Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 25-26, 2007

Evaluation of the Entrance Setpoint for Severe Accident Management Guideline

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1. Introduction

The Korea Ministry of Science and Technology (MOST) has issued the "Policy on Severe Accident of Nuclear Power Plants" at August 2001 [1]. According to the policy it was required for the utility to develop a plant specific severe accident management guideline (SAMG) for the operating plants and to implement it.

To cope with the government policy the utility has developed the SAMGs for each operating plant referencing the Westinghouse SAMG. The first principle of the SAMG is to use only the available equipments as is without introducing any system change.

According to the developed SAMG, once the core exit temperature exceeds 700 ^{o}C, we should consider that all the emergency operation procedure (EOP) actions have failed and the reactor core damage is occurring. From that point on the plant enters into severe accident management region and the operators will try to mitigate accident progress using SAMG. This entry setpoint of 700 ^{o}C was determined taking into account the damage at the fuel cladding [2]. During the safety review of KINS on SAMG, a question was raised whether this entry setpoint would provide the most right time for an accident management. In this paper we have analyzed the fitness of the setpoint for a specific plant of Uljin unit 1&2. The difference between the EOP actions and the SAMG actions is described first and the effect of differenct entry setpoint is analyzed using the MELCOR 1.8.5 code [3].

2. Management of High Pressure Accidents

In this section the difference of management actions between the EOP and the SAMG will be briefly explained. The difference between the two managements is mainly in the high pressure accident. The plant specific characteristic of depressurization equipment will be also described.

2.1 Management of High Pressure Accident in Uljin 1&2

The emergency operation procedure (EOP) of Uljin 1&2 is an operational procedure based on symptoms of plant. The Uljin EOP covers the accident until the core exit temperature (CET) exceeds 700 ^{o}C. In case the CET becomes higher than 700^{o}C, the severe accident management guideline (SAMG) overtakes the EOP.

The Uljin SAMG was developed referencing the Westinghouse SAMG. Main components of the SAMG are seven mitigative guidelines to mitigate the accident. In 7 guidelines from M-01 to M-07, a descriptive guideline of how to handle the accident is explained. The first 3 guidelines are 1) inject into the steam generator, 2) depressurize the RCS and 3) inject into the RCS. These guidelines are also actions adopted in the EOP. The guidelines specific for severe accident are from the 4th guideline which is to inject into the containment cavity.

We have reviewed the EOP and the SAMG and we found that the only difference lies in the RCS depressurization strategy. In EOP, operator will try to depressurize trying not to loose the RCS inventory. On the other hand, SAMG tries to depressurize even accepting the loss of RCS inventory because one purpose of the depressurization action in SAMG is to mitigate the direct containment heating(DCH) caused by high pressure melt ejection (HPME)

By the way, this difference is not clear for an accident of station blackout (SBO) in which there is no way for an operator to do anything without the recovery of power. Thus the question of whether it would be right to depressurize the RCS in case the CET exceeds 700 ^{o}C for an SBO accident arises.

2.2 POSRVs of Uljin 1&2 Plant

Uljin 1&2 has 3 safety relief valves for pressure control. The opening pressure and the closing pressure of the first valve is 166 and 160 bar respectively and the other 2 safety valves are open at 170 bar and 172 bar respectively. The maximum discharge rate of each valve is 170 ton/hr at the design pressure of 171.3 bar. In EOP these valves can be used for a feed and bleed operation. This feature is also adopted in SAMG to depressurize the RCS below 27.58 bar (400 psig).

3. MELCOR Modeling and Analysis of Entry Setpoint

According to the analyses of previous section, the only difference in the accident management between the EOP and the SAMG lies in the RCS depressurization. We have developed MELCOR 1.8.5 input to evaluate this difference and to verify the effect of the different SAMG entrance setpoint.

3.1 MELCOR 1.8.5 Modeling

Based on normal MELCOR simulation model for Ulchin 1&2 RCS and related safety system [4], detailed RCS natural circulation model was developed as shown in Figure 1. The RCS circuit was nodalized to allow the countercurrent flow of natural circulation in the RCS.

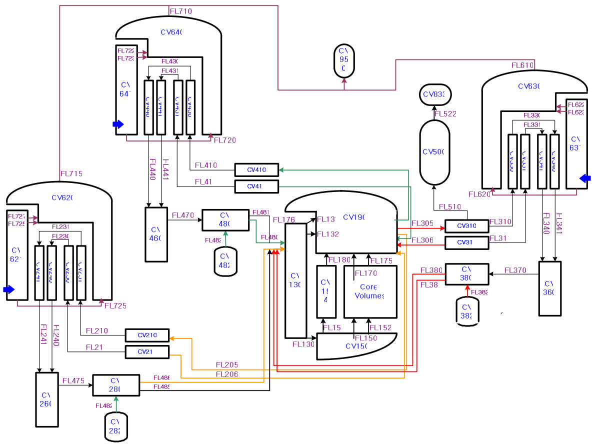

Figure 1. MELCOR RCS nodalization for Uljin 1&2

3.2 Analysis of RCS Depressurization Strategy

With the MELCOR code developed, we have simulated the RCS depressurization strategy. We tried to study the difference of plant behaviour depending on the starting time of depressurization. Thus we open the SRV at the time CET exceeds 700 °C, at the time 11,000 sec. and at the time 13,000 seconds. The results are compared with the reference case of doing nothing.

3.3 Analysis Result

The base case is when the operator does nothing. In this case the vessel breach occurs at 15,266 seconds. In case we open the SRV and thus depressurize the RCS at the time CET exceeds 700 °C, the vessel will fail at 23,210 seconds. The other values are shown in the table 1 below. From the table, it is clear that the time of vessel breach is delayed as we depressurize the RCS late. So from the point of vessel failure, we could say that there is no need to enter the SAMG when the CET temperature exceeds 700°C.

Table 1 The SRV opening time and the vessel breach time

SRV Open Time (sec.)	Vessel Breach Time (sec.)
No SRV Open	15,266
9,350 (CET>700°C)	23,210
11,000	25,414
13,000	27,328

The next thing we have analysed is the effect of this delayed vessel breach. Even if we can delay the vessel breach, if the plant condition becomes much worse as the breach is delayed there is no benefit of delaying the breach. The evaluation result is shown in Figure 2. The figure shows the amount of cumulative hydrogen produced during accident. For example, for a base case, the vessel breaches at 15,266 seconds and the cumulative hydrogen amounts to 400 kg. On the other hand, if we open the SRV at time 11,000 seconds, the cumulative hydrogen amount is 275 kg. Thus delaying the vessel breach by delaying the depressurization time is also beneficial from managing hydrogen point of view. In addition to this, by delaying the vessel breach we can have a much more chance of power recovery. The time difference of around 4 hours is an important time delay for an accident management point of view.

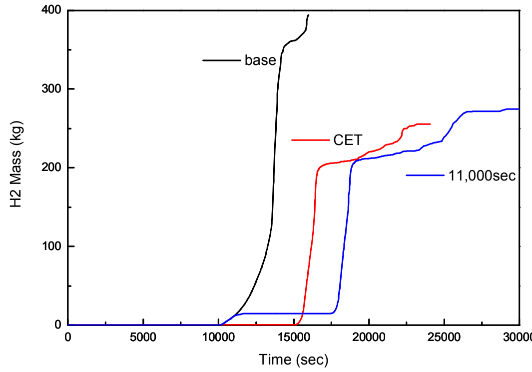

Figure 2 The cumulative hydrogen produced according to the depressurization time

4. Conclusion

We have analysed the entrance setpoint of SAMG for Uljin unit 1&2. According to the present SAMG, we enter the severe accident region when the CET exceeds 700 °C and operator will try to depressurize the RCS by opening the POSRVs. This entrance setpoint of 700°C is developed considering the fuel clad damage. But our analysis shows that there is no benefit of depressurizing the RCS early as was generally accepted. Delaying the depressurizaion is much more beneficial from accident management point of view. A new entrance setpoint of SAMG should be developed based on our analysis

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