Practical Completeness of the SAMGs for Power Uprates of Operating NPPs

Hyeong Taek Kim[a] and Byung Chul Lee[b]
[a]*Nuclear Environment Technology Institute, KHNP, Dukjin-dong, Yusong-gu, Daejeon 305-353, Republic of Korea*
Hyeong@khnp.co.kr
[b]*FNC Technology Co., Ltd, SNU RPIC #516, San 4-2 Bongchun7-dong, Gwanak-gu, Seoul 151-818, Republic of Korea*

1. Introduction

The plant-specific severe accident management guidances (SAMGs) have been developed and implemented to the Korean pressurized water reactors, operating or under designing. Providing practical software program coping with unlikely severe accidents, these activities enhance plant's safety in conjunction with emergency planning. Generally, these SAMGs reflect plant-specific design and operation parameters including reactor power, available equipments and instruments.

Among the plants implementing the SAMG, some are promoting power uprating in which additional thermal power can be obtained by making clear operational uncertainties of the plant. This motivates the reassessment of SAMGs for these plants for their completeness. The SAMG is composed of several detailed documents as well as the SAMG itself, which can be prepared by reviewing plant's vulnerability and plant resources and capability against challengeable threats [1,2]. This study presents a summary of all detailed requisites for revising plant-specific SAMGs practically.

2. Review of Power Uprating Design Parameters

First of all, the revision of plant-specific SAMG for power uprates needs to review resultant plant design changes and check whether they may influence on their SAMGs or not. Of course, it was found that major influencing design parameters are those related with stretched thermal power, typically 4.7% for first plants of power uprates. Table 1 summarizes the review results to be reflected into the SAMG revision.

Table 1. Major design change parameters

Design Parameter	Before	After
Reactor thermal power (MWt)	2,775	2,900
Core thermal design flow rate (gpm)	95,600	94,200
RCS average temperature (core) (°F)*	592.5	591.3
Inlet temperature of component cooling water (°F)	95	120
Containment relative humidity (%)	70	10
RWST cooling water temperature (°F)	92	100
Fission product inventory in core**	different	different

* It is a little different at various locations in the RCS.
** The amount of inventory depends upon fission product isotopes.

In addition to these parameters, plant's increased vulnerabilities induced by power uprates have to be considered since the SAMG contains the information on these changes; the review outcomes of probabilistic safety assessment (PSA) and severe accident environmental conditions.

3. Revision of Plant-Specific SAMGs

The revision of plant-specific SAMGs requires the reviews of several detailed documents as well as SAMG itself.

3.1 PSA Review

The effects of power uprates on the PSA results are investigated in a comparative and consistent manner like original efforts [3]. Although Reference 3 provides a detail of quantitative Level 1 and 2 results over internal and external events, overall results are not quite a different from those of the original efforts. Especially, dominant accident sequences inducing core damage and subsequent containment failure remained to be unchanged. Table 2 represents major accident sequences as a result of the PSA review of Kori units 3&4, which is considered in the derivation of severe accident environmental conditions and the revision of other detailed SAMG documents.

Table 2. Changes of plant damage states in Kori 3& 4

Priority	Before Power Uprating		After Power Uprating	
	Scenario	Frequency	Scenario	Frequency
1	SLOCA_S5	1.27E-06	SLOCA_S5	1.29E-06
2	SBO2_S60	8.29E-07	SBO2_S60	1.10E-06
3	SBO2_S42	6.02E-07	SBO2_S42	6.77E-07
4	SBO2_S75	5.17E-07	SBO2_S75	6.16E-07
5	LOCCW_S3	4.82E-07	LOCCW_S3	4.81E-07

3.2 Severe Accident Environmental Conditions

In order to generate input data required for SAMG and its technical background report and decide the conditions under which the usability of equipments and instruments can be achieved, MAAP4[4] calculations were performed for accident sequences as shown in Table 2. The accident progressions for each sequence are summarized in Table 3. Comparing them to those of the original efforts, timings of accident progression are much faster as expected. Due to more stored energy in the reactor core, the reactor vessel was failed at earlier time.

The thermo-hydraulic responses such as pressure, temperature, and radiation dose at various locations in the reactor vessel, RCS, and containment to which accident management actions are taken, can be obtained by MAAP4 calculation results. Depending upon the request timing, their peak values are applied to the determination of environmental conditions, of which they are found to be nearly similar between with and without power uprates.

3.3 SAMG setpoint document

Like emergency operating procedure, the SAMG has a lot of setpoints, which are used for entry point of SAMG strategies or various diagnostics during accident progression. By a review of setpoint technical background document, the power uprating is found to affect only a few setpoints such as F02, L07, and P10. Among them, the setpoint F02 was changed from 102.14 m^3/hr to 103.74 m^3/hr.

3.4 Computational Aids

The computational aids (CAs) have been developed to complement the unavailable instrument during the accident and to assist the operator's decision for SAMG action. There are seven CAs in SAMGs of domestic NPPs; (1) Injection rate for long term decay heat removal (2) Hydrogen flammability in containment (3) RCS injection to recover core (4) Containment water level and volume (5) RWST gravity drain (6) Volumetric release rate from containment ventilation and (7) Hydrogen impact on containment depressurization. Among them, power uprating led to make four CAs changed, which is summarized in Table 4.

Table 4 The revised computational aids

CV	Influencing Factor	Before PU	After PU
01	Reactor power (MWt)	2,775	2,900
02 & 07	Amount of noncondensible and noncombustible gas generated by MCCI (lbm-mole)	72.4	0.1435
	Containment atmosphere superheating by MCCI (°F)	14.0	40.80
03	Reactor power (MWt)	2,775	2,900
	ECCS cooling water temperature injected into RCS (°F)	92	100

3.5 SAMG and its Technical Background Document

In general, all the design and operational changes are reflected into SAMG and its technical background document. For power uprates, these activities were performed coupled with scheduled revision work. These revised documents will be published and used in the plants at the same time after power uprating license is issued. Of course, the validation of revised SAMGs needs to be performed. The main purpose of the SAMG validation is to confirm the capability of SAMG in order to assure its intended function. The other purpose is to reflect feedbacks from the plant personnel in using the SAMG material.

4. Conclusion

In this study, a summary of all detailed requisites for revising plant-specific SAMGs is presented for a provision of licensing amendment application for power uprating of operating domestic NPPs. These activities were performed based on an insight on the variation of plant risk and vulnerability and available severe accident mitigation strategy and/or tools. These experiences and outcomes will contribute on enhancement of plant safety by appropriately reflecting design and operational design changes on time.

REFERENCES

[1] KHNP, "Yonggwang 1&2 Severe Accident Management Guidance," 2004. 12. 30.

[2] KHNP, "Kori 3&4 Severe Accident Management Guidance," 2004. 12. 03.

[3] KHNP, "고리 3,4 호기 및 영광 1,2 호기 출력증강에 따른 PSA 영향 검토보고서," 2006. 6. 30.

[4] R.E. Henry, et al., "MAAP4 – Modular Accident Analysis Program for LWR Power Plants," User's Manual, Fauske and Associates, Inc., vol. 1,2,3, and 4, 1990.

Table 3 Major event timings for accident seqeunces

Event	SLOCA_S5		SBO2_S60		SBO2_S75		SBO2_S42		LOCCW_S3	
	before	after	before	after	before	after	before	after	before	after
Core Uncovery	41,104	37,150	57,477	53,390	10,332	10,306	57,298	53,390	11,473	11,409
Max. Core Temp. Exceeds 1,200 F	45,965	45,330	59,105	54,930	13,225	12,980	59,110	54,927	13,320	13,120
CM Relocation into Lower Head	52,706	50,777	63,206	60,248	16,421	17,649	63,206	60,248	23,645	19,238
Reactor Vessel Failure	-	-	67,523	61,154	-	-	-	-	32,803	27,119