Results of Reliability Evaluation of I&C Systems in Kori Nuclear Power Plant

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1. Introduction

There are several major factors to cause nuclear power plant (NPP) to shut down. The failures in the I&C systems were one of them and has come to over 25% in Korea for last 15 years. Accordingly, it is important to evaluate periodically I&C systems in operating power plants since they may have some problems with aging, obsolescence, high failure rates, etc. These problems may affect plant trip as well as increasing O&M (Operation and Maintenance) costs considerably. Therefore, to reduce such a risk and a great loss, proper transactions such as system replacement or system upgrade should be performed with timely method

This paper shows a practical methodology to evaluate the current status of I&C system of nuclear power plants prior to an upgrade or a replacement of system and the result of the methodology applied to Kori nuclear power plant.

2. Methods and Results

The proposed methodology for evaluating I&C systems in nuclear power plant has 6 phases as shown in Figure 1.

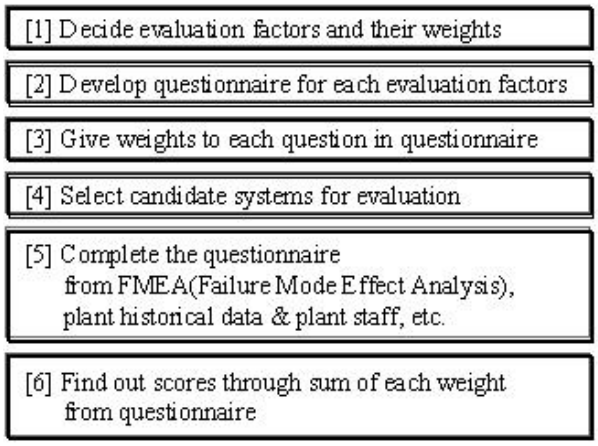

Figure 1. 6 phases on the work flow

2.1 Classification of Evaluation Factors

To assess the reliability of each I&C system, evaluation factors are required such as system importance, performance, maintenance, aging, economical efficiency, and the continuance of equipment supply. These factors are used to check up current status of each system through the proper questionnaire corresponding to each evaluation factor.

System Importance – the importance considering safety class, quality level, functionality in NPP, and failure mode effect on other systems

System Performance – the function and performance of the system satisfying the system requirements

System Maintenance – the status or ability of the system maintenance

System Robustness against Aging – the level of the system robustness against aging

Economical Efficiency – the current economical efficient that a system has or can make

Continuance of Equipment Supply – the possibility that equipment can be supplied continuously

2.2 Completion of the Evaluation Questionnaire

The questionnaire for each evaluation factor consists of several questions related to the factor. The related data to complete each question can be found from interview of plant staff or plant's historical operating records which include maintenance records, failure records and so on. From the collected data, we can find and evaluate the status for each system (or equipment) in the point of reliability, performance, aging, etc. and a model for evaluation can be extracted, covering system importance, cost-benefit aspects and other factors. System importance is more significant factor for evaluation than others. System importance is to be decided from FMEA (Failure Mode Effect Analysis) of the corresponding I&C system. Besides, reliability-based maintenance analysis including MTBF (Mean Time Between Failure) is also to be performed for estimating the life cycle of the I&C system.

To make a score of the resulting evaluation which is 100-point in sum for each factor. Each question within the factor is weighed according to its importance. Among evaluation factors for a system, there is also weight allocation process according to the importance of each factor. Through the two way of scoring process, final evaluation results are found.

2.3 The Applied Result of Kori Nuclear Plant

The proposed methodology was applied to 16 I&C systems in Kori Unit2 and 17 I&C systems in Kori Unit3. Both of the Units are a PWR (900MWe) type provided by Westinghouse Company and have been operated for more than 20 years since 1983 and 1985

respectively. Each Unit has performed I&C system upgrades in part and additional upgrades are expected continuously.

Table 1 shows the I&C systems which were selected for the evaluation of Kori unit 2 and 3 considering the importance on the plant availability and safety.

Plant	I&C Systems
Kori Unit 2	1) Steam Generator Leak Monitoring (SGLM) 2) Digital Flux Mapping System (DFMS) 3) Turbine Control System (TCS) 4) Turbine Supervisory System (TSS) 5) Annunciator System (AS) 6) Seismic Monitoring System (SMS) 7) Control Rod Position Indication (RPI) 8) Control Rod Control System (CRCS) 9) Boron Recycle System (BRS) 10)Radiation Monitoring System (RMS) 11)Heater Drain System (HDS) 12)W7300 Process Control System (W7300) 13)Rad Waste Disposal System (RWDS) 14)Nuclear Instrumentation System (NIS) 15)Solid State Protection System (SSPS) 16)Engineered Safety Feature Actuation System (ESFAS)
Kori Unit 3	Same as 1)~15) of Kori Unit 2 16) Solid State Interposing Logic System (SSILS) 17) Safe Guard Test Cabinet (SGTC) 18) Fisher Process Control System (FPCS)

Table 1. List of the I&C systems for evaluation

Evaluation factors		System Importance (100)	System Performance (100)	System Maintenance (100)	System Robustness against Aging (100)	Economical Efficiency (100)	Contiuance of Equip. Supply (100)
Candidates	CRCS	81	62,5	69,7	51	80	65
	W7300	97,5	75,5	74,3	71	90	77,5
	TCS	79	60,5	64,3	66	60	60
	RPI	81	76	71,5	66	60	65
	SMS	68,5	74	73,5	74	60	55
	NIS	97	92	65,5	75	70	80
	SSPS	100	82	76,8	85	70	72,5
	ESFAS	100	92,5	74,3	86	70	72,5
	DFMS	56	59,5	69,3	55	50	72,5
	BRS	51	53,5	82,6	55	50	77,5
	RWDS	47	53,5	80,1	55	50	77,5
	AS	77,5	85,5	86,3	71	50	85
	HDS	58,5	58,5	82,6	85	42,5	85
	DRMS	65,5	93	75,8	80	42,5	100
	TSS	58,5	85,5	71,1	95	52,5	100
	SGLM	47	67,5	86,3	92	42,5	100

Table 2. The Evaluation Results of Kori Unit 2

Table 2 shows the evaluation results of 16 I&C systems in Kori Unit2. Each system was evaluated on the 6 factors. From the results, some order was found out, which was arranged for the priority of upgrade necessity. For making the order, additional weight was considered according to factors and system importance.

There presents the priority order for upgrade or replacement of I&C Systems of Kori Unit 2 in Figure 2.

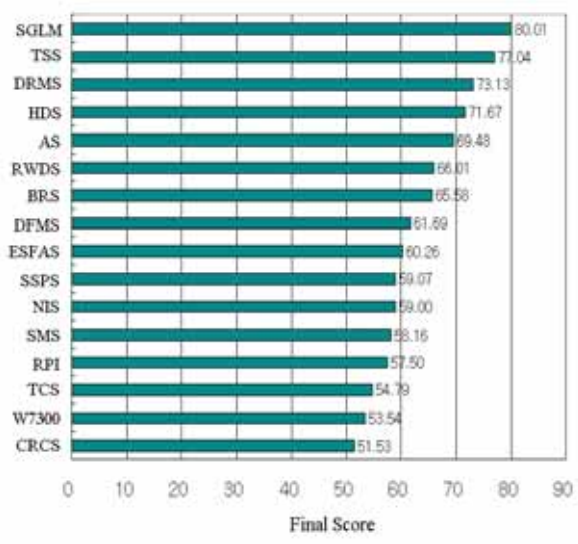

Figure 2. The Upgrade Priority & Final Score of Kori Unit 2 ; the smaller scored system has the higher priority

3. Conclusion

Generally, there are several methods to evaluate the reliability of I&C system but it is not easy to apply to nuclear power plant. Because nuclear power plant has lots of I&C equipment and the equipment consists of a large number of components. Accordingly it requires much effort and time to evaluate all of the equipment for making overall upgrade plan in NPP.

The proposed methodology presents a practical approach which is based on plant historical data including maintenance records, failure rates, design life and etc. and also experience of plant staff.

The final result of the Kori plant evaluation will be used to make an upgrade plan or a maintenance plan for I&C systems.

REFERENCES

[1] EPRI, " Instrumentation and Control Upgrade Evaluation Methodology", EPRI TR-104963-V2, 3373-10,-11, Final Report, July 1996.

[2] KEPRI, "Kori-2 I&C Upgrade Planning", South Korea, Daejeon, 1999.

[3] C. H. SUNG, H. Y. JEONG, and S.J.CHO, "A Methodology for Making an Upgrade Plan of Existing I&C Systems," *2004NPIC&HMIT*, ANS, USA, 2004.

[4] C. H. SUNG, H. Y. JEONG, and S.J.CHO "A Study on the Upgrade Methodology of I&C Systems in Operating Nuclear Plant ", KNS, South Korea, 2004.