A study on the On-Line Maintenance Risk Assessment Methods

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1. Introduction

With the increasing economic pressures being faced and the potential for shortening outage times under the conditions of deregulated electricity markets in the world, licensees are motivated to get an increasing amount of the on-line maintenance (OLM). The benefits of the OLM includes increased system and plant reliability, reduction of plant equipment and system material condition deficiencies that could adversely impact operations, and reduction of work scope during plant refueling outages[1]. NUMARC 93-01 presents OLM and it provides plan for analysis of reactor safety and risk assessment, and it approves selection of out of service (OOS) for single and multiple structure, systems, and components (SSCs) by performing appropriate risk assessment in quantitative and qualitative ways[2].

2. Methods and Results

In this section, searched domestic risk criteria and compare risk evaluation result with the risk criteria.

2.1 Accepted risk assessment guidelines

In Korea, allowance guidelines of risk assessment is specified in the safety regulation guidelines 16.7 of the Korea Institute of Nuclear Safety (KINS), which is "General guidelines of Risk-informed application for requesting permission of changes"[3]. Summary of the allowance guidelines for risk assessment is in table 1 down below.

Table 1. Allowance guidelines of risk changes by requesting for changes to a plant's license

ΔCDF		ΔLERF
$>10^{-5}$/yr	No Changes Allowed	$>10^{-6}$/yr
10^{-5} - 10^{-6}/yr	Further Evaluation Required	10^{-6} - 10^{-7}/yr
$<10^{-6}$/yr	Non-Risk-Significant	$<10^{-7}$/yr

But, if the baseline Core Damage Frequency (CDF) is more than 10^{-4}/yr, even though ΔCDF is less than 10^{-6}/yr, this further evaluation requires more detailed quantitative analysis. Likewise if the baseline Large Early Release Frequency (LERF) is more than 10^{-5}/yr, even though ΔLERF is less than 10^{-7}/yr, also requires more detailed quantitative analysis.

Based on the safety regulation guidelines 16.8[4] that present "Specification of risk-informed application for operation technical specification for requesting permission of changes." when changing the allowed outage time (AOT), it should satisfy the safety regulation guidelines 16.7 and additional allowance guidelines down below.

- The licensee should show that changes of AOT results slight effect to the plants. In the case of technical specification (TS) change evaluation, if incremental conditional core damage probability (ICCDP) is less than 5.0E-7 and incremental conditional large early release probability (ICLERP) is less than 5.0E-8, it can be regarded as slight effect. The allowance guidelines value of ICCDP 5.0E-7 is calculated by assuming the situation which causes increase of CDF to the 1.0E-3/RY by component failure for 5 hours at the plant of which average CDF is 1.0E-4/RY. (Tier.1)
- The licensee should prove that there are proper restrictions for configuration which has significant risk impact in proposed changes. (Tier.2)
- The licensee should fulfill risk-informed application (RIA) configuration risk management program and fill in the procedure for application, maintenance and management of relevant program. (Tier.3)

2.2 Risk assessment analysis by applying configuration changes

We select the emergency diesel generator (EDG) of the Ulchin unit 3&4 for risk assessment analysis by applying configuration changes. The EDG which has plant safety level 1E belongs to on-site standby power (A, B train EDG) in electric distribution system.

The EDG is important component because it should maintain standby status during plant is operating, therefore we select the EDG for target component of risk assessment analysis. The risk assessment is limited to CDF.

The risk assessment is performed by using MPAS-OOS in AIMS-PSA Release2. For describing unavailable status of train, assuming the situation that status of 01A and 01B train in 1E level EDG is OOS by fail to start, the quantification results are in table 2 down below.

Table 2. Results of quantification

	CDF_{Base}	CDF_{OOS}
EDG-01A	5.491E-6	1.177E-5
EDG-01B	5.491E-6	1.186E-5

We can evaluate ΔCDF_{AVG} by applying Risk quantification results to the equation (1).

$$\Delta CDF_{AVG} = CDF_{Proposed} - CDF_{Base}$$
$$= \left(\frac{T_A}{T_{Cycle}}\right) CDF_{AOOS} + \left(\frac{T_B}{T_{Cycle}}\right) CDF_{BOOS} + \left(1 - \frac{T_A + T_B}{T_{Cycle}}\right) CDF_{Base} - CDF_{Base}$$
(Eq1)

Based on TS of the Ulchin unit 3&4, AOT is 72 hours and test interval is 18 months (548days) when one of the two required EDG is unavailable[5]. By assuming AOT to 14 days as we try to extend, results of calculated CDF values are in table 3 down below.

Table 3. Results of ΔCDF_{AVG}

CDF_{Base}	CDF_{OOS}	ΔCDF_{AVG}
5.491E-6	AOOS: 1.177E-5	1.6E-7
	BOOS: 1.186E-5	1.62E-7

And we can calculate ICCDP by applying results of risk quantification to equation (2).

$$ICCDP = (CDF_{OOS} - CDF_{Base}) \times \frac{T_{AOT}}{365}$$
(Eq2)

Table 4. Result of ICCDP

CDF_{Base}	CDF_{OOS}	ICCDP
5.491E-6	1.186E-5	2.44E-7

For conservative calculation, we select train B between A and B, because CDF is higher when train B is OOS. The result of ICCDP is 2.44E-7.

On the basis of the result, we compare it with the safety regulation guidelines 16.8. By the result, ICCDP value of plant which assumes to be applied the OLM satisfies the allowance guidelines as shown in Fig. 1.

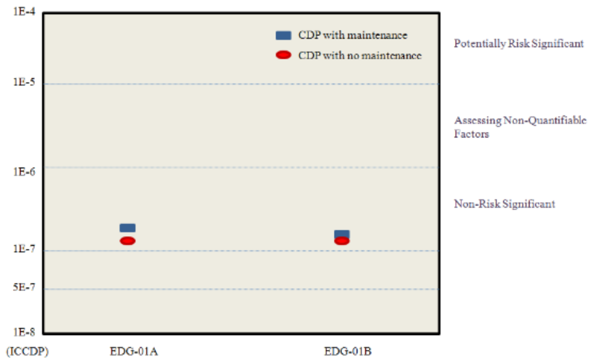

Fig. 1 Results of temporary risk assessment

3. Conclusions

We select EDG of the Ulchin unit 3&4 and perform risk quantification by using MPAS-OOS in AIMS PSA. We evaluate CDF by applying the configuration changes with some assumptions. This study has been performed for introducing a methodology and performing risk assessment. Because of uncertainty in input data, the results also contain uncertainty, so it requires supplement study. It is found that the human reliability analysis (HRA) study needs to be included for considering human errors in maintenance activity for further study.

REFERENCES

[1] USNRC Reg. Guide 1.182 "ASSESSING AND MANAGING RISK BEFORE MAINTENANCE ACTIVITIES AT NUCLEAR POWER PLANTS", U.S. Nuclear Regulatory Commission, May 2000.
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[5] Korea Electric Power Corporation "Technical Specification for the Ulchin unit 3&4", 1996