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Failure and Maintenance Analysis Using Web-Based Reliability Database System

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1. Introduction

Korea Hydro & Nuclear Power Company has lunched the development of a database system for PSA and Maintenance Rule implementation. It focuses on the easy processing of raw data into a credible and useful database for the risk-informed environment of nuclear power plant operation and maintenance. Even though KHNP had recently completed the PSA for all domestic NPPs as a requirement of the severe accident mitigation strategy, the component failure data were only gathered as a means of quantification purposes for the relevant project. So, the data were not efficient enough for the Living PSA or other generic purposes. Another reason to build a real time database is for the newly adopted Maintenance Rule, which requests the utility to continuously monitor the plant risk based on its operation and maintenance performance. Furthermore, as one of the pre-condition for the Risk Informed Regulation and Application, the nuclear regulatory agency of Korea requests the development and management of domestic database system.

KHNP is stacking up data of operation and maintenance on the Enterprise Resource Planning (ERP) system since its first opening on July, 2003. But, so far a systematic review has not been performed to apply the component failure and maintenance history for PSA and other reliability analysis. The data stored in PUMAS before the ERP system is introduced also need to be converted and managed into the new database structure and methodology. This reliability database system is a web-based interface on a UNIX server with Oracle relational database. It is designed to be applicable for all domestic NPPs with a common database structure and the web interfaces, therefore additional program development would not be necessary for data acquisition and processing in the near future. Categorization standards for systems and components have been implemented to analyze all domestic NPPs. For example, SysCode (for a system code) and CpCode (for a component code) were newly introduced for the categorization and statistical treatments such as Common Cause Failure analyses and Bayesian update. The web-based reliability database system would be useful not only for PSA and Risk Informed Application, but for the plant operation and maintenance optimization. Furthermore, the database system would effectively support the development and application of Preventive Maintenance (PM) template, implementation of Maintenance Rule, and Equipment Reliability (ER) improvement program as well.

This study was performed for recent four-year failure and maintenance data of Yonggwang unit 3, 4. Sensitivity analysis with the updated data needs to be performed for the result, later on.

2. Structure of Web-Based Reliability Database System

The first step to design a database system is to identify and define the relationship between entities. This database system has four major parts: Basic data, External data, Failure and maintenance analysis, and Statistic analysis. Figure 1 shows the main flow from the data acquisition to the statistical analysis.

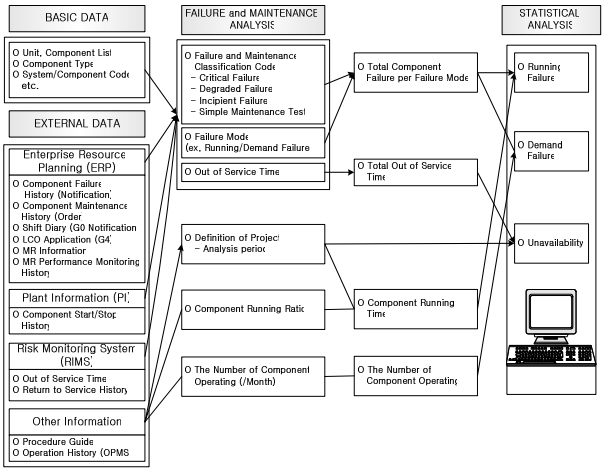

Figure 1. The process of reliability database analysis in web-based reliability database system

Basic data contain the master information such as units, component locations, functional locations (lists), component types, system codes, etc. They were defined and stored when web-based reliability database system was built based on ERP data. Other data from outside of this database system are stored in external data. Their main sources are DREAMS (KHNP ERP system), Risk Monitoring System (RIMS), Plant Information system (PI), and so on. These external data are raw data for the component reliability analysis. Failure and maintenance analysis is analyzing component failure and unavailability with the basic data and the external data. This system lists up the orders or notifications for the component failure and maintenance by users' condition selection. Users evaluate component failure catastrophe (failure classification), failure mode, out of service time, related PSA basic events, etc. The results of failure and maintenance analysis are used as the numerator in failure rate and unavailability calculation for PSA

assessment. For the statistical process, it is also necessary to set the period of time for the analysis, which is called a "Project period." As well as the data such as project period, component operating ratio, the number of monthly mean operational demand are required for each component. They are used as the denominator in failure rate and unavailability calculation. Updating the result with the generic data by Bayesian theorem is called Statistical analysis.

3. Basic Concept for Failure and Maintenance Analysis

Some important concepts and analysis methods for the failure and maintenance analysis in web-based reliability database system are documented below.

3.1 Failure Rate and Unavailability

The failure rate is the frequency that a component fails to operate. It is consisted of running failures and demand failures. The failure rate should be combined with failure modes, but unavailability is not related to the failure modes. A new concept "CalType" was introduced to effectively distinguish the failure rate from failure probability. CalType 1 is for the failure rate per project period. CalType 2 is for the failure rate per component running hour. CalType 3 is for the failure probability per operation demand. CalType 9 is for the unavailability dividing out of service time of a component per project period.

3.2 Failure Mode

The failure mode means the type of functional loss for the components. It was reviewed with the standard component code (CpCode) and the generic database. Additional general failure modes were applied along with the PSA failure modes to use the analysis result not only for PSA, but for other purposes. Table 1 shows an example of the failure modes for motor operated valves.

Table 1. Sample of Failure Mode for MOV

CpCode	FM	DES.	Cal Type	PSA FM	PSA FM _Trans.	DES
(C)MV	C	FTC	13	C	A	Fails to Operate
(C)MV	EL	EL[1)]	1			
(C)MV	I	SO[2)]	1	I		
(C)MV	IL	IL[3)]	1			
(C)MV	O	FTO	13	O	A	Fails to Operate
(C)MV	P	Plug.	1	T		
(C)MV	T	TC[4)]	1	T		

1) EL : External Leakage **2) SO : Spurious Operation**
3) IL : Internal Leakage **4) TC : Transfer Closed**

3.3 Failure and Maintenance Classification Code

Failure and Maintenance Classification Code shows how catastrophic the failure is[1]. The code classifies the component failure into four levels.

1) Critical(Catastrophic) Failure
2) Degraded Failure
3) Incipient Failure
4) Simple Maintenance Test

Figure 2 shows the number of failures of Yonggwang unit 3,4 components for each classification code.

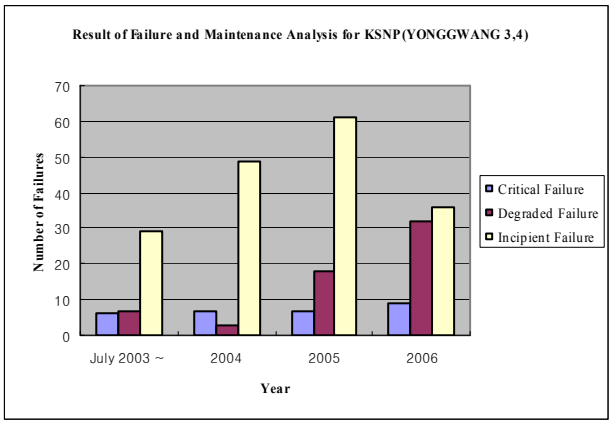

Figure 2. Result of Failure and Maintenance Analysis for KSNP (Yonggwang 3,4)

4. Conclusion and Future Study

A failure and maintenance analysis was performed in this study for the ERP raw data from July, 2003 to December, 2006. 17,512 notifications and orders for PSA related components were analyzed, and the result was sorted by years as shown illustrated Figure 2. Core Damage Frequency will be evaluated after update with the result above, and the value will be compared with the base case.

At this time, reliability data is being analyzed only for Yonggwang unit 3,4 and analysis for all domestic PWR NPPs along with the CANDU NPPs will be followed with this system. This database system and the result will be the essential part for the Preventive Maintenance (PM) template development, Maintenance Rule implementation, and Equipment Reliability (ER) improvement program.

REFERENCES

[1] "Development of Procedure for Collecting and Analyzing Component Reliability Data," KAERI, KAERI/TR-2132, March, 2003.