Validation Plan of Emergency Operating Guideline for Continuous Multiple Failure Accident in OPR1000 Nuclear Power Plants

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1. Introduction

One of the key lessons learned from the Fukushima Daiichi Nuclear Accident is that the tsunami exceeding design basis could lead the nuclear power plant to the conditions of loss of ultimate heat sink (LUHS) and extended loss of all AC power (ELAP). Loss of all AC power is classified as one of multiple failure accident by regulatory guide of Korean accident management program. Therefore, we should develop strategies for the emergency operating guideline (EOG), shutdown EOG (SEOG) and MACST operating guideline (MOG) and should perform validation of the guidelines in order to respond the continuous multiple failure accident (CMFA). This paper developed the validation plan for the EOG of CMFA including the extended loss of all AC power in pressurized water reactor.

2. Guideline Sets

2.1 Continuous Multiple Failure Accident

Nuclear safety and security commission (NSSC) notified Official Notification of Accident Management Plan including 9 scenarios of CMFA at March 2016. Accident prevention strategies for core cooling, containment and SFP are implemented by EOG, SEOG and Multi-barrier accident coping strategy Operating Guideline (MOG). The scenarios implemented by EOG are ATWS (anticipated transient without scram), Loss of All AC power, Steam generator multiple tube failure (MSGTR), Total loss of feed water (TLOFW), Inter system LOCA (ISLOCA), Loss of Ultimate Heat sink, SB LOCA with loss of SI or Recirculation. Loss of Shutdown cooling function is responded by SEOG. Loss of SFP cooling function is responded by AOP and MOG. The event importantly evaluated by PSA (Probabilistic Safety Assessment) is not yet determined. The guideline sets should be comprehensively validated including the interface procedure for implementation.

2.2 Validation Guideline Types

The guidelines validated are a set based on all the guidelines revised including SEOG, EOG and MOG.
SEOG and EOG will be validated accurately. However MOG cannot validate by complete accident scenario. MOG contains instructions for the use of installed plant and portable MACST equipment to mitigate an extended loss of all AC power (ELAP) and/or a loss of normal access to the ultimate heat sink (LUHS). Because the events that lead to the use of MOG are beyond design basis accident, validation of MOG utilizes stress test results and analysis results from system designer and equipment supplier without validating in simulator.

2.3 Guideline Upgrade

Major upgrade of guidelines is to use the MACST equipments in situation of ELAP and LUHS. Once through operation (feed and bleed) will start directly in situation of the total loss of feedwater (TLOFW) accident without entry into function recovery guideline by combing of TLOFW recovery guideline and once through operation. Recovery guideline of LUHS is added in Loss of outside power (LOOP) recovery guideline for long term cooling using MACST equipments (movable high flow pump and heat exchanger) after shutdown cooling system is connected. In order to meet the Korean reg. guide requirement to sustain DC battery for 8 hour after SBO, non-essential DC loads are shed by performing MOG-04. Finally recovery guideline for loss of shutdown cooling system during mid-loop operation is upgraded from AOP to SEOP to manage and control strictly core uncovery. Recovery guideline for Loss of spent fuel pool cooling is upgrade from AOP to MOG in situation of ELAP and LUHS to use the MACST equipment for the long term cooling of the SFP.

3. Method of EOG Validation

The validation evaluates the effectiveness of the revised guideline sets in responding to major plant transients including the CMFA. The revision sets of EOG, SEOG and MOG to respond the CMFA were modified to include Hanul Units 3&4 plant-specific technical guidelines (PSTG).

The EOG validation will evaluate that the operational guidance in the revise of plant-specific EOG responses adequately to manage emergency conditions. Validation team will comprehensively evaluate the level of detail, understandability and operational correctness of these guidelines for the CMFA.

The validation will be done on the Hanul Unit 3&4 simulator. Operating crews will use the draft of EOP, SEOP and MOG to guide their actions in response to simulator indications during plant transients. Detailed observations were made of performance, procedure usage and plant response by the observation team.
In order to accurately assess the effectiveness of revisions to the guidelines during simulated accident conditions, specific criteria and check lists have been

developed.

4. Operator Action Time

Operator action time due to an EOG revision could exceed safe shutdown time requirements or assuming values of safety analysis. Therefore, any revision which lengthens the time to complete time-sensitive EOG actions should be evaluated and validated if necessary. They should be assessed by considering scenarios that assess their integrated effects on the overall mitigation process. If a time-critical action flow-path is impacted by the EOG revision, then the validation program should ensure that revised EOG steps do not prevent execution of any time-critical action within analytically prescribed times. The validation program should validate that time-critical actions can still be executed within specified time periods in simulation test.

In the event of an SGTR, the operator is required to take actions to stabilize the plant and terminate the primary to secondary leakage. An evaluation has been performed to establish the operator action for use in the analysis of the SGTR to determine the dose evaluation. The operator actions which are required for recovery from the SGTR and the available data on the times to perform these actions have been reviewed. The available data on operator action times for the SGTR includes information which has been obtained from reactor plant simulator studies as well as plant data from five actual SGTR events as shown in Table-1. Operator action times have been assessed that they are appropriate for the SGTR event as shown Table-2. These operator action times can be used as input for the analysis of the SGTR to determine the dose evaluation if the times are confirmed by validation program.

Therefore, this validation program will assess the operator action time with Hanul 3&4 simulator. Operator action time data of Table-2 will be confirmed and calculated using revised EOG in this validation program for 5 tube rupture case and could be used continually for the SGTR analysis.

Table-1 Operator Action Time for SGTR (min)

Action	Prairie Island (1979)	Ginna SGTR (1982)	KEPCO E&C
Identify and Isolate ruptured SG	27	13	19
operator action time to initiate cooldown	6	0	5
cooldown	7	3	
operator action time to initiate Depressurization	2	26	
Depressurization	5	3	
operator action time to initiate SI termination	14	32	
SI termination and pressure equalization	61	77	

Operator action time for revised CMFA EOG will be checked comprehensively in this validation program. Except for SGTR, especially, operator action time for SBLOCA with HPSI fail, Loss of shutdown cooling system and total loss of feedwater accidents will be confirmed in simulator test.

Table-2 Operator Action Time for SGTR

Operator Action	Time for Safety Analysis
Identify and Isolate ruptured SG	Calculated from simulator for 6 units and average value
Operator action time to initiate cooldown	6 min (Calculated from operator action steps)
Cooldown	Calculated from simulator for 6 units and average value
Operator action time to initiate Depressurization	3 min (Calculated from operator action steps)
Depressurization	Calculated from simulator for 6 units and average value
Operator action time to initiate SI termination	2 min (Calculated from operator action steps)
SI termination and pressure equalization	Calculated from simulator for 6 units and average value

5. Conclusions

This paper prepared the guideline validation plan for the CMFA. To ensure that the approved revisions were properly incorporated into the EOG, a formal validation of the Revision 3 of the EOG will be conducted in Hanul NPP OPR1000 simulator. The validation consisted of simulator tests utilizing some scenarios. This validation will be demonstrated that Revision set of the EOG, MOG and SEOG have usability and operational correctness. Some discrepancies resulting from the validation tests will be incorporated and Revision 3 of the EOG for OPR1000 NPPs will be issued in December, 2018.

This validation program will show that these strategies and operator actions in guideline sets can deduce safe shut down from abnormal or emergency condition for the CMFA.

REFERENCES

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