Evaluation of Key Components for Improvement of Domestic SAMG

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1. Introduction

After the TMI accident, the US NRC required that the SAMG (Severe Accident Management Guide) should be developed for all NPPs (Nuclear Power Plants) as one of the Post-TMI Actions. Also, in Korea, the SAMG for all domestic NPPs been developed by the Nuclear Safety Policy Statement and successive Nuclear Power Plant Severe Accident Policy Decision. In 1994, the Korean Generic SAMG based on the WOG (Westinghouse Owners Group) SAMG for full power operation mode was firstly developed. Based on the Korean Generic SAMG, the plant specific SAMGs for all domestic NPPs had been developed and applied

After the Fukushima Accident, the importance of SAMG for LPSD (low power and shutdown) stage including the mitigation actions for severe accident in the SFP (spent fuel pool) was newly issued. In 2012, PWROG (Pressurized Water Reactor Owners Group) had developed the PWROG SAMG that covered the strategies for the severe accidents in LPSD stage and in the SFP. Also, in Korea, the LPSD SAMG for all domestic NPPs had been developed by the Post-Fukushima Actions. The current specific SAMG applied in each plants is the Integrated SAMG for full power and LPSD stage.

In 2019, the Accident Management Plan (AMP) for all domestic NPPs had been submitted to the Regulatory body and the licensing review process is progressed. During this review process, the effectiveness of current SAMG that is based on the symptom and qualitative decision making has been issued. In addition, the consistency and the suitability of the assumptions used in the assessment of mitigation capabilities and in the SAMG has been issued, specifically focused on the order of operator actions for initiating the MACST (Multi-barrier Accident Coping STrategies) facilities. And, eventually, the Regulatory body requires that the current SAMG should be revised based on the newest technical standards.

2. SAMG Improvement Plans

2.1. Requests for Improvements

The requests for improving the current SAMG for APR1400 type is classified as the short-term items that should be implemented as soon as possible and the long-term items that will be taken so many years. The major short-term items are described as below.

1) Improvement of Emergency-01 to guarantee the preferential execution of RCS depressurization, RCS Injection and Cavity flooding.
2) Guarantee the survivability of the equipment used in the mitigation actions.
3) Clarifying the conditions to use the Ex-Vessel Cooling strategies.

In addition to these, the regulatory body required the fundamental improvements of the current Integrated SAMG framework based on the WOG SAMG (1994). The major long-term items are described as below.

1) Pre-defined Instrumentation Information used in mitigation actions.
2) Diagnosis of the plant status using the quantitative measures.
3) Demonstrate the effectiveness of each strategies using the quantitative measures.
4) Provide the quantitative results for the adverse effects for each strategies.

Under the current SAMG framework, it is not easy to resolve the long-term issues since the current SAMG was composed of the mitigation actions based on the symptoms of the plant and the qualitative engineering judgements [1]. So, it is needed that the new SAMG framework should be introduced.

2.2. Introduction of PWROG SAMG (2016)

In 2016, PWROG published the new SAMG framework represented by the DPG (Diagnosis Process Guideline). The earlier WOG and PWROG SAMG had the DFC (TSC Diagnostic Flow Chart) and SCST (Severe Challenge Status Tree) as the diagnostic tools for status of NPPs [2]. The current domestic SAMG also followed that type of flow chart combined with DFC and SCST.

In addition, PWROG SAMG (2016) developed 5 types of new Technical Support Guideline (TSG) as below [3].

- TSG-1: INSTRUMENTATION GUIDELINE
- TSG-2: DECISION MAKER GUIDELINE
- TSG-3: SITE CAPABILITIES
- TSG-4: BENEFIT CONSEQUENCE INFORMATION
- TSG-5: COMPUTATIONAL AIDS

The PWROG SAMG (2016) has been modified as the PWROG SAMG for International. It was developed for Non-US NPPs which had the different design characteristics. In Table 1, the major characteristics of

WOG SAMG (1994), PWROG SAMG (2016), and PWROG SAMG for International Plants

Table 1: Characteristics of SAMG

	WOG SAMG (1994)	PWROG SAMG (2016)	PWROG SAMG for International Plants
Diagnosis	DFC, SCST	DPG	DPG
TSG	None	5	3
Type of Guideline	Guidelines	Procedure	Guidelines
MCR Pre-Action	None	Included	Included
LPSD Mode	None	Partially included	Included
PAR	None	None	Included
Guide for Loss of DC	None	None	Included

3. Key Component for Improvement of SAMG

3.1. Introduction of DPG

In the current Integrated SAMG used the DFC combined with SCST, the diagnosis and selection of mitigation strategy should be executed as the type of flow chart in a consecutive order except the case that the set-point for the severe challenge parameter is exceeded. However, in the DPG, the current status of the plant is represented as the 4 colors based on the continuously monitored some specific parameters, such as the water level in SG and RCS pressure, and the trend of these parameters. The 4 colors indicate the order of priority for mitigation strategies that should be urgently implemented [3]. So, TSC can select the needed mitigation strategy intuitionally. The main advantage of DPG is the flexibility and speed for implementing and transferring the mitigation strategy.

However, it is necessary to consider the method for trend indication of some important parameters in the DPG. Also, the determination of set-point value for entering the specific mitigation strategies is not the easy problems in the view point of the uncertainties included in the severe accident phenomena

3.2. Development of Instrumentation Guideline

The current SAMG evaluated the survivability of instrument used in the mitigation actions at the stage of SAMG development. However, there is no proper guideline for the usability or alternate measures for instrumentation in each guidelines. Actually, the current SAMG has no specific guidelines for TSC (Technical Support Center). PWROG SAMG provides the 5 types of TSC guidelines as TSG described above, and among these, “TSG-1 Instrumentation Guideline” can be the key component for application of DPG. In this guideline, the essential instruments for diagnosis of plant status and implementation of mitigation strategy are pre-defined. Also, the information for the scope and usability of instruments including the error bound and the survivability during the progression of severe accident is provided. In addition to documentation for TSG-1, it is necessary to develop the program to notice the usability of major instruments according to the changes in containment and RCS conditions.

3.3. Simplification of Mitigation Guideline

According to the current structure of mitigation guideline, firstly the ways and means for implementing the actions are confirmed. And then, TSC should have to find the adverse effects for that actions, and also find and evaluate the actions for mitigate the adverse effects. After that, in the determination stage of implementing the mitigation action, the results for the corresponding mitigation actions not to be implemented should be evaluated. And, after those results should be compared with the adverse effects, if the final results for those comparison are acceptable, mitigation action is implemented. At the early stage for developing the first SAMG in 1990s, it was inevitable that TSC should be responsible for the evaluation and comparison process about the positive and adverse effects, even though it was pointed that TSC did not have enough knowledge and time for driving the proper determination, practically. The reason for that is the lack of knowledge for the severe accident phenomena and the too much uncertainties included in the prediction of accident progression and mitigation actions.

During the last few decades, specifically after the Fukushima nuclear accident, there have been a lot of accomplishment in the research field for severe accident phenomena and coping strategies. Based on these results, PWROG revised the mitigation guidelines from the type of guideline to the type of procedure and simplified the comparison process about the positive and adverse effects. So, only the step for implementation of proper mitigation action and successive monitoring process is remained in the revised SAMG. However, in the PWROG SAMG for International Plants mainly used in European plants, the type of guideline is maintained.

4. Conclusion

KHNP has started the project for improving the current Integrated SAMG based on the WOG SAMG (1994). The main purpose of this project is the development of generic SAMG for the domestic PWR type NPPs representing the PWROG SAMG (2016). In order to apply the PWROG SAMG (2016) to the current Integrated SAMG, the key components are identified as bellows;

1. Development of plant specific DPGs based on the large amount of severe accident analysis including the sensitivity and uncertainty analysis.
2. Development of plant specific Instrumentation Guidelines including the analysis for the

equipment survivability and the alternate instrumentations.

3. Development of tools and methods to simplify the comparison process about the adverse effects and positive effects for specific mitigation actions.

In addition to those key components, there may be so many components to develop the new DPG based SAMG, such as the types of mitigation guidelines and the accuracy and clarity of Computational Aid. So, in the developing phase of generic DPG based SAMG, it will be the main focus to find the problems and the solutions for those.

Above all, the investigation of the uncertainties in the severe accident phenomena and the mitigations actions should be preceded. Because the uncertainty issue is the most important key factors in the development of robust and reliable SAMG.

REFERENCES

[1] Development of Severe Accident Management Guideline for Korean Standard Nuclear Power plants, KAERI, 1999
[2] Westinghouse Owner's Group Severe Accident Management Guidance, 1994.
[3] PWROG Severe Accident Management Guidelines, PWROG, 2016