

Determination of Plant Level Performance Criteria for Maintenance Rule Implementation in KHNP

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1. Introduction

Korea Hydro & Nuclear Power Co. (KHNP) has been developing and implementing a Maintenance Rule (MR) program to monitor the effectiveness of maintenance at nuclear power plants since 2003. This maintenance effectiveness monitoring program is developed based upon the NUMARC 93-01 guidelines. To implement the program, the performance criteria should be established to monitor their system functions according to safety significance. Among the performance criteria, Plant Level Performance Criteria (PLPC) is to establish the acceptable operational level of the plant performance. In KHNP, PLPC is labeled as Unit Level Performance Criteria (ULPC) because they are set for each unit of a plant consisting of two units. PLPC are set up for Low Safety Significance (LSS) that are normally operating functions [1].

PLPC significantly depends on company policy for the overall plant performance goals in relation with operational records. For this reason, the PLPC are found different from one utility to the other in the United States since implementing Maintenance Rule in 1996.

2. Establishment of Performance Criteria

Performance criteria for system functions scoped for monitoring are established to provide a basis of determining satisfactory performance according to the characteristics of the functions. For example, specific performance criteria, i.e. availability, reliability or condition monitoring criteria, should be established for all High Safety Significance (HSS) functions and for LSS standby functions whose failures can be found by surveillance tests. For all remaining LSS normally operating functions, PLPC are established. The (a)(1) evaluation is performed when the PLPC are not met.

3. Guidelines for PLPC Determination and Review of the US Utilities' Experience

In this section, the guideline of PLPC determination and how the US utilities established PLPC are reviewed.

3.1 Guidelines

NUMARC 93-01 provides guidelines for PLPC determination and minimum requirements suggested as follows: 1) unplanned automatic reactor scram per 7,000 hours critical, 2) unplanned safety system actuations or 3) unplanned capability loss factor (UCLF). The USNRC's position is more rigorous, requiring that all unanticipated scram including manual scram should be counted [2].

3.2 Cases of the PLPC Determination in US Utilities

The PLPC in US utilities vary as shown on Table 1 depending on their policy and strategy for performance. Some utilities have established criteria at minimum as NUMARC 93-01 recommended. However, other plants set additional PLPC such as "no entry into Red or Yellow risk level" to monitor LSS functions whose adverse performance would affect shutdown risk. Additionally the number of power change causing the unplanned loss greater than 20% electrical power output is also utilized as one of the PLPC [3].

Table 1 The examples PLPC used in US utilities in comparison with NUMARC93-01

NUMARC 93-01	Performance Criteria	US Utilities' PLPC			
		Exelon	Entergy	NMC	PVNGS
Unplanned Automatic Rx Scram	Unplanned Rx Scram	2/2yrs	2/1yr	2/2yrs	2/1yr 4/1yr
	Scram with Loss of Heat Removal	N/A	2/3yrs	N/A	2/3yrs
Unplanned Safety system actuation	Unplanned ESFAS Actuation	2/2yrs	Site specific	2/2yrs	N/A
Unplanned capability loss factor	UCLF or FLR	FLR 4%/m	N/A	0.2%/y 25000 MWh/y	3%/18m
N/A	Number of more than 20% power change	4/2yrs	N/A	N/A	N/A
N/A	Shutdown Risk	No Red/Yellow	N/A	N/A	*2/3yrs

* Count the number of Loss of Inventory and Reactivity Changes

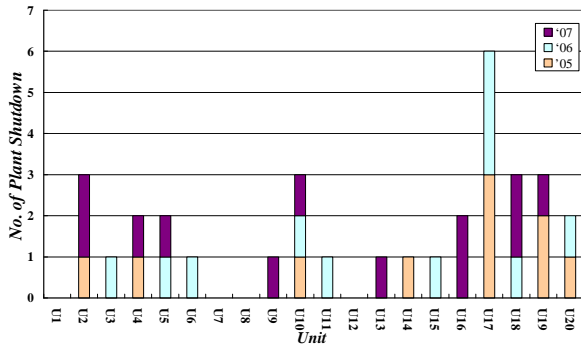
4. Analysis of Operating Records and Determination of Performance Criteria for KHNP

4.1 Unplanned Reactor Scram Performance Criteria

At present, the performance goal of KHNP is called 9204 which means to maintain the operational performance higher than 92 % capacity factor and lower than 0.4 unplanned plant shutdowns a year per unit. Every event that the generator breaker opens is counted as a plant shutdown, irrespective of reactor scram or turbine trip without reactor scram. This is a tighter implementation than what NUMARC 93-01 required, especially for the Korean Standard Nuclear Power plants that can prevent the reactor scram if an event causes turbine trip.

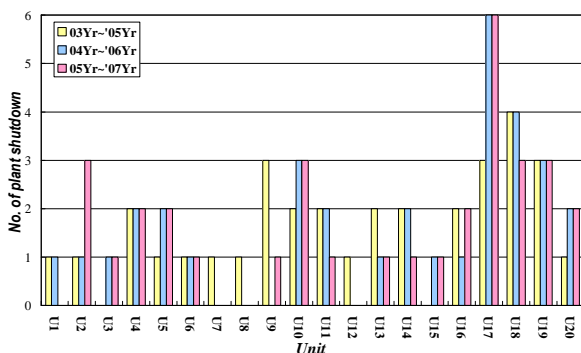
A review of plant shutdown data of 20 units in KHNP during the past 3 years from year 2005 to 2007, shows that 4 units did not experienced any plant shutdowns, 11 units had one or two plant shutdowns and the remaining of the units have more than 2 plant shutdowns as shown in Fig. 1.

Fig.1 Number of plant shutdowns in KHNP from year 2005 to 2007



Hence, considering the past plant shutdown records shown in Fig.1 and Fig.2, the plant shutdown criterion is set at 2 times/unit/3years. It does not exactly match with the 9204 performance goal which allows only one or two shutdowns per unit for 3 years. However, the level of this criterion is thought to be reasonable as it requires that about one quarter of the KHNP units should improve their performance above the current level. In addition each plant shutdown including turbine trip should be evaluated whether it is Maintenance Preventable Functional Failure (MPFF), and if so, it will be entered into intensive monitoring status to meet the performance goal.

Fig.2 Number of plant shutdown in 3 year term from year 2003 to 2007 for KHNP fleet



If plant shutdown in a unit occurs more than twice per 3 years, plant system engineers will evaluate common cause analysis for those functional failures to take corrective actions to prevent recurrence.

4.2 Unplanned Safety System Actuation

According to Atomic Energy Act, a verbal report within 4 hours and a detailed report within 30 days will be made for an actuation of the systems such as ECCS, Containment Isolation, Containment Spray, Aux or

Emergency Feed Water system, and automatic starting of Emergency Diesel Generator due to loss of safety bus voltage. From year 2005 to 2007, unplanned safety system actuation experienced in KHNP unit is very low, i.e. one time at worst. However, two actuations per unit are set to be allowed in 3 years following the US utilities' cases.

4.3 Unplanned Capability Loss Factor

For this performance criterion, the number of power change has been considered, because it is easier to count and related to the Safety Performance Indicator (SPI) defined by Korea Institute of Nuclear Safety (KINS). One of the SPI is an unplanned reactor power change greater than 30% of full power. Less than 1.5 times per unit per quarter gives the unit green meaning excellence. On the basis of this, 18 times per unit in 3 years are allowed. It is, however, recognized that this level would be too loose. Therefore it has been determined that 4 times/unit/3years referring to US utilities' experience is a stronger criteria. Meanwhile Forced Loss Rate (FLR) is being considered as an additional or substitute criterion. The final performance criteria for this will be determined after reviewing the appropriateness of the criteria from the view point of meeting the goals and guidelines.

4.4 Shutdown Risk

Even though some risk management systems have been implemented in KHNP, it is not yet in affect because on-line maintenance (OLM) and shutdown risk assessment are not presently performed. For this reason, a shutdown risk performance criterion is not considered as one of PLPC, however, it will be reviewed when on-line maintenance and risk informed maintenance programs are established.

5. Conclusions

How to establish the PLPC have been studied and they are determined reflecting the performance goal of KHNP as 1) Two unplanned plant shutdowns per unit, 2) Two unplanned safety system actuations and 3) Four unplanned power changes greater than 30% FP. These criteria are based on 3 years of operation and will be used to monitor normal operating functions of LSS. Whether to use UCLF or FLR is still in review process and will be determined from the view points of the effectiveness of applying as a criterion.

REFERENCES

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- [4] Annual Nuclear Operation Report 2007, KHNP, p217~344, April 2008