Preliminary Study on Mass and Energy Release and Containment Vessel Response during Postulated Feedwater Line Break (FWLB) in i-SMR Using SPACE Code

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Introduction

- The Innovative SMR (i-SMR) employs a steel containment vessel (CV) and must maintain its integrity under both LOCA and secondary-side pipe ruptures.
- The feedwater line break (FWLB) accident is generally bounded by the main steam line break (MSLB) accident, since steam release through the break typically contributes more to the pressurization of the containment than the release of subcooled liquid.
- Since the i-SMR is a newly developed design, it is necessary to perform a quantitative evaluation of the FWLB and compare it with the MSLB to confirm the limiting secondary side pipe rupture.
- Therefore, this study analyzes the mass and energy (M/E) release and CV response during FWLB in the i-SMR using the SPACE code.

Analysis Methodology

- The M/E release and CV response during the FWLB accident were analyzed using **SPACE ver. 3.3.1**, modified by KAERI for the safety analysis of the i-SMR.
- The **standard input deck** based on the i-SMR DPL-2 was used, which was jointly developed by participating organizations, including KEPCO E&C, KHNP, KEPCO NF, FNC Tech.
- To maximize M/E release and CV response, the standard input deck was modified by incorporating conservative assumptions.
- A double-ended guillotine break of a single feedwater line with an area of 28,100 mm^2 inside the CV was assumed.

Table I. Major assumptions for the M/E release and CV response analysis during FWLB in the i-SMR

Parameters	Assumptions
Break location	Feedwater line inside CV
Break size	Maximum
Critical Flow Model	Henry-Fauske (Sub-cooled) Moody (Two phase)
Core Power	103% of full power (including instrument uncertainty)
Decay Heat	1979 ANS Standard + 20% uncertainty
AC[1)] Power	Loss at break
DC[2)] Power	Available
Single Failure	FIV failure (No significant effect to results)
Low Riser Level Setpoint	Maximum in harsh environment
SOPM[3)] Setpoint	Nominal

1) Alternative Current
2) Direct Current
3) Spurious Opening Protection Module

Analysis Results & Discussion

Mass and Energy Release of FWLB Accident

- If a rupture occurs in the feedwater line, feedwater is discharged into the CV through the break as a **two-phase flow**.
  - Liquid (most of discharged feedwater)
  - Steam (flashed due to depressurization)
    → increasing CV pressure
- FWLB → increase in CV pressure → high containment pressure (HCP) reactor trip → CV isolation, PAFS actuation
- When the helical-coiled steam generators (HCSGs) are isolated for PAFS operation, a pressurization of the affected HCSG causes a temporary increase in the liquid mass release rate. (see Figure 2)
- Once the HCSG inventory is depleted, the blowdown is terminated.

Figure 1. i-SMR FWLB Location

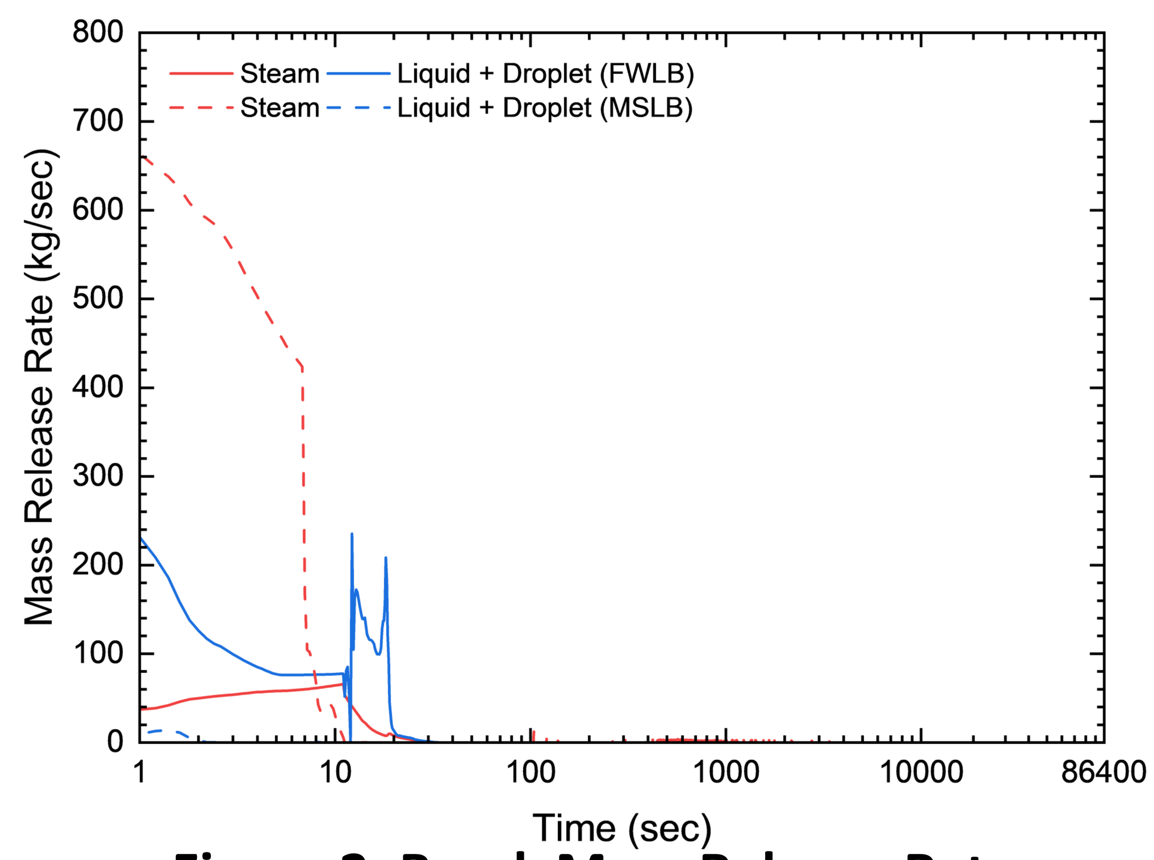

Figure 2. Break Mass Release Rate during FWLB and MSLB

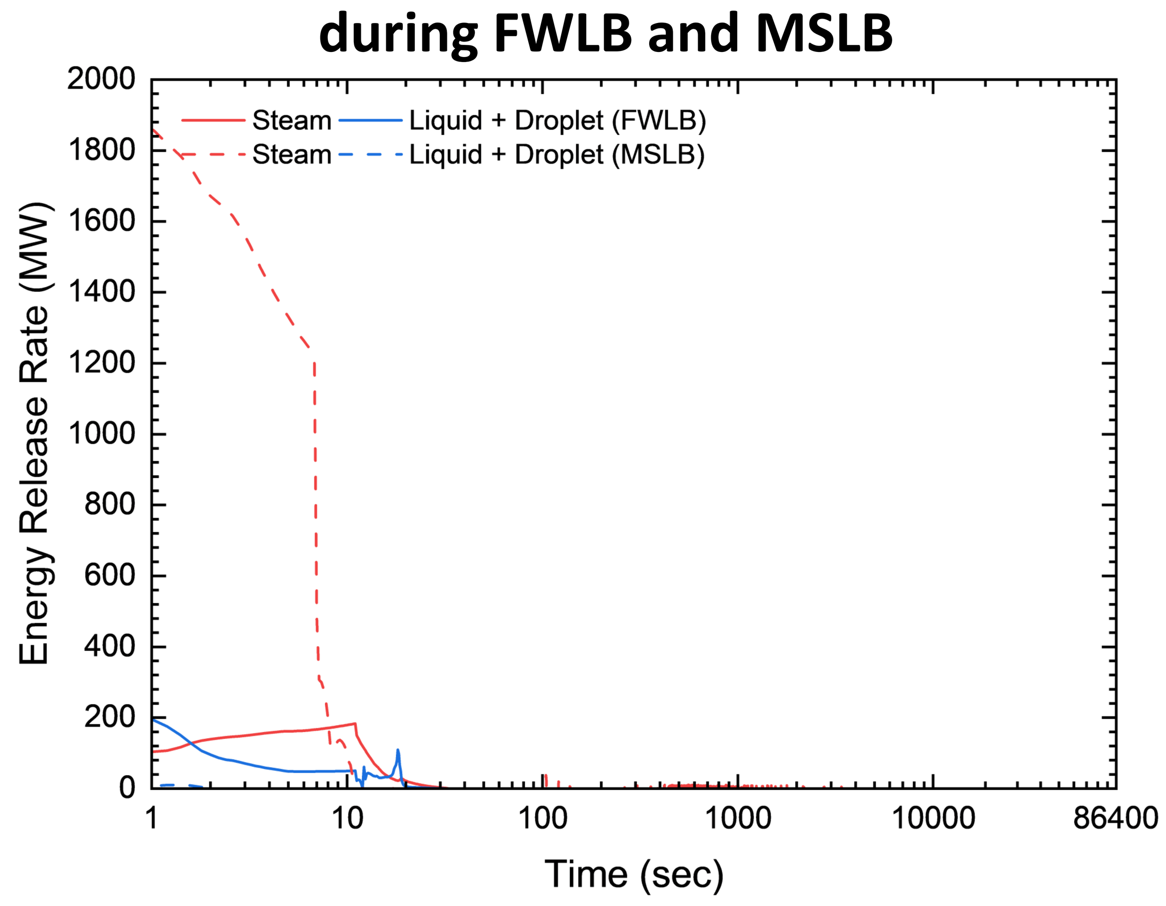

Figure 3. Break Energy Release Rate during FWLB and MSLB

Containment Vessel Response of FWLB Accident

- Although FWLB M/E release ended at 30 s, CV pressure increases until 68 s due to **heat transfer from RCS to CV through RV wall**.
- CV peak pressure results
  - MSLB: **0.65 MPa** at 8 s ← superheated steam release
  - FWLB: **0.30 MPa** at 68 s ← two-phase flow release

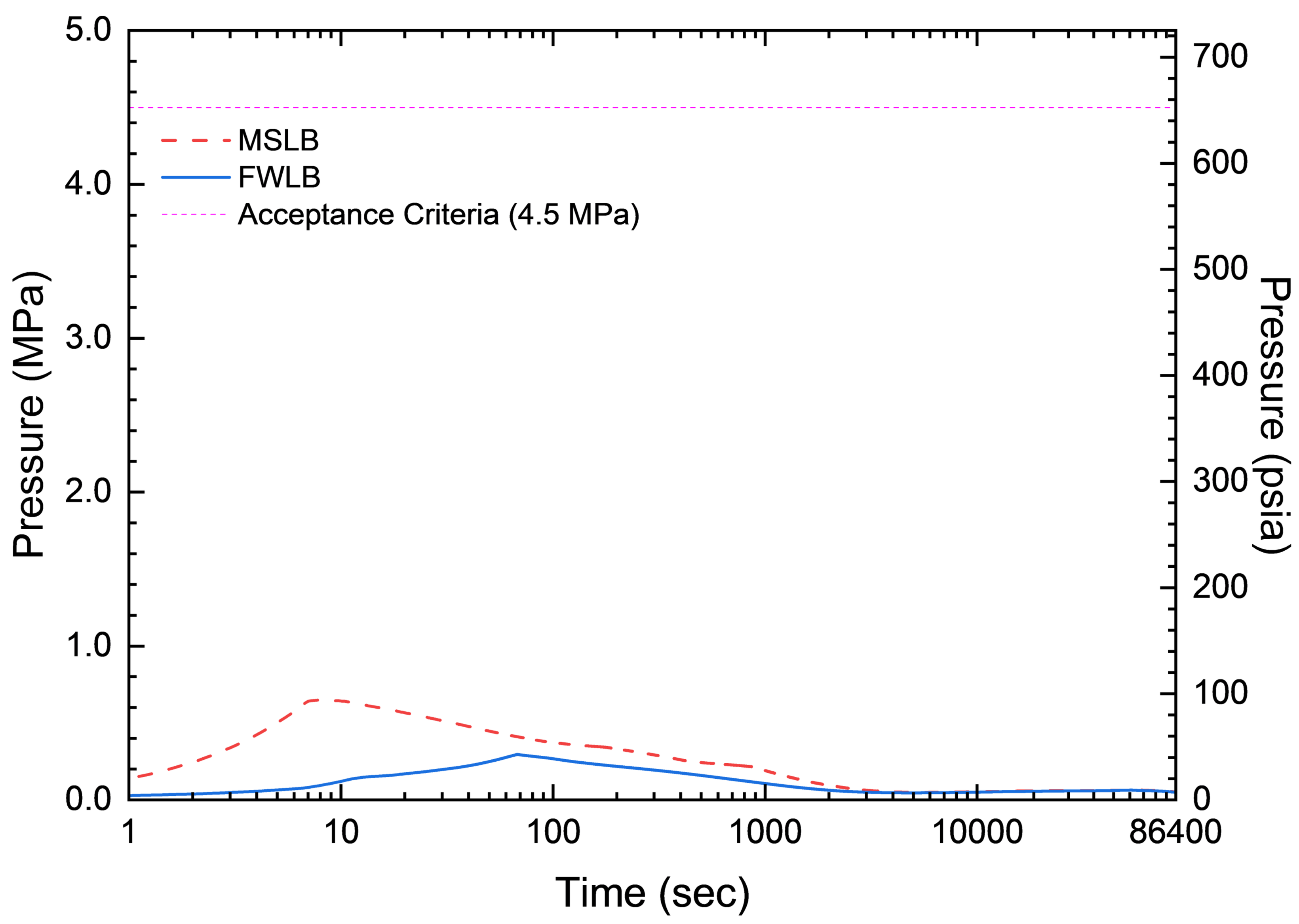

Figure 4. CV Pressure during FWLB and MSLB

Conclusions

- The M/E Release and CV response of i-SMR during postulated **FWLB** accident were analyzed using SPACE ver 3.3.1.
  - compared with **MSLB** presented orally in Session 5A at 09:00
  - → **Limiting secondary-side pipe rupture: MSLB**
- Future research will focus on advancing the methodologies for M/E release and CV response analyses to support i-SMR SDA.