

LERF Assessment on the AOT changes for Kori 3&4 / Yonggwang 1&2

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1. Introduction

Allowed outage time (AOT), which is required by the technical specification of nuclear power plants (NPPs), has been determined on the basis of deterministic analysis or engineering judgment. AOT is defined as the time for which safety related components can remain inoperable before a plant state is changed. Recently, plants' operating experiences and probabilistic safety assessment (PSA) results show that the AOT could be optimized.

Foreign NPPs licensees have changed their technical specifications including AOT using PSA techniques. In 1998, U.S. NRC issued the regulatory guides on risk informed decision-making and technical specification changes, and these are Reg. Guide 1.174, and 1.177. The US NRC accepted AOT extension proposals including the safety injection tank (SIT) and low pressure safety injection system (LPSI) for the ABB-CE designed plants.

This paper discusses interim results of AOT changes of the SIT, LPSI, CSS (Containment Spray System) and EDG for Kori 3&4 / Yonggwang 1&2. We reviewed Reg. Guide 1.174 and 1.177, and re-quantified LERF (Large Early Release Frequency) to analyze the overall effects of AOT on the level 2 PSA results. The items for risk assessment are Δ LERF and ICLERP (Incremental Conditional Large Early Release Probabilities).

2. Methods and Results

2.1 Acceptance Criteria Analysis

We have established acceptance criteria for this study after reviewing Reg. Guide 1.174 and 1.177 even though there is no quantitative target in Korea. As shown in Table 1, Δ LERF and ICLERP are used as the screening analysis acceptance criteria for risk assessment.

Table 1. Acceptance criteria of Δ LERF and ICLERP on AOT changes

Category	Δ LERF	ICLERP
Criteria	< 1.0E-7	< 5.0E-8

Δ LERF is the difference between the proposed LERF for AOT changes and the current LERF. The proposed LERF analysis is performed through quantification of the Level 2 PSA model which is updated due to the test or maintenance alteration caused

by the changed AOT. ICLERP is the difference between the conditional LERF with the affected component out of service and the baseline LERF with nominal component unavailability (no maintenance).

2.2 Updated PSA Model and LERF

As shown in Table 2 and Table 3, there were needs for the PSA model modifications to include the combined effects of the AAC (Alternate Alternating Current) system which was installed in the Kori 3&4 recently and scheduled in the Yonggwang 1&2 in 2008. The modifications also include the increase of LOOP (Loss of Offsite Power) frequency, addition of SIT's test or maintenance, the effects on the AMSAC (ATWS Mitigation System Actuation Circuitry) installation in Kori 4 (this already has been modeled in Yonggwang 1&2), and installation of the permanent pipe (this has not been modeled in Yonggwang 1&2) to supply the demineralized water for the charging pump. The results showed that the LERF was improved up to approximately 8.5% in Kori 3&4 and 15% in Yonggwang 1&2.

Table 2. Kori 3&4 Modified PSA model

Classification	LERF(/YR)	Δ LERF
Year 2003 model	1.04E-06	-
LOOP frequency	1.33E-06	+27.94%
AMSAC installed	1.02E-06	- 2.53%
Demi. water line	1.04E-06	- 0.07%
SIT T/M	1.05E-06	-
AAC installed	8.88E-07	- 15.07%
AOT Base Model	9.57E-07	- 8.47%

Table 3. Yonggwang 1&2 Modified PSA model

Classification	LERF (/RY)	Δ LERF
Year 2003 model	7.59E-07	-
LOOP frequency	9.61E-07	+26.50%
AMSAC installed	-	-
Demi. water line	-	-
SIT T/M	7.59E-07	-
AAC installed	6.17E-07	- 18.66%
AOT Base Model	6.42E-07	- 15.40%

2.3 Δ LERF and ICLERP on AOT Changes

The Δ LERF quantification results on AOT changes of the SIT, LPSI, CSS and EDG for Kori 3&4 / Yonggwang 1&2 show that the Δ LERF is estimated below the acceptance criteria of 1.0E-7 /yr .

As shown Table 4, the LERF for Kori 3&4 internal events was increased from 9.57E-07/year of a baseline LERF to 9.94E-07 /year (3.86%) after all AOT changes including 14 days extension for EDG. And Δ LERF values were increased no more than 1% for SIT, LPSI and CSS. And as shown in Table 5, the LERF for Yonggwang 1&2 internal events was increased from 6.45E-07/year of a baseline LERF to 6.65E-07/year (1.7%). And Δ LERF values were increased no more than 1% for SIT, LPSI and CSS. Since the Δ LERF values for Kori 3&4 / Yonggwang 1&2 are less than 1.00E-07/year, they satisfy the risk acceptance guideline which is established in Table 1.

Table 4. Δ LERF on AOT changes for Kori 3&4

System	Classification	Result (/year)			
SIT (1hr→24hr)	LERF	9.57E-07			
	Δ LERF	1.67E-10(0.02%)			
LPSI (72hr→168hr)	LERF	9.61E-07			
	Δ LERF	4.84E-09(0.51%)			
CSS (72hr→168hr)	LERF	9.58E-07			
	Δ LERF	1.47E-09(0.15%)			
EDG (72hr→7day, 10day, 14day)	Day	7	10	14	
	LERF	9.69E-07	9.77E-07	9.87E-07	
	Δ LERF	1.25E-08	1.99E-08	3.00E-08	
Cumulative Effect	LERF	9.76E-07	9.83E-07	9.94E-07	
	Δ LERF	1.93E-08	2.68E-08	3.71E-08	

* AOT baseline LERF : 9.57E-7/yr

Table 5. Δ LERF on AOT changes for Yonggwang 1&2

System	Classification	Result (/year)			
SIT (1hr→24hr)	LERF	6.45E-07			
	Δ LERF	1.53E-10(0.02%)			
LPSI (72hr→168h)	LERF	6.48E-07			
	Δ LERF	3.58E-09(0.56%)			
CSS (72hr→168hr)	LERF	6.45E-07			
	Δ LERF	4.19E-10(0.07%)			
EDG (72hr→7day, 10day, 14day)	Day	7	10	14	
	LERF	6.53E-07	6.55E-07	6.59E-07	
	Δ LERF	7.96E-09	9.84E-09	1.41E-08	
Cumulative Effect	LERF	6.56E-07	6.59E-07	6.65E-07	
	Δ LERF	1.10E-08	1.42E-08	1.99E-08	

* AOT baseline LERF : 6.45E-7/yr

Table 6 and Table 7 summarize the effects on the ICLERP values for the 7 days, 10 days, 14 days AOT extension for EDG, and these also include the SIT(1 day), LPSI(7 days) and CSS(7 days) AOT extension for Kori 3&4 / Yonggwang 1&2.

The revised results of ICLERP values associated with the AOT changes of SIT, LPSI, CSS, and EDG meet the acceptance criteria of 5.0E-08 on ICLERP in Table 1.

Table 6. ICLERP for Kori 3&4

System	Classification	Result		
SIT (1hr→24hr)	ICLERP	8.30E-11		
LPSI (72hr→168hr)	ICLERP	6.42E-09		
CSS (72hr→168hr)	ICLERP	6.61E-10		
EDG (72hr→7day, 10day, 14day)	Day	7	10	14
	ICLERP	1.15E-09	1.25E-09	1.84E-09

Table 7. ICLERP for Yonggwang 1&2

System	Classification	Result		
SIT (1hr→24hr)	ICLERP	6.92E-11		
LPSI (72hr→168hr)	ICLERP	5.33E-09		
CSS (72hr→168hr)	ICLERP	1.04E-10		
EDG (72hr→7day, 10day, 14day)	Day	7	10	14
	ICLERP	1.26E-09	1.53E-09	1.89E-09

3. Conclusion

From the point of view of Δ LERF and ICLERP, the current AOTs of SIT, LPSI, CSS, and EDG can be extended to the proposed AOTs for Kori 3&4 / Yonggwang 1&2. In the evaluation results of PSA, the values meet the guidelines of 1.0E-07/yr for Δ LERF and 5.0E-08 for ICLERP in Table 1. But, as noted in Regulatory Guide 1.177, the acceptance guidelines should not be interpreted as being overly prescriptive. The acceptance guidelines are intended only to provide an indication, of what is considered acceptable. Thus the numerical values estimated are approximate values that provide an indication of the changes that are generally acceptable.

REFERENCES

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