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An Estimation of Operator Action Time during SAMG execution

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1. Introduction

The current severe accident prevention and mitigation strategies have emergency operating procedures (EOP) and severe accident management guideline (SAMG). The SAMG was developed after TMI accident in 1979 because EOPs were inadequate to enable operator success in controlling/preventing/mitigating accident at nuclear power into significant core damage accidents. Also, for post-Fukushima follow-up actions, the SAMGs were revised to enhance effectiveness of severe accident strategies. Therefore, verification and validation (V&V) of the developed SAMG is needed to manage the severe accidents properly. Especially, the experts for severe accident management are recommended as follows in 2016 IAEA technical meeting. Symptom based SAMG requires more knowledge and training in order to countermeasures aimed to mitigating severe accidents. And the time required to implement an action should reflect the performance of operator during SAMG execution.

In severe accident states, the operators in a highly confusing state will try to mitigate the condition of NPP. Thus, the operator must have enough time to mitigate the severe accident. To provide enough time for operators to mitigate severe accidents, the entry condition and timing of SAMG is very important. The current SAMG entry condition for Korean NPPs is met when the core exit temperature (CET) reaches 650℃. However, the current SAMG entry condition for Korean NPPs is not reasonable, since this entry condition was determined without considering operator action time. Therefore, the SAMG entry condition needs to be reconsidered with operator action time. Before reconsidering the operator action time, the operator action time is needed first. In this paper, operator task analysis in SAMGs performed and the operator action time was assumed based on ANSI-ANS-58.8 [1]. Also, assumed operator action time was verified using MAAP code.

2. Operator task analysis in SAMGs

The SAMGs for OPR1000 were developed by quantitative risk analysis through probabilistic safety assessment (PSA) analysis based on Westinghouse PWR [2]. The objectives of SAMGs are as follows: Protect fission product boundaries, mitigate radioactive material releases, and mitigate severe accident phenomena. The SAMGs was supplemented since the occurrence of the Fukushima nuclear accident. Also, the SAMGs are implemented by the technical support center (TSC). As mentioned earlier, the current SAMG entry condition depends only on CET = 650℃. The SAMGs consist of an emergency strategy, a control strategy, a monitoring strategy, and seven mitigation strategies. The seven mitigation strategies in SAMGs are divided into two objectives: in-vessel and ex-vessel strategies.

2.1 Task analysis

When the SAMG is entered under severe accident status, plant safety parameters are monitored, and mitigation 01 to 07 strategies are conducted according to the flow chart in control strategy. The operator task in SAMGs can be classified into monitoring, control, and evaluation tasks. For examples, the monitoring tasks are to check the PRZ water level, the availability of SI pump, etc. The control tasks are to adjust the PRZ pressure and to open the valve for examples, and an example of the evaluation tasks is to evaluate the adverse effect when adjusting the valve.

2.2 Assumption of operator action time

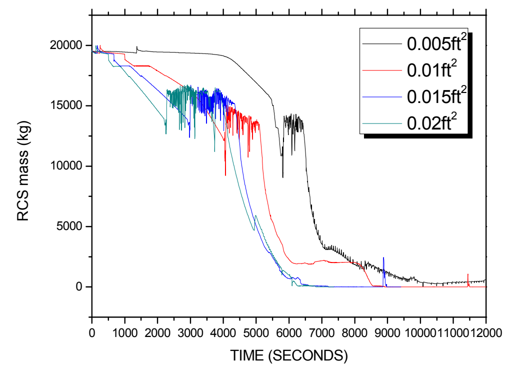
To assume the operator action time during the SAMG strategies, the various papers are reviewed. In this paper, the operator action time was assumed based on ANSI-ANS-58.8. The possible assumption methods described in ANSI-ANS-58.8 are as follows: Operator interviews and surveys, operating experience reviews, use of control/display mockups, and expert judgment. Unfortunately, the OPR1000 as well as all NPPs in South Korea do not equipped with the simulator for severe accident. Therefore, expert judgement was used in this paper out of 4 possible assumptions. Table 1 shows the assumed operator action time for each task.

Table I: Assumed operator action time

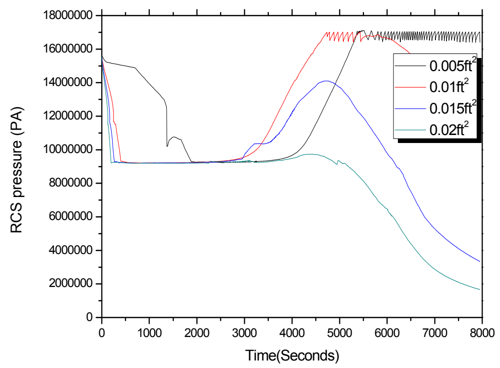
	Monitoring	Control	Evaluation
Time	30/task	40/task	12/task

3. Results

In order to verify the assumed operator action time, the maximum allowable time for the operator was estimated using MAAP code. Therefore, the success criteria for operator action is needed. In this study, the SBLOCA and MBLOCA requiring manual Aux. feed-water (AFW) start are selected as initiating event. The operator action is to establish AFW (Mitigation 01 strategy). Also, the operator actions considered in the analyses delayed of AFW pump manual start according to Mitigation 01 strategy. Therefore, the success criteria for operator action is AFW pump manual operation to depressurize the primary system. Fig. 1 shows the result on RCS mass inventory and pressure for SBLOCA when the HPSI system is not available. Fig. 2 shows the result on a 0.015ft^2 break size (SBLOCA) with different AFW delay. As shown in Fig. 2, the maximum available time to start the AFW pump according to the success criteria is 80 min. In other words, the maximum operation action time when performing the Mitigation 01 strategy is 80 min. Also, Table 2 shows the comparison of assumed and estimated operator action time. As a result of comparison between assumed operator action time and analyzed operator action, the results are similar. Therefore, it can be confirmed that the assumed operator action time is reasonable.

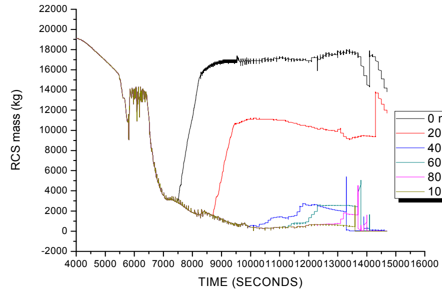


(a) RCS mass inventory

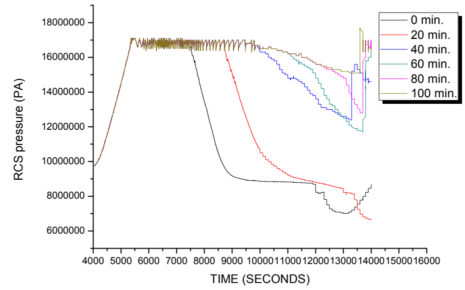


(b) RCS pressure for

Fig. 1. SBLOCA



(a) RCS mass inventory



(b) RCS pressure for

Fig. 2. The results for a 0.015^2 break size with different Aux. feed-water for SBLOCA

Table Ⅱ: Assumed operator action time

AFW delays	SBLOCA	MBLOCA	Assumed operator action time
20 min.	Success	Success	Min. task: 3000 sec (50 min.) Max. task: 5320 sec (About 86 min.)
40 min.	Success	Success	
60 min.	Success	Success	
80 min.	Success	Failure	
100 min.	Failure	N/A	

4. Conclusion

Based on ANSI/ANS 58.8, operator' task in SAMGs were analyzed. The task in SAMGs was divided into monitoring, control and evaluation in accordance with task characteristic and analyzed the amount of each task from emergency 01 to mitigation 07.The operator action time for each task was assumed.

In order to verity the assumed operator action time, the MAAP code was applied to the selected initiating events and scenarios. The success criteria is AFW pump manual operation to depressurize the primary system. As a result of comparison between assumed operator action time and analyzed operator action, the results are similar.

Therefore, it can be confirmed that the assumed operator action time is reasonable.

REFERENCES

[1] ANS, 1996, Time response design criteria for safety-related operator actions, NUREG-0471.
[2] J.J. Ha et al., 1998, Development of Severe Accident Management Guidance, KAERI/RR-1939/98.