Failure Rate Prediction of Active Component Using PM Basis Database

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1. Introduction

The safety security and efficient management of NPPs (Nuclear Power Plants) have been increased after the accident of TEPCO's Fukushima nuclear power stations. The needs for the safety and efficiency are becoming more important because about 90 percent of the NPPs all over the world are more than 20 operation years old [1]. The preventive maintenance criteria need to be flexible, considering long-term development of the equipment performance and preventive maintenance.

The PMBD (Preventive Maintenance Basis Database) program was widely used for optimization of the preventive maintenance criteria. PMBD program contains all kinds of failure mechanisms for each equipment that may occur in the power plant based on RCM(Reliability-Centered Maintenance) and numerically calculate the variation of reliability and failure rate based on PM interval changes[2].

In this study, propriety evaluation of preventive maintenance task, cycle, technical basis for cost-effective preventive maintenance strategy and an appropriate evaluation were suggested by the case application of PMBD for major components in the NPPs.

2. Overview of PMBD

2.1. Definition and Objective of PMBD

PMBD is the program developed by EPRI to develop, document and manage the preventive maintenance strategy of plant components. The objective of this program is to propose the PM optimization through analysis of future failure rate changes based on PM activities/adjustment of active components. PMBD addresses the following characteristics of total 33 kinds including 152 components.

- Failure Location
- Degradation Mechanism
- Degradation Influence
- Failure Timing
- Discovery Method

2.2. Vulnerability Analysis Method

PMBD consists of 7 tabs (Template Data, PM Basis, Vulnerability, Definition, Failure Location, Apparent Cause, Cause Evaluation). Among these tabs, the vulnerability tab performs a key function of PMBD that calculates the changes in failure rate and reliability numerically, if the execution of preventive maintenance tasks or cycles is changed.

3. PMBD Application

3.1. Pump-Horizontal

The analysis was implemented for the preventive maintenance strategy by applying PMBD to the horizontal pump, which is a typical pump in NPPs. First, the domestic preventive maintenance template and EPRI PMBD were compared. Second, failure rate changes were calculated depending on the PM and cycle change. Finally, an analysis was performed to predict G-Factor depending on the cycle set-up of preventive maintenance task which were originally AR (As Required) cycle.

3.1.1 A Comparison with Domestic Preventive Maintenance Template (PMT) and EPRI PMBD

Functional importance of horizontal pumps is designed as CHS (Critical/High/Severe), and changes in failure rate and reliability were calculated based on the domestic PMT and EPRI PMBD using the vulnerability method.

Table I: Comparison of Domestic and EPRI PMBD

PM Task	Domestic	EPRI PMBD
Vibration Analysis	1M	1M
Oil Analysis	3M	3M
Performance Trending	6M	6M
Thermography	6M	6M
Motor Current Trending	**AR**	**3M**
System Engineer Walk down	**3M**	**1Y**
Operator Rounds	1S	1S
Oil Filter Change, Clean and inspect	1F	18M
Coupling Inspection	**2F**	**18M**
Nozzle NDE Inspection	**6F**	**10Y**
Partial Disassembly(AR)	AR	AR
Refurbishment(AR)	AR	AR
Functional Testing(AR)	AR	AR

Failure rate based on the ERPI PMBD was calculated as 0.20 approximately. When applying the domestic preventive maintenance template, the calculation value was 0.18, down to 10 percents, and reliability benefit has risen by 1 percent. In this way, we can verify the suitability and feasibility based on the domestic preventive maintenance template of the horizontal pump.

3.1.2 Failure Rate Changes Depending on PM Tasks

If all PM tasks are performed, the failure rate (when applied domestic PM) was calculated 0.1831 using the vulnerability tab. To calculate the failure rate changes depending on the specific PM, the calculation was performed after eliminating each PM. When compared to baseline, the biggest change in the failure rate was the vibration analysis which increased 2.7 times.

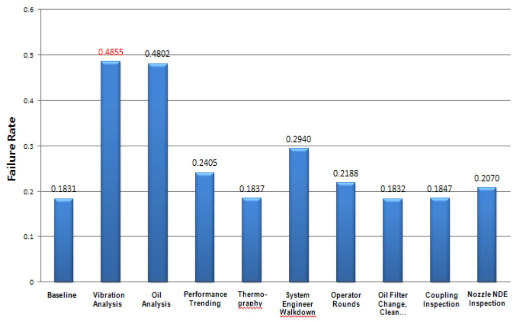


Fig. 1. Failure rate changes of the Horizontal Pump depending on the each preventive maintenance

Therefore the most important PM task of the horizontal pump is vibration analysis, and the next important tasks are oil analysis, and system engineer walkdown.

3.1.3 Failure Rate Changes Depending on the PM Task Interval

The vibration analysis among PM tasks, has the biggest affect and influence on the failure rate of the horizontal pump. Using the vulnerability tab, changes in failure rate and G-Factor were calculated to identify the failure rate changes depending on the PM cycle changes. Here, G-Factor means a parameter that indicating increase/decrease of the failure rate based on PM strategy changes, and figures are shown through the failure rate of changes by 1.0.

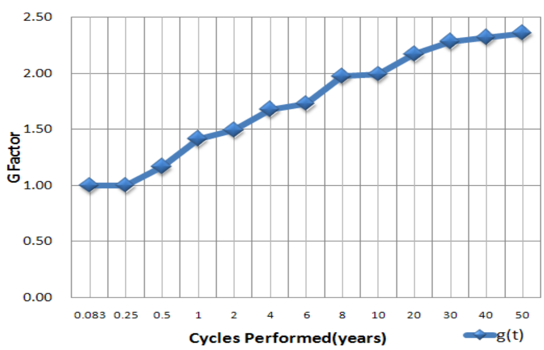
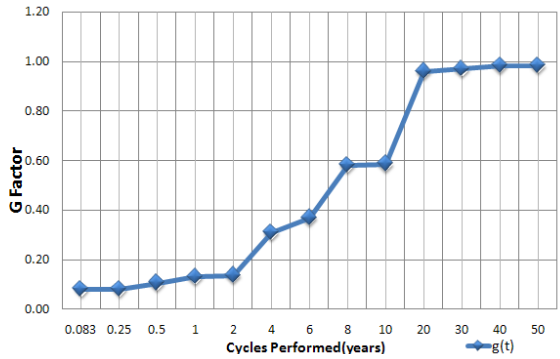


Fig. 2. G-Factor variation according to interval changes of the Vibration Analysis

As can be seen from the graph, vibration analysis indicates the constant G-Factor values for up to three months. After three months, the numerical value is growing. It indicates that vibration analysis based on domestic preventive maintenance cycle is reasonable. And even if the period extends to three months, it does not affect the results of changes in failure rate.

3.1.4 Failure Rate Changes Depending on PM Task which has AR Interval

The refurbishment is performed AR cycle. After setting certain cycle and calculating the G-Factor, the



graph is as follows.

Fig. 3. G-Factor graph depending on interval changes of the refurbishment

When the refurbishment is performed in one month, G-Factor reduced to 0.08, but it is too costly to perform refurbishment in a one month period and is not valid economically. However, if the failure rate is to reduce by half, the period of refurbishment is 7 years adequately. Thus, if a specific facility is to reduce the failure rate, PMBD can be used as a technical basis of period set-up.

4. Conclusion

The ultimate goal of PMBD is to obtain technical information that can be a basis related to life and failure rate of main facilities of NPP and to support the decision making for strategy of preventive maintenance. In this paper, a case study of PMBD application was performed for changes in failure rate and reliability depending on PM tasks and intervals. Thus PMBD can be utilized to develop the cost-effective aspect of PM tasks, and thus contributing of PM optimization is expected.

REFERENCES

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[2] EPRI Project Manager, J McKee, Nuclear Maintenance Applications Center: Preventive Maintenance Basis Database 2.0 User's Guide, pp. 3-18~3-33, 2008.