Assessment of Kori-1 Severe Accident Management Guidelines using MELCOR Code

Namduk Suh, Hyojung Kim
Korea Institute of Nuclear Safety, Yusung-gu Kusung-dong 19, Daejon, k220snd@kins.re.kr

1. Introduction

Following the Policy Statement on Severe Accident of government, the utility has developed plant specific severe accident management guideline (SAMG) and is implementing it to operating plants. The developed SAMG which refers the Westinghouse SAMG for its technical background was submitted to the government and Korea Institute of Nuclear Safety is reviewing it from the point of view whether the plant specific features were properly taken into account in the guideline. This paper introduces part of the KINS' efforts to assess the mitigative capability of Kori Unit 1 SAMG[1].

2. MELCOR 1.8.5 Analysis of Kori Unit 1 SAMG

When a plant is under severe accident, the first two mitigative actions to take are 1) injection into steam generator and 2) RCS depressurization. The entry conditions for these actions of highest priority will be surveyed and in case the conditions are met, the operator should react using whatever ways available in-situ. The MELCOR 1.8.5 [2] calculation was performed to assess whether these actions can really accomplish what was supposed to accomplish in the SAMG for Kori Unit 1 plant. The accident scenario adopted in the analysis is a high pressure sequence caused by either a loss of instrument air or a station black out. According to the probabilistic safety analysis (PSA) of Kori unit 1, this high pressure sequence initiated by loss of instrument air contributes most to core damage. Thus the aim of our MELCOR calculation is to assess whether the proposed SAMG can really mitigate the accident progression under this accident scenario.

2.1 Injection into Steam Generator

According to the flow chart of SAMG proposed, the first mitigative action is to inject water into the steam generator in case the narrow range level of steam generator is lower than 26%. Some results we obtained through the MELCOR analysis of high pressure sequences are the following;

① entry condition of 26% NR steam generator level is reached within ~ 60 seconds.

② steam generator dry outs at ~ 5,300 sec. Recognizing the accident, the operators can make the turbine driven auxiliary feed pump run at ~ 30 minutes later, but once the TDP runs the core melting is prevented.

These analyses results stress the importance of heat removal through secondary side. In any case, once the auxiliary feedwater pumps could work, the core melting did not occur. And when a severe accident takes place, the steam generator drys to 25% NR level so quickly, so we can have some doubts whether we can really rely on this strategy after entering the severe accident management domain because we have so little time to react againt the progression of severe accident.

2.4 RCS Depressurization

The second high priority strategy to look for in the SAMG flow chart is the RCS depressurization. For Kori unit 1 plant the PORVs will not work in case we lose the instrument air. Under this circumstance, the only possible accident mitigation action is to depressurize the RCS by manually opening the PORV(s). The MELCOR 1.8.5 calculation was performed to assess how effective this RCS depressurization strategy could be for Kori unit 1 plant. Two PORVs are installed in parallel and each valve can remove steam at the rate of 26.4 kg/s . The points to assess are ;

① how effective is a depressurization action when it was applied during severe accident domain, which means the core exit temperature exceeds 922K.

② will it be more effective if we depressurize the RCS earlier based on other entry condition ?

To answer the above questions 3 cases were analysed with the MELCOR code.

Base : loss of instrument air accident without any accident management actions

Case-I : loss of instrument air accident openingonePORV at the time the RCS pressure becomes larger than 168 bar. This value is the one when operator will do bleed and feed operation in EOP.

Case II : loss of instrument air accident opening one PORV at the time the core exit temperature exceeds 922K.

The analysis results are summarized in the table 1 below. We can interpret the analysis result from accident management point of view like the following. For Case-1, the PORV opens early before the fuel melts and opening the PORV at this time, both water and steam could come out of the PORV. This reduces the water inventory in the RCS and consequently the core dry outs faster than the other cases. But reducing the RCS pressure enables the SIT water to be injected into the core and consequently the fuel melting begins much later than the base case anyway. There was a generally accepted worry that opening the PORV will reduce the water inventory in the core and thus make the situation worse. But from severe accident point of view this shorcoming was not such a serious one and the vessel failing time was much delayed compared to the base case.

To open the PORV and thus depressurize the RCS after recognizing the core exit temperature exceeds 922K which is an entry criteria of SAMG was still effective in delaying the vessel failure time. If we open the PORV at this somewhat later time , only steam was coming out of the valves. The time we gained in this case is around 3 hours. But in case we cannot find a way to cool the core within this 3 hours, the vessel will breach anyway. One question to follow is whether this 3 hours will be sufficient to make the SI pumps work and thus cool the core in a real condition of severe accident.

Table 1. MELCOR Prediction for Depressurization

	Base	Case I	Case II
Core Dry Out (s)	10,958	8,912	10,645
Begins Fuel Clad Melting (s)	14,550	22,529	23,127
Fuel Relocated To Lower Head (s)	15,053	23,586	26,883
Lower Head Penetration Failed (s)	17,830	30,370	31,189

The other strategies in the SAMG are all to cope with the accident after the vessel has been failed. Thus to prevent the vessel failure, we must absolutely be able to make the SI pumps work within this 3 hours.

3. Conclusion

The SAMG strategies for Kori unit 1 are assessed using MELCOR 1.8.5 code. The results show the importance of heat removal through secondary side. In case any auxiliary feedwater pumps could work, we will not have a severe accident. But we have a question whether this strategy of injecting water into steam generator could be classified as one severe accident strategy, because once we enter the severe accident domain, we found little time margin to inject water into steam generator and we think that this strategy should be performed early during the EOP. The RCS depressurization strategy using PORV was analyzed also. In case we open the PORV early before entering the severe accident domain, we can lose the water inventory in RCS because both water and steam comes out of the valve. But the shortcoming of losing water inventory was not such a serious one from delaying the vessel breach point of view. The start time of depressurizing the RCS didn't change much the ability to delay the vessel failure. If we can open the PORV in the Kori unit 1, we will gain around 3hours more before vessel breach compared to the case of doing nothing. Thus to prevent the vessel breach in severe accident we must be able to depressurize the RCS first, and then we must be able to make the SI pumps work and thus cool the core within 3 hours. Otherwise, the vessel will breach anyway and we will confront a ex-vessel severe accident phenomena.

REFERENCES

[1] Severe Accident Management Guideline for Kori Unit 1, KHNP, 2003.

[2] R.O. Gauntt et al., MELCOR Computer Code Manuals, NUREG/CR-6119, 2000.