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PLANT LIFETIME MANAGEMENT AND RESEARCH PROGRAM

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1. INTRODUCTION

The importance of nuclear power generation has been increasing in Japan. Because the lower generation cost and more stable fuel supply, in comparison with the case of fossile plants, are beneficial to Japan which has scarce natural resources. In addition, nuclear power generation is expected to help reduce carbon dioxide emission which causes global warming.

In these circumstances, the safe and stable operations of nuclear power plants are of prime importance, and the frequency of unscheduled shutdown has been kept low in Japan as a result of thorough periodic inspections supported by aging management.

This paper covers the development process of the aging management program and related research programs in The Kansai Electric Power Co., Inc. (KEPCO).

KEPCO runs 11 nuclear power units (PWR). Table 1 shows the commencement date of commercial operation and operating hours for each unit. The early plants, such as Mihama #2 Unit, have been operated for more than 100,000 hours and are in the phase of aging management.

Accordingly, we have been conducting aging management programs since 1987, in order to identify age-related degradation and work out countermeasures.

Table 1 Date of Commercial Operation and Operating Hour of KEPCO's Nuclear Power Plants (As of September, 1992)

Name of Plant	Date of Commercial Operation	Operating Hours
MIHAMA #1	November 28, 1970	89,000
MIHAMA #2	July 25, 1972	105,000
MIHAMA #3	December 1, 1974	101,000
TAKAHAMA #1	November 14, 1974	94,000
TAKAHAMA #2	November 14, 1975	90,000
TAKAHAMA #3	January 17, 1985	56,000
TAKAHAMA #4	June 5, 1985	54,000
OHI #1	March 27, 1979	66,000
OHI #2	December 5, 1979	83,000
OHI #3	December 18, 1991	7,000
OHI #4	February, 2, 1993	-

2. AGING MANAGEMENT PROGRAM

2.1 Outline of Aging Management Program

The purpose of our aging management programs is to identify age-related degradation, evaluate component life and put the results into maintenance plan. To achieve this purpose, the program comprises the following four tasks:

(1) Selection of important components
(2) Identification of important degradation modes
(3) Life assessment
(4) Countermeasures in maintenance

Fig. 1 shows the process chart of the aging management program.

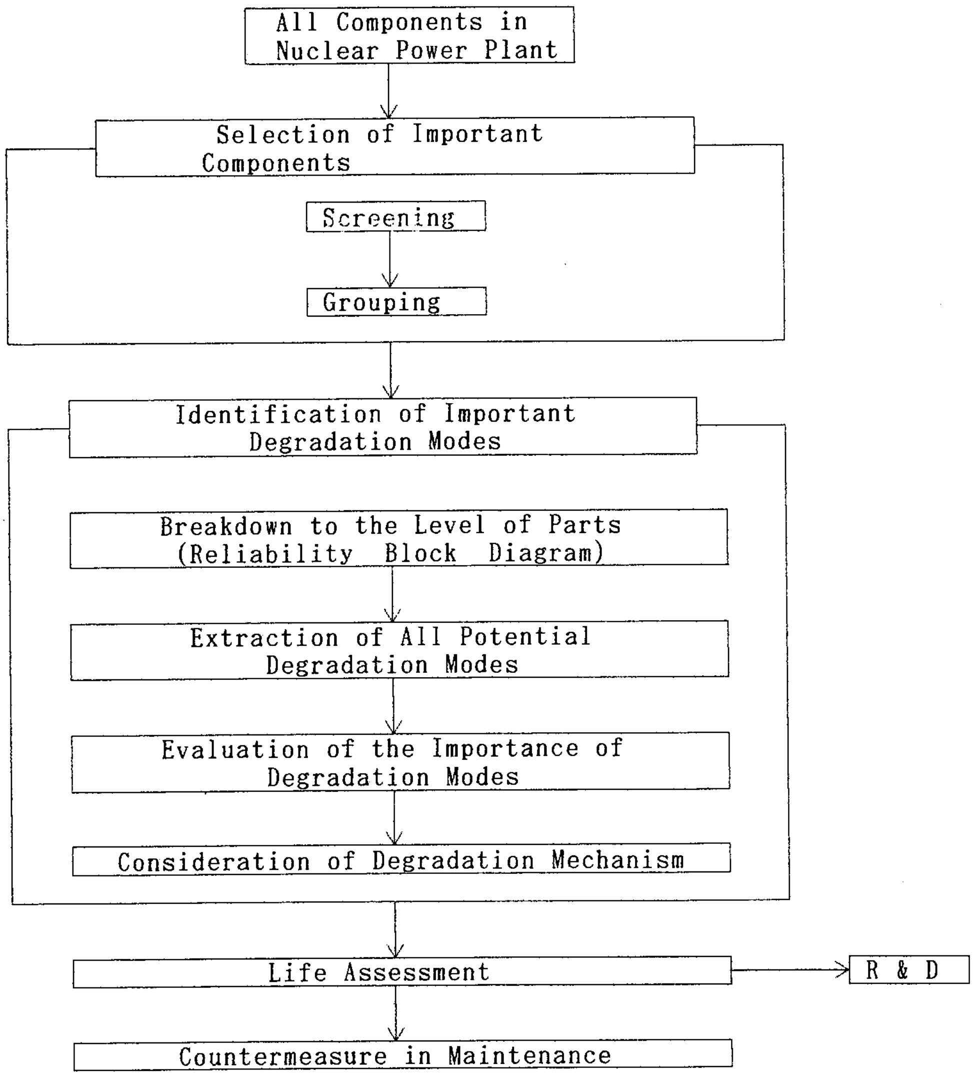

Fig. 1 Process Chart of Aging Management Program

2.2 Selection of Components

A nuclear power plant consists of approximately 2,300 kinds of components. From these, important components were selected as shown below.

2.2.1 Screening Criteria for Important Components

The following three criteria were applied to all the components.

(1) Components whose failure would impact on plant safety, cause

immediate shutdown or cause the limitation of power supply.
(2) Components whose failure would cause a long period for repair or replacement.
(3) Components whose failure would cause much radiation exposure for repair or replacement.

(1) criterion was applied to all the components for the first priority. Then (2) and (3) criteria were applied to the remaining ones for the second priority.

2.2.2 Grouping

Selected components were classified into similar groups, and representative ones were selected from each group. The following classification conditions were taken into account.
(1) Types (pumps, valves, pipes, high-pressure vessels etc.)
(2) Materials (carbon steel, stainless steel etc.)
(3) Operating conditions (water chemical, temperature, pressure, etc)

Fig. 2 is the example of the important components selected as a high pressure vessel or tank. In this group, the reactor vessel and pressurizer were selected as representatives in view of high temperature and high pressure.

Type	Component or Structure	Material	Environment			
			Irradia-tion	Water Chemistry	Temp. [°C]	Pressure [Kg/cm²]
High Pressure Vessel or Tank	Reactor Vessel	Low Alloy Steel with stainless overlay	YES	Primary Water	343	157
	Pressurizer	Same as Reactor Vessel	NO	Same as R/V	360	157
	Accumulator	Same as Reactor Vessel	NO	Same as R/V	150	50
	Boron Injection Tank	Same as Reactor Vessel	NO	Same as R/V	150	2

Fig. 2 Example of Selected Important Component

2.3 Identification of Important Degradation Mode

For the representative components selected as shown in 2.2, important degradation modes were identified as follows.

2.3.1 Breakdown to the Level of Parts

Selected components were broken down to the level of parts by means of reliability block diagrams. Fig. 3 shows the example of the reliability block diagram of a reactor vessel.

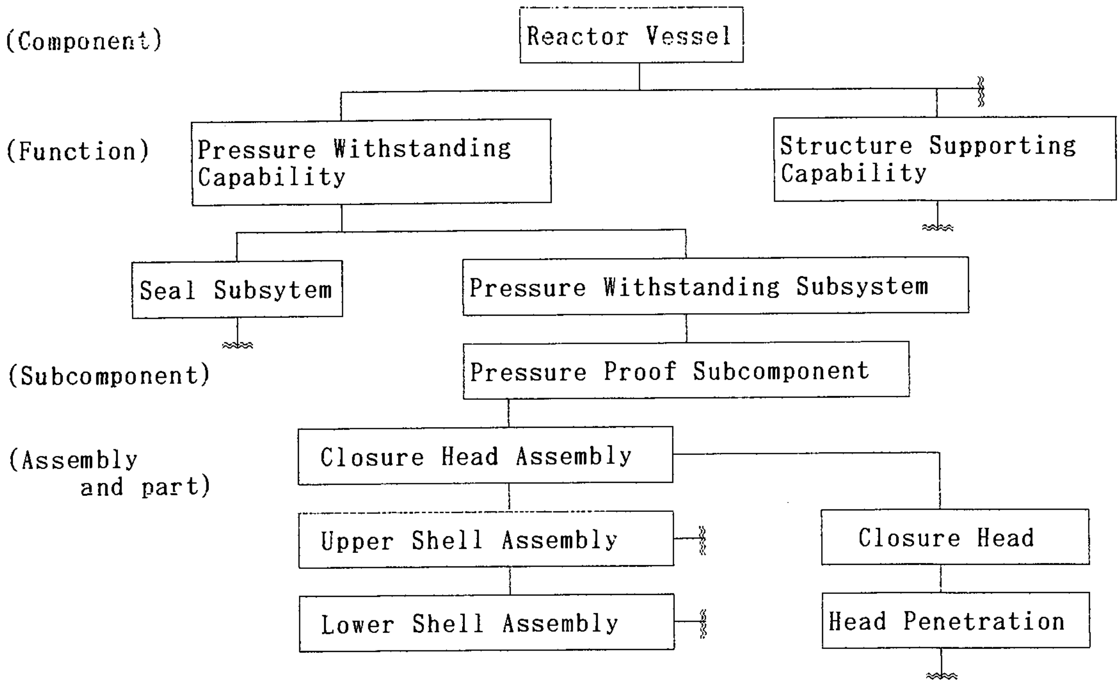

Fig. 3 Example of Reliability Block Diagram of Reactor Vessel

2.3.2 Identification of Important Degradation Modes

For each part, all possible degradation modes were extracted based on all available information such as design documents, malfunction records and research papers. Then, important degradation modes were selected in view of the effect on plant operation, the probability of degradation occurrence and the difficulty in maintenance. The part of important degradation modes of the Reactor Vessel is shown in Fig. 4 .

Part	Function	Degradation Mode	Importance Evaluation			
			E*1	P*2	D*3	Rank
Closure Head	Pressure Proof	Fatigue	A	B	A	0
		Corrosion	C	A	A	0
Head Penetration		Fatigue	A	B	A	0
		PWSCC	A	A	A	1
Lower Shell		Embrittlement	A	A	A	1

A: Large
B: Medium
C: Small

0: Not important
1: Important

*1: Effect on plant operation　*2: Probability of occurrence　*3: Difficulty in maintenance

Fig. 4 Example of Identification of Important Degradation Modes

2.4 Life Assessment

Component life was assessed as to each degradation mode identified in 2.3. Typical life assessment method which have been applied are inspection data trend analysis, statistical data analysis, analysis such as stress analysis, fatigue analysis, fracture mechanical analysis and so on. The following examples are some of them.

2.4.1 Example of inspection data trend

In degradation modes whose mechanism are clear and whose progresses depend on time, degradation data trend analysis was conducted. Fig. 5 is an example of inspection data trend analysis, concerning the erosion of the piping of the secondary system in PWR.

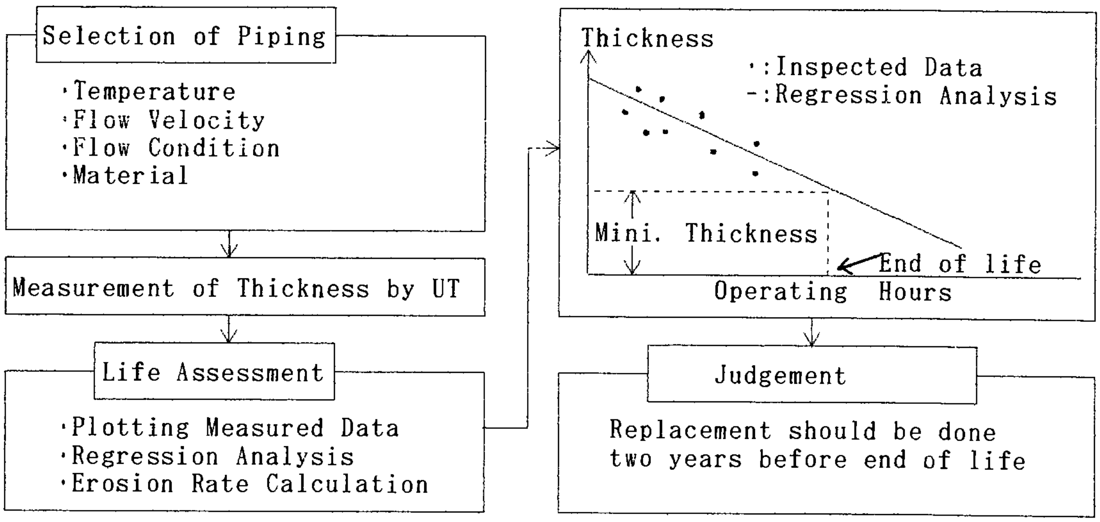

Fig. 5 Example of Life Assessment (Piping Erosion)

2.4.2 Example of Analysis

The life of a low pressure turbine rotor was assessed by the combination of experimental data, actual inspection data and fracture mechanical analysis as shown in Fig. 6. It is the example of stress crrosion crack growth.

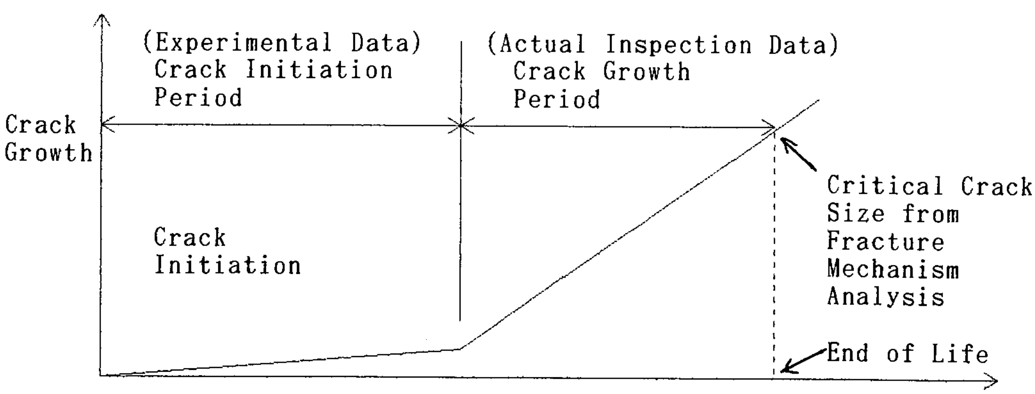

Fig. 6 Example of Life Assessment (Turbine Rotor)

3. Research and Development

As shown above, important degradation modes were checked if they had the life assessment methods. Unless any of them had the life assessment methods, the proper research and development programs were planned and carried out. The follow reseach and development are a portion of KEPCO's program which have been carried out.

- Radiation embrittlement of reactor vessel
- Fatigue of stainless steel
- Development of fatigue monitoring system
- IGA of S/G
- SCC of turbine rotor
- SCC of closure head penetration of R/V
- Repair equipment of closure head penetration of R/V
- Thermal embrittlement of dual phase stainless steel

4. CONCLUSION

The aging management programs have ensured safe and stable operation of nuclear power plants.

Each result of the lifetime assessment has provided us with the information which helps establish maintenance programs. For example, the result of the lifetime assessment has been reflected to the intervals of overhaulings and inspections, and the replacement timing of some components.

As the future plan, we should review our activities of aging management which have been carried out, and should focus lifetime assessment on components which give us difficulties in inspections because of high radiation exposure or high inspection cost.

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