Transactions of the Korean Nuclear Society Autumn Meeting
Busan, Korea, October 27-28, 2005

Establishment of Performance Criteria for Maintenance Rule(MR) Implementation in Uljin units 3&4

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1. INTORDUCTION

Performance criteria (PC) for evaluating SSCs are necessary to identify the standard against which performance is to be measured. These criteria are established to provide a basis for determining satisfactory performance and the need for goal setting. In this paper, the developed method and results of performance criteria for maintenance rule implementation in Uljin 3,4 nuclear power plants were described.

2. METHOD and RESULTS

2.1 Functional Dependency Analysis

MR functions and SSCs interact with each other very strongly, and they both interact with the performance criteria shown as *Fig. 1*. This activity will help the analyst to better understand each function defined and the role of each SSC in the plant. During the PC development, the functions and SSCs will be grouped and linked in order to optimize the monitoring process. Both RPC(Reliability Performance Criteria) and CMC(Condition Monitoring Criteria) tends to have much impact on grouping and linking, where APC(Availability Performance Criteria) tends to be isolated with the train level

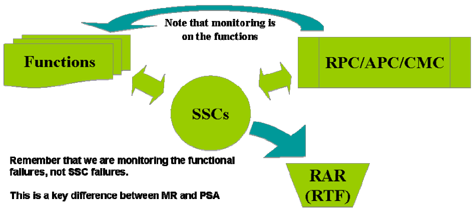

Fig. 1. Interactions of PC and Function/SSCs

Examples of PC boundary identification results through MR functional dependency analysis are shown at *Table 1*.

Table 1. Examples of the functional dependency analysis

FID	Function Description	Code	FID	PCID	Comments
CS-01	Containment Spray	S	CS-03	CS01	
CS-02	Maintain CV Recir. sump Ph	S	CS-01	CS01	
CS-03	Support LPSI pp function	K	CS-01	CS01	Cont. spray pps
		S	SI-08	SI01	Diversity function
CS-04	Mini flow operation	P	CS-01	CS01	
CS-05	MCR alarms and indications	P	CS-01	CS01	
CS-06	CV Isolation	P	PC-01	PC01	
VY-01	Cubicle Cooling	S	CS-01	VY01	CS Pp Room Cooling
CC-01	Supply CCW	S	CS-01	CS01	CS Hx
EF-03	Provide CSAS signal	S	CS-01	EF01	Logic dependency
CV-15	Borated water source for ESF	S	CS-01	CV05	Water source for CS Pps
PB-01	C-11E 4.16KV Power supply	S	CS-01	PB01	Electrical source for CS Pps

Codes were developed for MR functional dependency analysis not PSA or other programs. Codes mean as follow.

- D : Directed Functional Dependency(bi-directional)
- S : Supporting Functional Dependency
- P : Same Performance Criteria
- K : Shares Key SSCs

2.2 Monitoring Level & Functional Failure

Specific PCs are established for all risk significant functions and for non-risk significant functions that are in a standby mode. Functional failure definition differs depending on the determination of monitoring level. Therefore, the adequacy of PCs was determined after deciding monitoring level and defining relevant functional failure with consideration of followings;

- Improve Maintenance Effectiveness
- Shadowing Effect
- Unavailability monitoring
- Consistency with RPC calculation

2.3 Key SSCs Mapping to PC

Key SSCs list for each function is for analyzer to understand the scope of function correctly and to utilize this list in the process of defining PCs. In terms of function determination, key SSCs are the SSCs which perform the critical roles for relevant function, and key SSCs determined in terms of PC determination are the SSCs which affect the PC mostly. Examples of key SSCs mapping to MR function and MR PC are shown at *Table 2*.

Table 2. Examples of key SSCs mapping results

Tag No	Equipment name	Sys	Train	Class	S/B	PSA	FID	PCID
CS-V0035	CS Hx TRN-A CV ISO VV	CS	A	Q	Y	Y	CS-01	CS01
CS-V0036	CS Hx TRN-B CV ISO VV	CS	B	Q	Y	Y	CS-01	CS01
CS-V1003	CSP-01A SUCT CHK VV	CS	A	Q	Y	Y	CS-01	CS01
CS-V1004	CSP-01B SUCT CHK VV	CS	B	Q	Y	Y	CS-01	CS01
CS-V1007	CSP-01A DISCH CHK VV(A)	CS	A	Q	Y	Y	CS-01	CS01
CS-V1008	CSP-01B DISCH CHK VV(B)	CS	B	Q	Y	Y	CS-01	CS01
CS-V1011	CS HT EXCH CV ISO CHK VV	CS	A	Q	Y	Y	CS-01	CS01

2.4 RPC Development

For the case of SSCs modeled in PSA and for the case in which PSA extended application is possible, RPC were determined using EPRI methodology. For other cases, 90% or 95% of success probability which was statistically derived, was used in RPC calculation. When the calculated results were decided as they were not appropriate, expected failure probability was estimated based on the failure rate of same type SSCs or from generic data. The values for RPC's were determined as reasonable ones by comparing above two values for RPC. Figure 2 shows the RPC determination process for UCN 3&4.

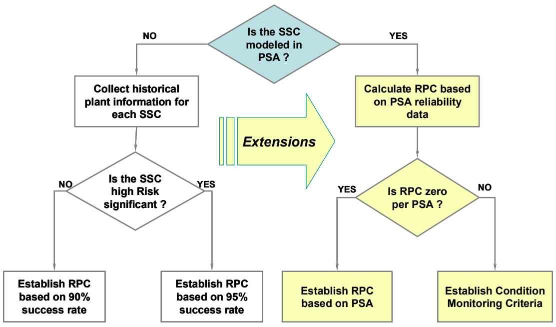

Fig. 2. RPC development process

2.5 APC Development

APC determination process was illustrated in figure 3. For functions modeled in PSA, APCs were determined through all process as below. For the functions which were not modeled in PSA but PSA surrogation is possible, APCs were determined through process ③,④, and ⑤. The other functions were determined through process ③, and ⑤.

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.

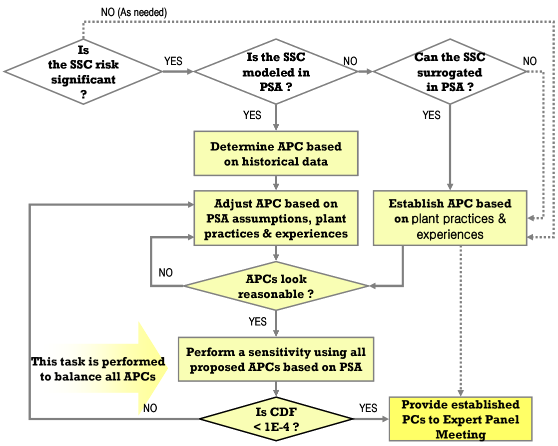

Fig. 3. APC development process

④ Determine whether APCs can be allowed by performing sensitivity analysis. Perform CDF sensitivity analysis for APCs which were modeled in PSA or for which PSA surrogation is possible. In PSA sensitivity analysis, target value of 1.0E-4/year which is used in US, was used. This target value should be adjusted when regulatory policy in Korea is decided.
⑤ Confirm the calculated APC's through expert panel.

2.6 Expert Panel meeting

Determined draft of PC's should be confirmed through expert panel. During the expert panel for PC's determination, the adequacy of determined PCs was evaluated with consideration of the principles as below;

- Must be risk informed
- Provide performance monitoring capability
- Must improve maintenance effectiveness
- Monitoring program

The maintenance effectiveness can be improved via the corrective actions, but more importantly via better understanding of PM basis and effective use of the PM program.

2. 7 Results

For the management of 59 systems and 312 functions which were decided as MR scope, were determined as 105 PCIDs, excluding structures. The distribution of PCs was shown as in Table 3 and figure 4. Most of APCs were less than or equal to 7 days, and dominant RPC were 1 or 2 times.

Table 3. Results Establishment of PCs

Category	RPC		APC		CMC
	ID	PC	ID	PC	
Completion	103	128	38	43	13
Pedning	2	2	8	13	1
Total	105	130	46	56	14

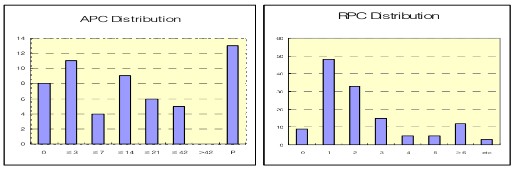

Fig. 4. APCs and RPCs Distribution

3. CONCLUSIONS

Some of PC's are expected to be modified through 4th expert panel meeting with reflection of plant experiences and practices. Through the implementation process, PC's should be adjusted for following cases;

① When Preventive Maintenance (PM) program basis, PSA results and design are changed,
② When necessity of PC modification is raised through industry operating experiences and,
③ When performance criteria does not work properly.

When PM basis is changed, PC can be changed because number of demand or operating time is changed. As PSA results are changed, importance of function can be changed and PSA information which was used in determination of PC's might be changed. The fact that PC does not work properly means that the degradation of relevant functions is not monitored by related PC. If PC were set too high or too low apart from reality, malfunction of PC occurs.

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