Improvement of Equipment reliability for Auxiliary Feed Water System

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1. Introduction

There are many efficient methodologies to improve safety and reliability of Nuclear Power Plant. Such results came out Methodology like Maintenance Rule, RCM(Reliability Centered Maintenance) and ER(Equipment reliability). According to AP913(ER) of INPO, Number of the event related to equipment is higher than others like external or human performance. In the top 25 systems, Auxiliary feed water system is the seventh highest among systems. AWFS consists of many component and complex system and Main Function of AFWS is to supply feedwater to the steam generators for the removal of heat from the RCS(Reactor Coolant System) in event the main feedwater system is unavailable following a transient or accident. Reliability of component means how well operate on demands and monitoring is necessary to keep track of condition of component. If component performance is lower than the required value, corrective action for failure mode should be done. The objective of this study is focused to improve of AF pump by adding the tasks of SHR(System Health Report) into the task of system engineer walkdown of PMT(Preventive Maintenance Template). Increasing the reliability of AF pump will contribute to improvement of reliability of AFWS.

2. Operating history of AF pump in Korea NPP

It is difficult to find component failure case in Operation Experience for Stand-by System because Stand-by system is operated in case of transient and accident. Table 1 shows the history of Auxiliary Feedwater pump in NPP(Nuclear Power Plant). Cause of failure is related to pump vibration and pump bearing oil leakage in pump side.

Table 1: Operating history of AF pump in Korea

Case	Component	Cause	Action	Duration of Unavailability
1	PUMP-MOTOR DRIVEN PUMP	Motor breaker Rack-in failure	Wear measurement of contact Replace of wear parts General cleaning and inspection for all accessible parts and surfaces	2007-07-31 14:08 2007-07-31 16:14 (Unavailable)
2	PUMP-MOTOR DRIVEN PUMP	EXTERNAL LEAKAGE Pump bearing oil leakage	Disassemble inspection of leakage part	2010-05-19 09:48 2010-05-19 13:41 (Unavailable)
3	PUMP-MOTOR DRIVEN PUMP	Pump high vibration and temperature during periodic test	Bearing replacement Oil pipe disassemble Pump alignment in hot condition.	2006-03-03 13:00 2007-02-10 (Unavailable)
4	PUMP-MOTOR DRIVEN PUMP	Motor disconnection	Stator rewinding Rotor balancing/Space heater replacement Road side bearing scraping	1999- 07- 09 13:48 1999- 07-17 17:40 (Unavailable)

3. Methodology

The main function of AF pump is to maintain steam generator water level according to classification of MR. In this study, the reliability of system can be increased by focusing on AF pump which is risk significant component. All activity related to NPP safe operation is within Scope of MR (Maintenance Rule).In order to increase the reliability and health of system, component health report and PMT(Preventive Maintenance Template) is adopted.

3.1 Current Preventive Maintenance Template

Table 2 represents common PM template which is used. There are many tasks in PMT. But in this study, SE walk down of condition monitoring task and failure finding task can be used because AF pump is not operated during Normal Operation.

Table 2 : Typical PM Template of Horizontal Pump

Revision No.	0	PM Template								Classification	Pump
Revision Date	06.12.31.									Code	PPHC
FID(Functional Importance Determination)										Horizontal Pump	
Importance		Critical				Minor					
Operation Frequency		High	Low	High	Low	High	Low	High	Low		
Operation Environment		Severe		Mild		Severe		Mild			
PM Task		CHS	CLS	CHM	CLM	MHS	MLS	MHM	MLM	Task and Frequency selection Criteria	
Condition Monitoring Task											
Vibration analysis		1M	1M	1M	1M	3M	3M	3M	3M	EPRI, Exelon company	
Oil Analysis		3M	1F	3M	1F	1F	1F	1F	AR	EPRI, Exelon company	
Performance Trending Analysis		6M	6M	6M	6M	6M	6M	1F	1F	EPRI, Exelon company	
Thermography		6M	6M	6M	6M	12M	12M	12M	12M	EPRI, Maintenance experience	
Motor Current Analysis		AR	AR	AR	AR	AR	AR	AR	AR	Application of Motor PM Criteria	
System Engineer Walkdown		3M	3M	3M	3M	3M	3M	3M	3M	EPRI, Maintenance experience	
Operator Rounds		1S	1S	1S	1S	1D	1D	1D	1D	EPRI	
Time Directed Task											
Oil filter inspection		1F	AR	1F	AR	1F	AR	AR	AR	EPRI, Maintenance experience	
Coupling inspection		2F	3F	2F	3F	AR	AR	AR	AR	Exelon company, Maintenance experience	
Nozzle NDE inspection		6F	AR	6F	AR	6F	AR	6F	AR	Exelon company, Maintenance experience	
Partial Disassembly		AR	AR	AR	AR	AR	AR	AR	AR	EPRI, Exelon company	
Complete Disassembly		AR	AR	AR	AR	AR	AR	AR	AR	EPRI, Exelon company	
Failure Finding Task											
Performance Test		AR	AR	AR	AR	AR	AR	AR	AR	EPRI, Exelon company	

3.2 Application of System Health Report

System health report is the process of deciding the whole status of system based on input data from system performance monitoring. System Health Reporting Guideline is presented in Performance Engineering Handbook. This report is made by system engineer with reference of SHR guideline. The contents of SHR can be different according NPP condition. SHR of most of system is made quarterly but SHR is made half-yearly in reality.

3.2.1 Classification of Grading

Color		Explanation
Red		Poor
Yellow		Marginal
White		Good
Green		Excellent
Blue		Not Evaluated

3.2.2 Criteria of Grading

Red	Functional loss of component, Corrective Maintenance
	Degradation of function for most of Equipment
	Related SHR is Red if any equipment is Red by the CEHR(component and equipment health report) If the Red is not indicated, the reason should be explained
Yellow	Degradation of one or one more component performance and progressing of performance degradation symptom
	Excess of Alarm Alert Limitation
	Related SHR is Yellow if any equipment is Yellow by the CEHR(component and equipment health report) If the yellow is not indicated, the reason should be explained.
White	Symptom for Degradation of performance is showed but it is not reached to the alert value.
	The speed of performance degradation is slow and the function of system is not affected
Green	Most of equipment don't have symptom of performance degradation and is operated without main maintenance within 5 years

3.2.3 Application of CHR for AF Pump

System Health Report can be made from combining condition of components which organize AFWS. Focus on Component Health Report of AF Pump(Stand-by component) can be concentrated on performance monitoring and Functional Failure in SHR(System Health Report) composition because failure of Stand-by pump can be prevented from continuous monitoring and performance test. The contents for SHR of AFWS consist of 5 parts like following Table 3. In this study, Field 1 and 5 will be mentioned. And Detail of these two fields is represented in Table 4 and Table 5.

Table 3: Assessment of SHR(System Health Report)

	Field	Status
1	Part of Performance Monitoring	Green
2	Part of recurrence or consideration	Green
3	Part of component management status	Green
4	Part of derate or latent derate	Green
5	Part of MR and Function Failure Assessment	Green
6	Part of Design and Configuration	Green
	Sum	0

Table 4: Details of Performance Monitoring

	Weighted Value	Count	Score	Criteria
Problem of Component degradation	3	0	0	Below 1.0 = Green 1.0~Below 2.0= White 2.0~Below 3.0=Yellow Above 3.0 = Red
Problem Necessary Measure	1	0	0	
Sum		0	0	

Table 5: Details of MR and Functional Failure Assessment

	Weighted Value	Count	Score	Criteria
MRFF(MR Functional Failure)	0.5	0	0	Below 1.0 = Green 1.0~Below 2.0= White 2.0~Below 3.0=Yellow Above 3.0 = Red
MPFF(Maintenance Preventable Functional Failure)	1	0	0	
RMPFF(Repetitive Maintenance Preventable Functional Failure)	3	0	0	
Sum		0	0	

4. Conclusion

Based on operating history, there was high vibration of AF pump during performance test. In that case, there were a lot of maintenance works for normal operation of AF pump. Vibration problem related pump can't be detected by tasks of SE walkdown because it's not running during normal operation except for surveillance test. CHR(Component Health Report) of AF pump in AFWS can be made from necessary part which means monitoring and functional failure because problem of Stand-by pump can be covered by conducting monitoring and analysis of functional failure. To improve reliability of AF pump, walkdown of PMT and SHR should be conducted both in accordance with surveillance test frequency. Health of AF pump based on operation history can be verified first and then can find out which parts of pump are weak. Finally, weak part can be managed intensively and failure can be reduced according to SE walkdown. But this work can be risky and burdensome because all parts of CHR are not considered and SHR should be made still quarterly.

REFERENCES

[1]INPO AP-913"Equipment Reliability Process Description" ,March 2011
[2]System Health Report of Shin Kori 1 NPP.
[3]PM Template of Hanbit NPP(Yonggwang NPP)