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Comparative Analysis of MELCOR 1.8.5 and RELAP5 Codes for a SBO accident

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

1. Introduction

Severe accident analysis code MELCOR 1.8.5 [1] plays a role of a regulatory audit code in Korea Institute of Nuclear Safety (KINS). The code is widely used for the analyses of hydrogen risk, of severe accident management guideline and of level 2 PSA etc.. Though the code was verified intensively against severe accident experiments, we should be always careful about the capability of a code in simulating an accident progression. As part of our efforts to verify the code capability, we have performed a comparative analysis using MELCOR code and RELAP5/MOD3 code [2]. Actually the MELCOR code can simulate all the spectrum of accident , from initiation of an accident to the final source term analysis. Meanwhile, the RELAP5 code can simulate only to the beginning of fuel damage. Because the RELAP5 code was more richly verified against experiments simulating reactor coolant system (RCS) during accident, it is generally expected that the RELAP5 would simulate the RCS behaviour with more confidence than the MELCOR code. Thus we have performed the comparative analysis of MELCOR code with RELAP code mainly to confirm the capability of the MELCOR code in simulating initial RCS behaviour.

2. System Modeling

Figure 1 shows the MELCOR modeling of Kori-1 RCS. The RCS model includes the core, the primary and secondary systems. The core is modeled as 5 radial rings and 16 axial levels including top- and bottom-end fittings. The RCS model includes 2 steam generators, 2 reactor coolant pumps and 1 pressurizer. The containment is modeled with 28 control volumes.

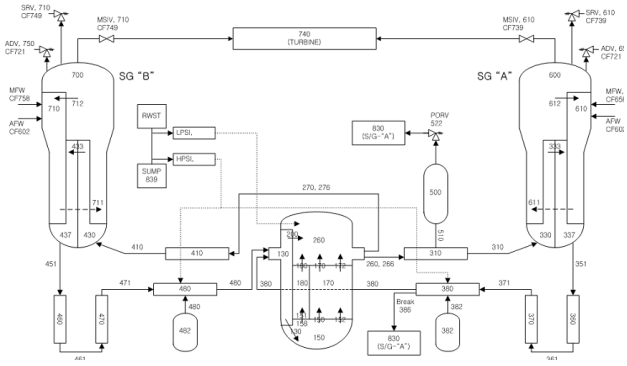

Figure 1 MELCOR Modeling of Kori-1 RCS

Figure 2 shows the RELAP5/MOD3 modeling of Kori-1 RCS. This model is the typical one used in KINS for audit calculation and it has more detailed control volumes than the MELCOR code.

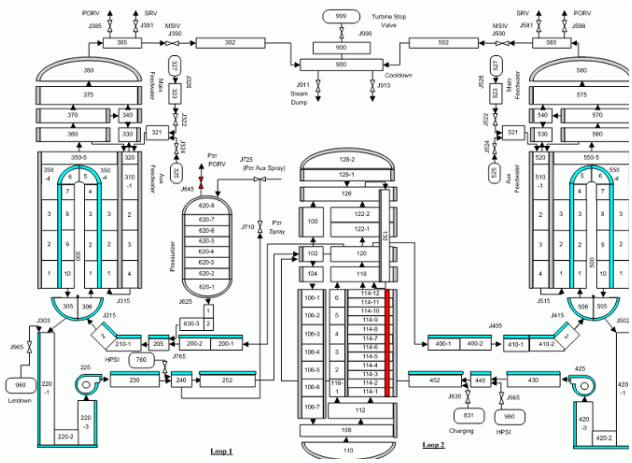

Figure 2 RELAP5 Modeling of Kori-1 RCS

3. Results of Comparative Analysis

The accident scenario chosen for analysis is a station black out (SBO) accident. This high pressure accident shows a complex accident progression and the contribution to the core damage frequency of Kori-1 is also important.

3.1. Steady State Initial Condition

Table 1 shows the steady state condition of normal operation. The simulated values are the ones each code calculates. These values will be taken as an initial condition before the accident starts. Except the RCS flow rate of MELCOR, the other values are in good conformance with the design values.

Table 1 Steady State Initial Condition

Parameter	Design	MELCOR	RELAP5
Rx. Pwr	1,758.0 MWt	1,758.0	1,758.0
RCS Rate	8.673 lbm/s	8,956	8,673
PZr Pr.	2,302 psia	2,302	2,302
PZR Lev.	60 %	61	59
HL Temp.	617.95 °F	612.65	618.65
CL Temp.	546.98 °F	546.51	544.51
SG N.Lev.	67 %	65	70.7
Feed Rate	1131 lbm/sec	1131	1131
Feed T	440 °F	440	440
Stm Rate	1131 lbm/sec	1138	1124
Stm Pr.	841.2 psia	821	832

3.2. *Analysis Results*

Table 2 compares the sequence of accident events calculated by the two codes. The exact timing of events are not the same, but the difference should come from the difference in system nodalization and from code specific features. But we think this magnitude of difference is within the range of phenomena uncertainties and thus acceptable.

Table 2 Comparison of Accident Sequence

Event	MELCOR	RELAP5/MOD3
Accident Initiation	0 sec.	0 sec.
Rx Trip	0 sec.	0 sec.
RCP Trip	0	0
Turbine Trip	1 sec.	1 sec.
PZR PORV Open	2,710 sec.	1884 sec.
SG Dryout	2920 sec.	3180 sec.
Core Uncover Starts	7,800 sec.	8,700 sec.

Detailed comparison is shown in figure 3 and 4. Figure 3 shows the pressures of pressurizer and of steam generators. The pressure of pressurizer calculated by the RELAP5 code is higher than the MELCOR calculation, thus the PORV opens earlier as in table 2. But the difference of two pressures are less than 7% and we think this difference is acceptable one. This is clearly shown in the figure 3. The time of steam generator (SG) dryout is later than the PORV opening time. The timing of SG dryout depends on how we define the SG dryout. In RELAP5 code, the dryout is defined when the water level is really 0. So even when the SG water level is low enough such that the heat removal from the RCS is negligible and thus the RCS pressure increases, the SG still is not defined as dried out in RELAP5 code. This is why the SG dryout occurs later than the PORV opening. In MELCOR calculation, the dryout is defined earlier. So the differences in table 2 sequence and the figure 3 come from the code specific definition of SG dryout level. Otherwise, the pressure of steam generators match very well in the two calculations.

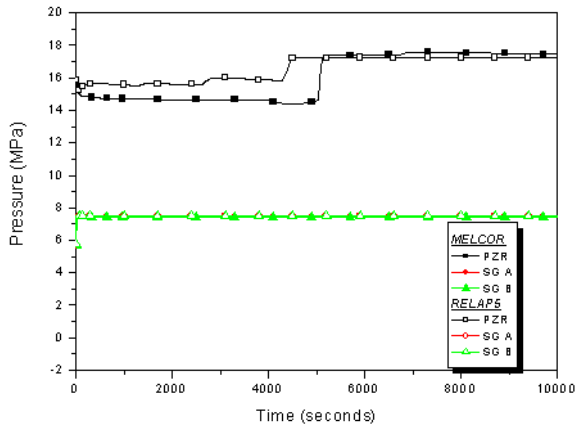

Figure 3 Comparison of PZR and SG Pressure

Figure 4 shows the mass flow rate of the reactor coolant system. The flow rate calculated by the MELCOR is higher than the RELAP5 calculation. Even though the flow rate of MELCOR is higher than the RELAP5, the initial SG water level of RELAP5 is lower than MELCOR input as in table 1, so the core uncover starts earlier in MELCOR calculation. Thus considering the tables 1 and 2 with the figures 3 and 4 , we can conclude that we understand the behaviour of the analysis results and they are in good agreement.

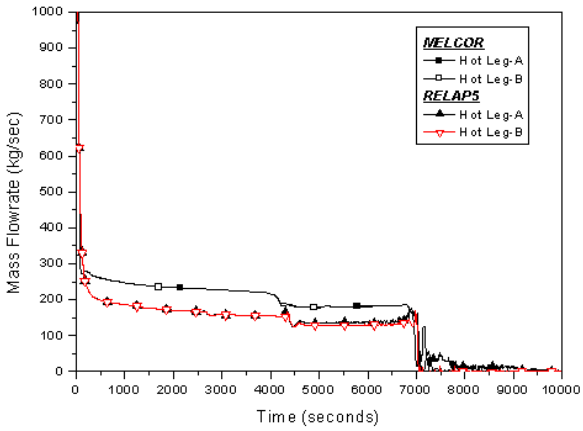

Figure 4 Comparison of RCS Mass Flow Rate

4. Conclusion

We have performed a comparative analysis of MELCOR 1.8.5 code with RELAP5/MOD3 code for a Kori-1 SBO accident. Some differences in the calculation results are coming from the code specific features of how they define the phenomena and also from the difference in the system nodalization. But the results behave reasonably and they are in good agreement with each other.

REFERENCES

[1] R.O. Gauntt et al., MELCOR Computer Code Manuals, NUREG/CR-6119, SAND2000-2417, 2000
[2] RELAP5/MOD3 Code Manual, NUREG/CR-5535, USNRC, June, 1999.