Management at Reactor Facilities (August, 2005)**
3. **Introduction of New Inspection System based on Maintenance Program (January 1, 2009)**



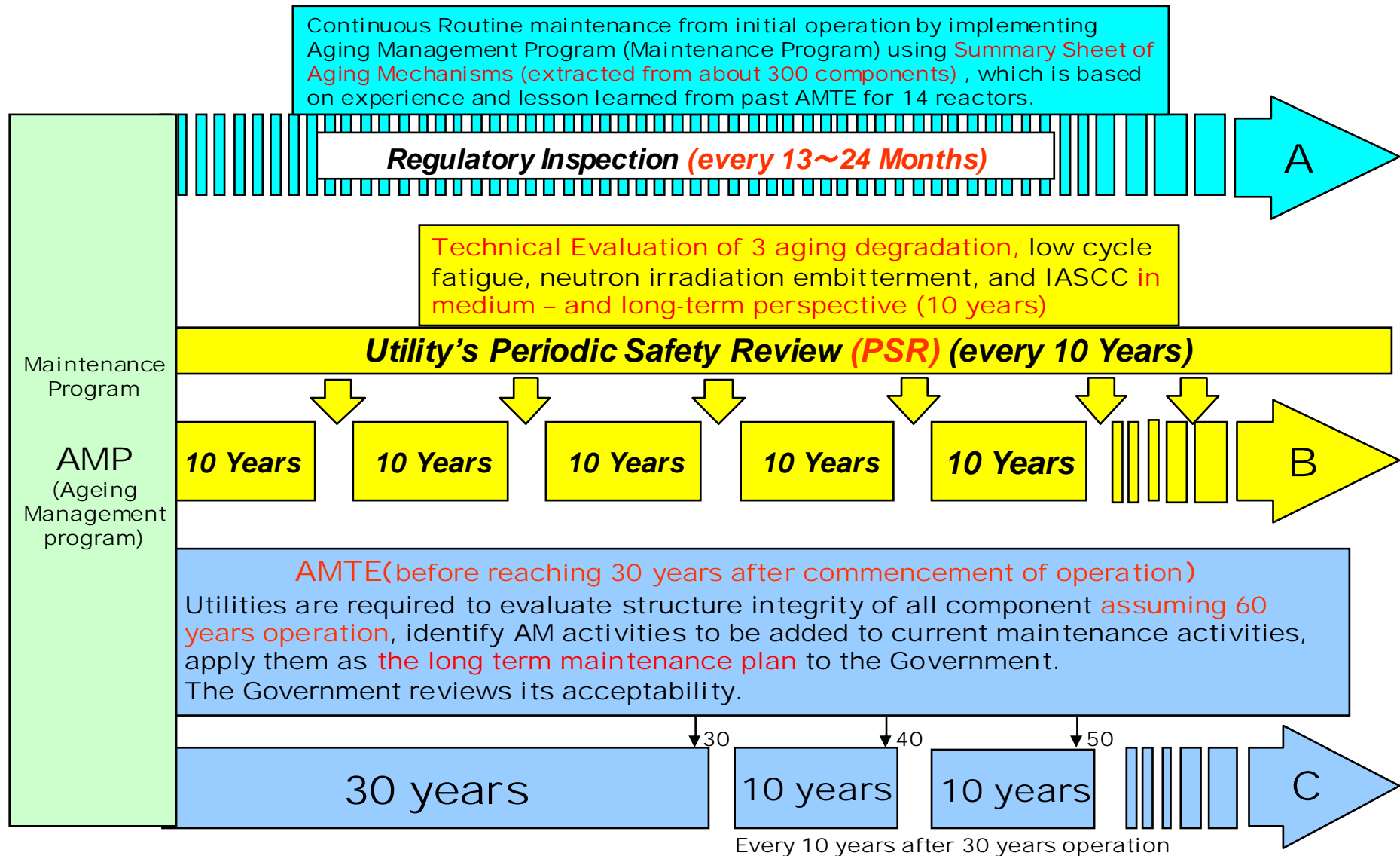
Committee on Ageing Management



Site Audit for AMTE Review by NISA & JNES



Aging Management Regulatory Framework in Japan (Regulatory Inspection, Periodic Safety Review and Ageing Management Technical Evaluation)



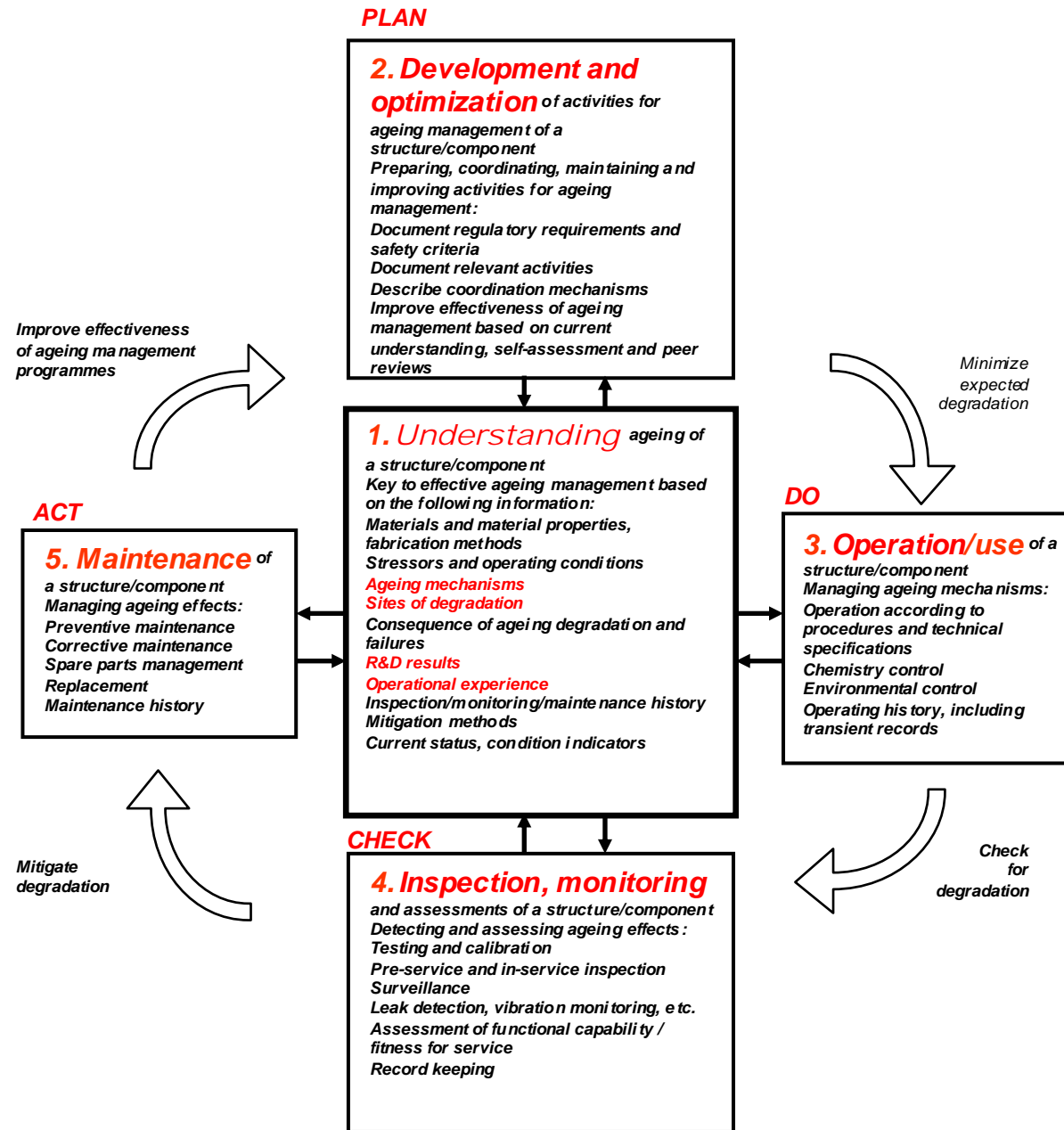


FIG.1. Systematic approach to manage ageing of a structure or component

TABLE 2 *GENERIC ATTRIBUTES OF AN EFFECTIVE AMP*

<i>Attribute</i>	<i>Description</i>
1. Scope of the ageing management programme based on understanding ageing	<ul style="list-style-type: none"> ▪ Structures (including structural elements) and components subject to ageing management; ▪ Understanding of ageing phenomena (significant ageing mechanisms, susceptible sites): <ul style="list-style-type: none"> -Structure/component materials, service conditions, stressors, degradation sites, aging mechanisms and effects; -Structure/component condition indicators and acceptance criteria; -Quantitative or qualitative predictive models of relevant aging phenomena
2. Preventive actions to minimize and control ageing degradation	<ul style="list-style-type: none"> ▪ Identification of preventive actions ▪ Identification of parameters to be monitored or inspected; ▪ Service conditions (i.e. environmental conditions and operating conditions) to be maintained and operating practices aimed at slowing down potential degradation of the structure or component
3. Detection of ageing effects	<ul style="list-style-type: none"> ▪ Effective technology (inspection, testing and monitoring methods) for detecting ageing effects before failure of the structure or component
4. Monitoring and trending of ageing effects	<ul style="list-style-type: none"> ▪ Condition indicators and parameters monitored; ▪ Data to be collected to facilitate assessment of structure or component ageing; ▪ Assessment methods (incl. data analysis and trending);
5. Mitigating ageing effects	<ul style="list-style-type: none"> ▪ Operations, maintenance, repair and replacement actions to mitigate detected ageing effects / degradation of structure/component.
6. Acceptance criteria	<ul style="list-style-type: none"> ▪ Acceptance criteria against which the need for corrective action is evaluated
7. Corrective actions	<ul style="list-style-type: none"> ▪ Corrective actions if a component fails to meet the acceptance criteria
8. Operating experience feedback and feedback of R&D results	<ul style="list-style-type: none"> ▪ Mechanism that ensures timely feedback of operating experience and R&D results (if applicable), and provides objective evidence that they are taken into account in the ageing management programme
9. Quality management	<ul style="list-style-type: none"> ▪ Administrative controls that document the implementation of the ageing management programme and actions taken; ▪ Indicators to facilitate evaluation and improvement of the ageing management programme; ▪ Confirmation (verification) process for ensuring that preventive actions are adequate and appropriate and all corrective actions have been completed and are effective ▪ Record keeping practices to be followed

Future Activities for Ageing Management and Maintenance of Light Water Reactors

(1) Implementation of New Regulatory Inspection System

- *Requirement to prepare the maintenance plan based on previous events and ageing issues*
- *Requirement to submit the maintenance plan for review and approval by regulators*
- *Requirement to perform in-service monitoring using applicable new technologies*

(2) Continuous Revision of Strategy Maps for Ageing Management

- *Improvement of Technical Information Basis*
- *Promotion of Safety Research*
- *Development and Endorsement of Codes and Standards*
- *Maintenance Optimization and Human Resources*

(3) International Cooperation and Joint Research Collaboration

- *International standardization through the involvement in OECD/NEA SCAP, IAEA I-GALL and other international initiatives*
- *Information exchange with the US NRC, France IRSN and other regulatory agencies*
- *International joint research, such as neutron irradiation testing in Halden, JMETR and others*

(4) Application of Current Ageing Management Experience to Design Activities of New Generation Light Water Reactor

- ***National project to design 1800MWe PWR and BWR for 80 years operation***

Thank you very much.