Derivation of New Set Points for DPG Based Generic SAMG

Min-gyu Kim[a*], Mi-ro Seo[a], Ji-eun Oh[a], Su Won Lee[b], Myeong Kwan Seo[b]
[a]*Korea Hydro & Nuclear Power Co., Ltd., Yuseong-Gu, Daejeon, Korea*
[b]*FNC Technology Co., Ltd.,10 Fl., 13 Heungdeok 1-ro, Giheung-gu, Yongin-si, Gyeonggi-do, Korea*

[*]*Corresponding author: kimmingyu@khnp.com*

Keywords : Severe Accident, SAMG, DPG, MAAP5

1. Introduction

Since 2022, improvements to domestic nuclear power plants SAMG(Severe Accident Management Guidelines) have been conducted, updating from based on the WOG(Westinghouse Owners Group) SAMG (1994) to the latest technology standards of PWROG (Pressurized Water Reactor Owners Group) SAMG (2016). Due to the operation of MACST (Multi-barrier Accident Coping Strategies) facilities and diagnostic tools, DPG SAMG includes a variety of set points compared to WOG SAMG. The set points can be used samely if they have the same technical background both of WOG SAMG and DPG SAMG [1]. However, if two backgrounds are different, severe accident analysis should be conducted to develop and use new technical backgrounds. This paper describes the process of deriving new set points for WH-type(Westing House-type) nuclear power plants, focusing specifically on the stop pressure of the high-capacity mobile pump used for containment pressure control.

2. Analysis methods

The high-capacity mobile pump in MACST facilities is important to control containment pressure even when there is no power supply for extended periods of time. Due to its design that uses external water sources, flooding inside the containment beyond the maximum flooding level may cause submergence of devices used for accident mitigation. Therefore, an analysis was conducted to derive the set points of the high-capacity mobile pump that control the state of containment while preventing exceedance of the maximum flooding level. The analysis was conducted using the MAAP 5.06 code [2].

2.1. Accident Scenario Selection

Five major accidents involving damage to containment and unavailability of fixed pumps were reviewed to select a scenario. Station blackout (SBO) represent the initial event of loss of all AC power supply including offsite and onsite and has the highest failure of fixed pumps. Therefore, SBO is selected as the target scenario for this analysis.

2.2. Major Assumptions for Accident Analysis

The initial conditions for SBO accident scenarios are shown in Table I. All equipment is unavailable except for the passive device, which are accumulators. It was assumed that RCS depressurization by PORV(Power Operated Relief Valve) using batteries would be available 30 minutes after entering a severe accident. Also, it was assumed that RCS injection using the low-pressure mobile pump would be available 2 hours after entering a severe accident. Additionally, the startup of the high-capacity mobile pump is assumed to be available at the time when containment design pressure is reached.

Table I: Initial Condition for Accident Analysis

Scenario	SBO
Auxiliary Feed Water System	N/A[1)]
Safety Injection Pumps	N/A
Accumulator	3 Available
Containment Spray	N/A
Reactor Coolant Depressurization	Entry of Severe Accident + 30minutes
Low-pressure mobile pump	Entry of Severe Accident + 2hours
High-capacity mobile pump	Available at the time of containment design pressure

1) N/A : Not Available

2.3. Sensitivity Analysis

The start and stop set points for the high-capacity mobile pump used in sensitivity analysis are shown in Table II. The start pressure of the pump was fixed at the containment design pressure. When the pump was started, the stop pressure was reduced by 0.5 bars to analyze the sensitivity of the stop pressure. The lower the stop pressure of the high-capacity mobile pump, the more external cooling water is supplied to the containment. This is a major cause of exceeding maximum flooding level. So, it was only analyzed up to 2.1 bars.

Table II: Assumption for Sensitivity Analysis

Start pressure	• Containment Design Pressure
Stop pressure (bar)	• 4.6, 4.1, 3.6, 3.1, 2.6, 2.1

3. Analysis Results

3.1. The Derived Results of Set points

Analysis results for the spray time and frequency and containment water level according to pump stop conditions are shown in Table III.

Table III: Analysis Results

Case	Stop pressure (bar)	Spray time (min)	Spray frequency (hr)	Containment water level (m)
1	4.6	10.0	1.1	6.35
2	4.1	15.0	2.6	6.54
3	3.6	30.0	4.1	6.87
4	3.1	40.0	5.0	7.62
5	2.6	55.0	8.0	7.62
6	2.1	80.0	10.4	7.62

The results indicate that the higher the pump stop pressure, the lower the containment water level. When high-capacity mobile pump is stopped at 4.6 bar or higher, the containment spray time is less than 10 minutes. High-capacity mobile pump is started and stopped by field operator according to the instructions of the TSC(Technical Support Center). A spray time of less than 10 minutes has negative effects from the field operator's perspective due to frequent operation. Therefore, considering the results in Table III and from the operator's perspective, the stop set point for the high-capacity pump was determined as 4.1 bar.

Figure 1 shows that the maximum flooding level of the containment was exceeded under all high-capacity mobile pump stop conditions. According to the results, in addition to high-capacity pumps, other devices should be considered that do not raise the water level in containment.

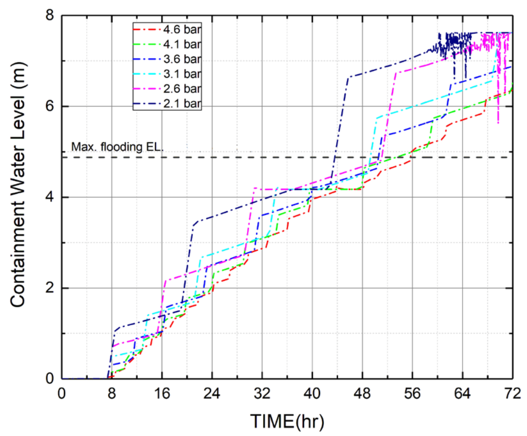

Fig. 1. Containment level under high-capacity mobile pumps stop conditions

3.2. Assumptions and Analysis Results for Additional Devices

Additional devices were assumed to be used for cooling of the reactor containment fan cooler (RCFC) and the reactor coolant system (RCS) using steam generators. Assumptions of additional devices were shown in Table IV.

Table IV: Assumptions for Additional Devices

Case	Assumptions
1	Upon reaching maximum flooding level, stop external injection and use RCFC to control containment pressure, The RCFC power is supplied by a 1MW mobile generator
2	After starting the low-pressure mobile pump, the mobile pump of secondary side was started to inject water to the steam generator at 30 minutes.

In Case 1, if the maximum flooding level in the containment was exceeded, the high-capacity pump stopped and the pressure inside the containment was controlled using RCFC. As a result of the analysis, the atmosphere in the containment was condensed by RCFC and the containment water level exceeded the maximum flooding level at 72 hours.

Case 2 assumed core heat removal through steam generator using a mobile pump of a secondary side. The RCS is cooled by injecting steam generator and the heat energy released from RCS is released through the secondary side of the steam generator. It has the effect of reducing the heat energy that increases the containment pressure. Therefore, as the time for the containment pressure to reach the containment design pressure was delayed, the frequency of spraying also decreased. And the water level in the containment did not reach the maximum flooding level, as shown in Fig 2.

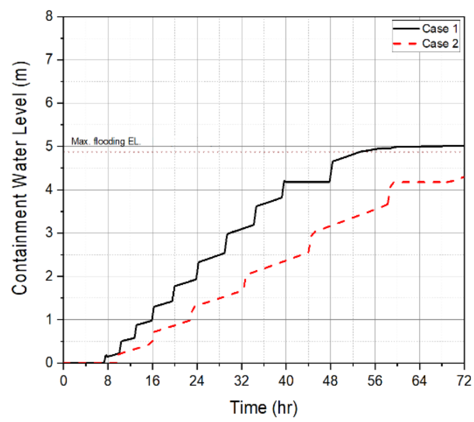

Fig. 2. Containment water level under the case of additional assumptions

4. Conclusions

This paper describes the process of deriving new set points for generic SAMG based on DPG for WH-type nuclear power plants. Through the effects of the spraying of the high-capacity mobile pump, the stop set point considering the maximum flooding level of the containment was derived as 4.1 bar.

To apply a this set point, additional devices of containment pressure control were needed to prevent exceeding the maximum flooding level of the containment. The containment pressure control was analyzed using RCFC and a mobile pump on secondary side. In particular it was confirmed that core heat removal through steam generator resulted in the containment pressure increase to be controlled so that it did not exceed the maximum flooding level of the containment. This will be used in future developments of generic SAMG and provide the technical background for the WH-type nuclear power plant.

REFERENCES

[1] PWROG-15015-P Revision 0, "PWROG Severe Accident Management Guidelines", February 2016.
[2] EPRI, 2013. Modular Accident Analysis Program Version 5.06.