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MELCOR Code Source Term Characteristics for Fast SBO Scenario of OPR1000 Plant

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1. Introduction

Off-site consequence analysis in Level 3 PSA is mainly affected by source terms release characteristics of nuclear plant. The severe accidents analysis codes for quantifying the source terms release characteristics, such as MELCOR or MAAP, could be available to provide the detailed information of these characteristics to assess off-site consequence [1]. To utilize these characteristics from severe accident analysis codes, MELCOR code [2] was used in a specific severe accident scenario, i.e., fast station black-out (SBO) for OPR1000 plant [3].

2. Fast SBO Scenario

A considered accident scenario for large release of source terms is an early containment failure. Although there are several causes of early containment failure, in this study two scenarios are considered such as (1) over-pressurization and (2) energetic ex-vessel steam explosion. A difference between these two scenarios may be caused from cavity flooding conditions during severe accident progression. It is usually assumed that all auxiliary feedwater systems are unavailable in the fast SBO scenario.

3. Results and Discussion

Accident conditions and event progression of the selected scenario obtained from MELCOR code are shown in Table 1.

Table 1. Essential features of early containment failure during fast SBO

(a) Accident conditions

System	State
Initiating event	Station blackout(SBO) with DC power loss at time 0 sec.
Reactor trips	at off-site power off
Reactor coolant pumps	trip at off-site power off
All AFW pumps	Fail at off-site power off (not recovered)
HPSI/LPSI	No activate
SIT	Operable (4 SITs)
Containment Spray	Power Recover at 3 hrs (two pumps)
Recirculation	Spray recirculation fails due to the energetic steam explosion at RV failure
Containment	Ruptured due to the energetic steam explosion at RV failure

(b) Event Progression

Event	Time (sec)	
	Spray On at 3hr	Spray not worked
Reactor Trip, MSIV closed	0.0	Same
SG dryout	3502	Same
Core uncovered	6556	Same
Fuel melt starts	8826	Same
Containment spray starts	10800	-
RV Lower head failure	15237	15282
Containment Rupture	15961	16044
24hr from containment failure	102361	102444

Typical accident progression times are as follows:

- Core melt starts at about 3hrs
- Reactor vessel (penetration) failure occurs at 4.2 hrs

Fig. 1 shows the RCS pressure response for these scenarios.

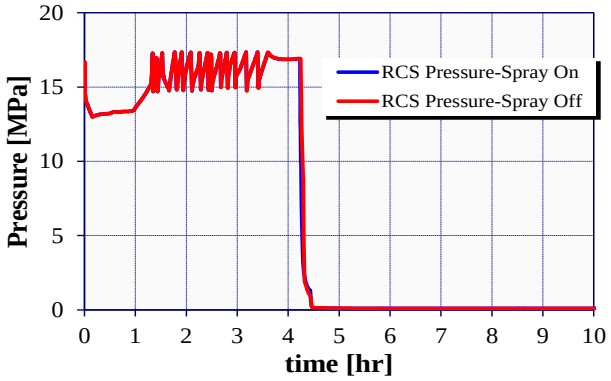


Fig. 1. RCS pressure response for fast SBO

Fig. 2 shows core melt ejection to cavity during accident progression.

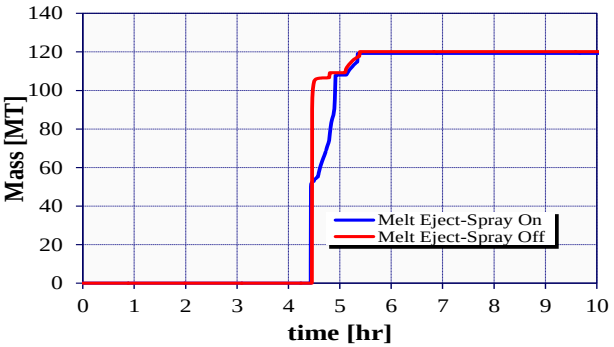


Fig. 2. Core melt ejection to cavity during accident progression

Fig. 3 shows containment pressure response during accident progression.

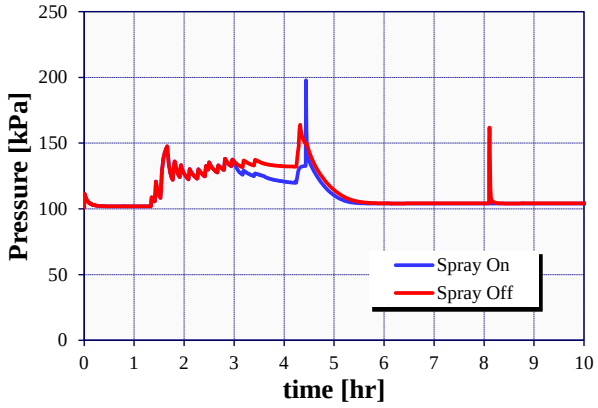
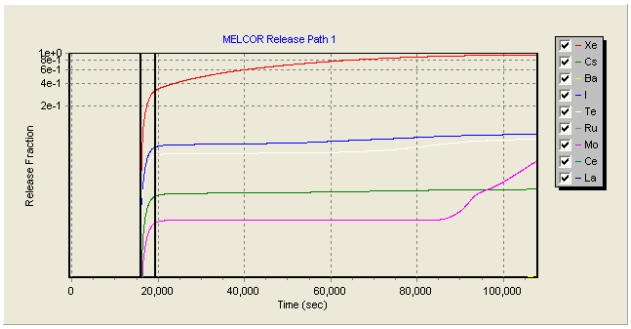
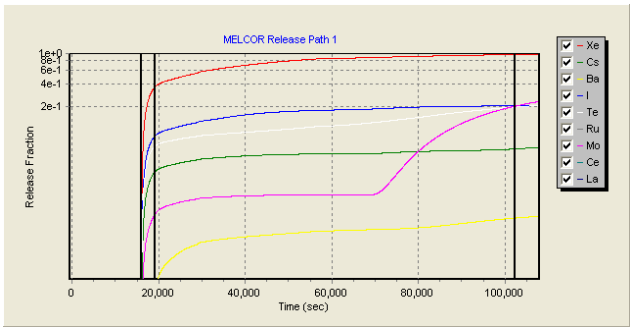


Fig. 3. Containment pressure response during accident progression

The release fraction of source term groups from the containment to environment is a major concern of off-side consequence analysis. The MELMACCS can generate this release fraction by using MELCOR output file [4].



(a) Spray on



(b) Spray off

Fig. 4. Cumulative source terms release fraction during accident progression

To utilize MELCOR output to consequence analysis, two-step manipulation is required:

- Conversion of release fraction for interested radioisotope group
- Dividing release segments into three phases to fit a plume model in the consequence analysis

Considering the release characteristics as shown in Fig. 4, three plume segments were applied:

- Plume 1 : Dominant release phase for initial massive release
- Plume 2 : Continuing release phase
- Plume 3 : Residual phase for assessing additive effects

Table 2 shows the generated source term release fraction from MELMACCS for these scenarios

Table.2. Generation of source term release fraction from MELMACCS for these scenarios

	Xe	Cs	I
Spray on			
Plume 1	0.3039	0.0119	0.0538
Plume 2	0.6385	0.0032	0.0279
Plume 3	0.0058	0.0001	0.0014
Sum	0.9482	0.0152	0.0831
Spray off			
Plume 1	0.3623	0.0269	0.0806
Plume 2	0.6057	0.0272	0.1224
Plume 3	0.0077	0.0024	0.0034
Sum	0.9757	0.0565	0.2064

4. Concluding Remark

Since the shocking accident of Fukushima, the assessment of source term and their effects on environment is a major concern for general public as well as nuclear safety experts. As an effect to precise analysis of these aspects, a major scenario, i.e., early containment failure were assessed in order to utilized source term information provided from MELCOR code to off-site consequence analysis. Obtained insights of source term characteristics from this study will be used in the off-site consequence analysis.

ACKNOWLEDGEMENT

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