Comparison of MELCOR and MAAP calculation results in evaluating risk of early fatality for OPR-1000 plant

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1. Introduction

Currently, Korea Institute of Nuclear Safety (KINS) developed a draft for the performance goals based on PSA results[1,2] and insights obtained from the consequence analysis. Consequence analysis results depend on many site-specific factors such as source term information, meteorological data, population distribution and protective actions. In this study, we compared the source term data for the representative LER sequences by performing MELCOR and MAAP code calculation for the Optimized Power Reactor (OPR). Also, Level 3 PSA estimating the risk of early fatality was performed using MACCS2 code to find the effects of two different computer codes.

2. Data and Methodology

2.1 Selection of representative LER accident sequences

The result of preliminary consequence analysis shows that the main contributor to the risk of early fatality is containment bypass case. In the case of Ulchin units 3,4, steam generator tube rupture (SGTR) source term category (STC) explains about 90% of total risk of early fatality. The next significant categories are early containment failure (ECF), alpha mode and isolation failure. Thus, following two severe accident sequences were selected to evaluate and compare LER accident source term characteristics.

- Steam Generator Tube Rupture (SGTR)
- Early Containment Failure (ECF)

2.2 MELCOR and MAAP model

Results of MAAP calculation in this study were generated and reported by licensee during Shinkori units 1,2 PSA review process. MELCOR input was made at KINS based on the licensing documents[3]. Due to the limitation of available design data and code capability, there exist some differences in the plant modeling including control volumes, flow paths, physical parameters and control logics, etc

2.3 Accident Scenarios

In SGTR scenario, accident begins with one steam generator tube guillotine break. Also, a main steam atmospheric dump valve stuck open at the same time. All safety systems including auxiliary feed water, emergency core cooling and containment spray are assumed to fail. The ECF scenario is initiated from total loss of feed water. All safety systems fail except 4 safety injection tanks (SITs). Early containment failure originating from direct containment heating (DCH) is modeled by opening a flow path to environment at the timing of reactor vessel failure.

2.4 Evaluation of early fatality risk

To model early phase release of radioactive materials and public protective response activities, source term release within 24 hours was modeled. To treat the time variation, the release was divided into 4 plumes. Population and meteorological data at Kori site were used for MACCS2 code calculation. Risks were determined based on the NUREG-1860 methodology[4].

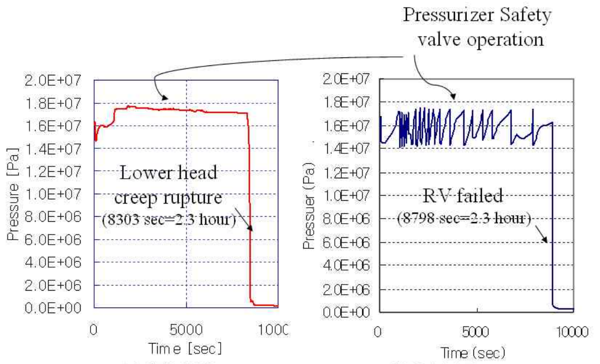
3. Results and discussions

3.1 System response

Table 1 shows the sequence of major events obtained, and Figure 1 shows reactor coolant system (RCS) pressure behavior during accident in the case of ECF scenario. As the data show, system responses slightly differ between MELCOR and MAAP code depending on the plant models such as safety system, control volume and trip logics, etc.

Table 1: Calculated sequences of events

Events	MELCOR	MAAP
Steam Generator Tube Rupture		
SGTR Start, ADV stuck open	0.0 s	0.0 s
Core uncovered	10,996 s	10,624 s
Clad (Zr) melt start	13,850 s	12,278 s
UO2 relocated to lower head	14,896 s	19,128 s
Lower head penetration	17,982 s	
RV failed		20,894 s
Early Containment Failure		
Stop to supply MFW	0.0 s	0.0 s
Core uncovered	1,916 s	1,648 s
Clad Melt Start	4,168 s	4,297 s
RCS Hot leg rupture	5,511 s	5,618 s
Lower head creep rupture	5,619 s	
RV Failed	8,303 s	8798 s

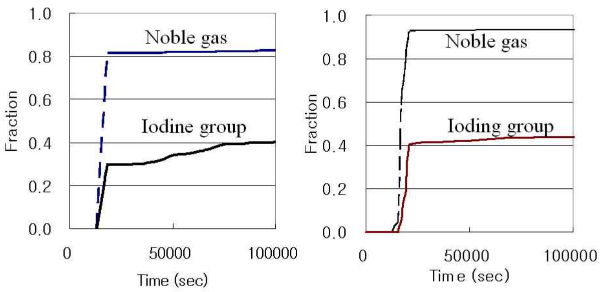


a) MELCOR b) MAAP

Figure 1: RCS Pressure (ECF)

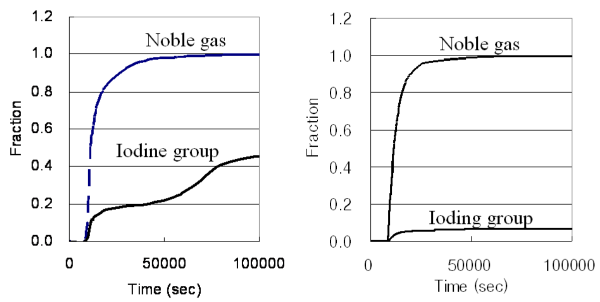
3.2 Released source term

Figure 3 and 4 show the radioactive material fractions released to the environment in each case. CsI release fraction within 24 hour is similar in the case of SGTR (40%,44% for MELCOR and MAAP calculation respectively), but it greatly differs in the case of ECF sequence (44%,6%). MELCOR calculation shows distinct late in-vessel release (re-volatilization of deposited radio-nuclides). However, MAAP calculation does not show such late in-vessel phenomena.



a) MELCOR b) MAAP

Figure 2. Radioactive material fractions released to the environment (SGTR case)



a) MELCOR b) MAAP

Figure 3. Radioactive material fractions released to the environment (ECF case)

3.3 Risk of early fatality

Table 2 shows the risk of early fatality evaluated at the Shinkori unit 1,2 NPP for the case of SGTR and ECF categories. The risk values show wide discrepancy between two computer codes depending on the released quantity and time characteristics of the release.

Table 2: Estimation of early fatality risk (/yr)

Cases \ Protective Actions	95% evacuation, 5% sheltering, relocation
Due to SGTR category accidents	
MELCOR	2.81E-9
MAAP	7.87E-9
Due to ECF category accidents	
MELCOR	3.73E-8
MAAP	7.74E-10

4. Conclusions

In this paper, Source term data for major LER sequences were evaluated and compared using MELCOR and MAAP code. Also, the risk of early fatality was compared using MACCS2 code calculation based on the derived source term data. The results show that CsI release fraction within 24 hour is similar in the case of SGTR, but greatly differs in the case of ECF sequence. However, the two codes (MELCOR, MAAP) show distinct differences in late in-vessel phase release of radioactive materials. Further works should be done to evaluate this difference.

REFERENCES

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