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Results of study for Maintenance Rule(MR) Implementation at Ulchin units 3&4

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1. Introduction

Korea has initiated two pilot programs to implement the Maintenance Rule(MR) program similar to the United States in 2003. One for the pilot implementation is Kori 3&4 units and another is Ulchin 3&4 units, where Kori 3&4 units are Westinghouse reactor type units and Ulchin 3&4 units are Korean Standardized Nuclear Power(KSNP) Plant units. Pilot implementation study on the KSNP units was initiated in October 2003 and will be completed in September. 2006.

MR implementation processes are consisted of several processes that are scope determination process, safety significance determination process, performance criteria development process, performance monitoring process including data analysis process, disposition process between enforcement monitoring(a(1)) and routine monitoring(a(2)). Up to date, almost of guideline of implementation process were developed and being reviewed for application in plants. In this implementation process, data analysis is necessary to monitored the reliability and availability and conditions of key SSCs (Structure, Systems and Components) in function. In this paper, major results in each of implementation process and some experiences at Ulchin 3,4 nuclear power plants were summarized.

2. Summary of Results

Maintenance Rule implementation process in this study is showen as Figure 1.

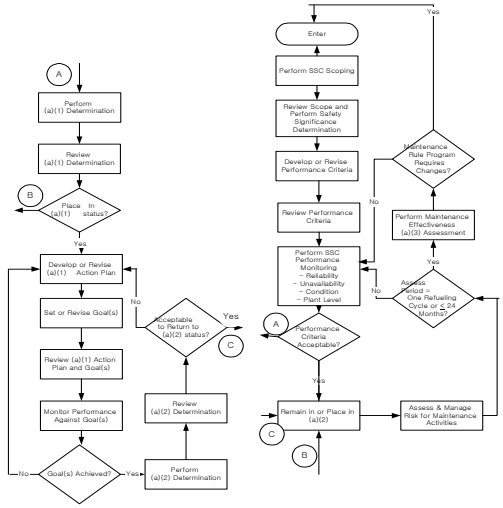

Figure 1. MR implementation process in pilot study

2.1 Function Scope

The scoping screening criteria is seven criteria based on NUMARC 93-01, Rev 3. These criteria is classified as three criteria for safety related function and four criteria for non-safety related function.

Decision Basis for whether the function is safety related or non-safety related does not depend on SSC design classification but inherent character of function included these SSC. Even though some component in the function is safety related, that function may not be safety related.

In application of NSR 4 (Non safety related SSCs whose failure cause a reactor scram or actuators safety systems) on KSNP, Turbine trip does not lead to reactor scram due to plant's reactor protection design concept.

Among the functions which is not classified as In-scope function, especially NSR 4, major functions as trip initiator to the turbine are selected as "In scope" of maintenance rule.

Through discussion on first Expert panel meeting, 56% of total functions are screened as within the scope of maintenance rule as following Table 1. The other 44% functions are out of scope of maintenance rule.

	In scope	Out of scope	Total
System	312	255	567
Structure	27	13	40
Sum	339	268	607

Table. 1 Function Scoping Result of Ulchin 3&4

2.2 Safety Significant Level

After the selection of those functions in maintenance rule scop, safety significant level of each function should be determined for use of establishing of performance criteria to monitor the performance of SSCs within the scope. In evaluation of safety significance on each scoped function, quantitative method and qualitative method are used. Importance values in case which is modeled by PSA (Probabilistic Safety Assessment) are used in quantitative method. This connection between MR and PSA was performed by mapping the basic events of PSA model to functions in MR scope. Risk significance of RRW, RAW, CDF on each functions are represented by this mapping. This method was evaluated on function's risk significance level.

For non-PSA model, delphi process was used as qualitative method. In this delphi process, experience of operating and maintenance or application of as-built field programs were evaluated for safety significance of functions. Final safety significant levels were determined through evaluation process at expert panel meeting by comparing the each results from both quantitative method and qualitative method. All functions within the scope of Maintenance Rule are evaluated. These result are summarized in Table 2.

	Safety significant function		Sum	Remarks
	High	Low		
System	140	172	312	45%

Table. 2 Summary of Safety significant result

2.3 Data analysis

For purpose of determination for performance criteria and performance monitoring, data analysis on maintenance history and operating history is necessary for determined the functional failure(FF) and Maintenance Preventable functional failure(MPFF) and Repetitive MPFF(R-MPFF). Data collection Period for data analysis was for three years (two cycles) prior to start point of this pilot study.

Insights gained from data analysis in this pilot study are as follows.

1) Functional failures are not same as SSC failures. A SSC failure may or may not be a functional failure, depending on the function under the examination. On the other hand, there may be functional failures that are not related to SSC failures (e.g., procedure errors, process deficiencies, etc.).

2) System Engineer initially screens Maintenance Rule Functional failure (MRFF), which is then reviewed by the MRC(Maintenance Rule Coordinator). The expert panel makes the final determination of whether it should be a maintenance preventable functional failure (MPFF).

3) PSA analyst (or Risk Management engineer) should further review each MRFF to determine whether it is applicable failure in PSA space. The review should be done at least on a monthly basis, before expert panel reviews them for MPFF determination so that PSA analyst is aware about the events.

4) It is important to clearly define what the functional failure definition (FFD) is. Importance of clearly defining the FFD cannot be over emphasized, since System Engineers will need clear guidance as to how to determine the functional failure. Much of these definitions will be refined during initial phase of the data analysis.

5) Monitoring differences between MR and EDG Reliability program – a failure in EDG reliability program should be same as in the MR program, at least from the initial screening perspective. Each failure analysis should follow the existing program.

2.4 Performance Criteria

In the PC development, the functions and SSCs were linked for optimizing the monitoring process. Both RPC(Reliability Performance Criteria) and CMC(Condition Monitoring Criteria) tends to have much impacts on grouping and linking.

PCs at train level are established for all safety significant functions and for non-risk significant functions in a standby mode. Functional failure definition differs depending on the determination of monitoring level.

RPCs in case of SSCs modeled in PSA or the non-PSA that extension is possible were calculated using EPRI methodology. For other cases, 90% or 95% of success probability calculation was used in RPC calculation. In case that they were not appropriate at the calculated results, expected failure probability was estimated based on the failure rate of same type SSCs or from generic data.

APC were calculated by several steps. 1) Identify PSA basic events related to MR function. 2) Calculate average unavailability time of each train during 3 years which is monitoring period from PSA model. 3) Adjust APC to the appropriate level based on the plant practices and experiences. 4) For the functions which were not modeled in PSA but in case that PSA surrogation is possible, APCs were determined through sensitivity analysis. Final PCs were determined at the expert panel. The result of PC determination is shown Table 3 and Figure 2. Number of RPC were determined as 135 and number of APC were 50.

Category	RPC		APC		CMC	PLPC
	ID	PC	ID	PC		
Completion	106	135	44	50	11	1

Table 3. Results Establishment of PCs

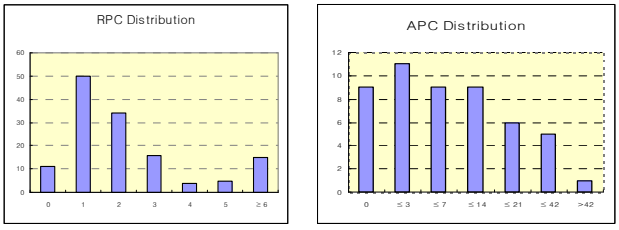

Figure. 2 APCs and RPCs Distribution

2.5 Performance monitoring

Performance monitoring process in MR implementation is necessary to determine that performance criteria of functions within maintenance rule scope have been met or exceeded. To determine shift from routine monitoring (a(2)) to enforcement monitoring(a(1)), MPFF and R-MPFF are counted. MRFF is focused for performance criteria process and MPFF is focused for performance monitoring process.

When MRFF has been happened, but did not over performance criteria(MPFF), this function should not be classified as a(1). But R-MPFF have been happened, that PC shoud be classified as a(1).

In this pilot study, several PC were classified as a(1). Among them one PC was counted as a(1) due to R-MPFF.

3. Conclusions

In pilot implementation study at Ulchin unit 3&4, we have get insights and results on each step. About 56% of total functions are selected as “in scope” function and 25% of total functions (system only) were determined as “safety significant function”. Functional failure definition were made on each function. RPC, APC, CMC and PLPC were developed on each PCID by linking between functions and key SSCs. In pilot analysis for performance monitoring, it were found to (a(1)) for enforcement monitoring.

For success of implementation, better understanding of MR is necessary for management level as well as field expert member. And preventive maintenance program and corrective action program are necessary to be linked effectively for performance monitoring.

REFERENCES

[1] Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NUMARC 93-01 Revision 3, NEI, July 2000

[2] Interim report, “Development of Monitoring Technologies for the Effectiveness of Maintenance at KSNP, KEPRI, 2005.

[3] A study on maintenance rule program and its application to Korean NPP, KAERI/TR-1788/2001

[4] Development of Regulatory Techniques for Operational Performance Evaluation of Nuclear Power Plants, KINS/PR-220, 2004.