# Preliminary Mass and Energy Release Analysis for Postulated MSLB Accidents on APR1400 Using SPACE-ME Methodology

*Jisu Kim*, Seng Ho Jee, Sung Yong Kim, Min Shin Jung, Eun Ju Lee, Seok Jeong Park*
*Safety Analysis Department, Korea Electric Power Corporation Engineering and Construction Company Inc.,*
*111, Daedeok-daero 989 Beon-Gil, Yuseong-gu, Daejeon 34057, Republic of Korea*
**Corresponding author: jisukim@kepco-enc.com*

## Introduction

- The release of coolant mass and energy (M/E) resulting from postulated loss of coolant accidents (LOCAs) and main steam line break accidents (MSLBs) must be performed for the functional design of light water reactor containment.
- A novel methodology for M/E release analysis, known as SPACE-ME methodology, is currently being developed by KEPCO E&C[3,4].
- In this study, the preliminary study of the M/E release from the postulated MSLB accidents on APR1400 with MSIV failure and loss of containment cooling (LCC) was performed using SPACE-ME methodology.

## Methodology

- SPACE-ME methodology utilizes Safety and Performance Analysis CodE for nuclear power plants (SPACE) and nuclear Containment Analysis Package (CAP) codes[5,6].
- The M/E release data resulting from the steam line ruptures in various postulated MSLB accidents on APR1400 were analyzed by SPACE-ME methodology.
- Using the M/E release data for MSLB accidents, assessments of containment P/T behavior were performed using stand-alone CONTEMPT4PC code.

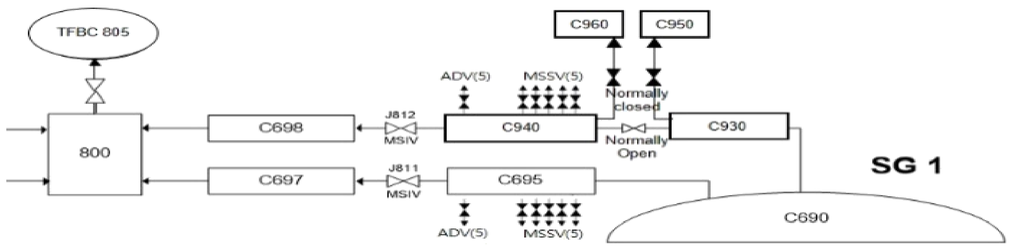



Figure 1. SPACE node configuration of steam line break

- Major assumptions of the postulated MSLB accidents on APR1400 for the M/E release analysis were from basically the same with those of KIMERA methodology[1,2].

Table I: Major assumptions of the postulated MSLB accidents on APR1400

| Parameters | Assumptions |
|---|---|
| Evaluation time | 30 min. from the accident initiation |
| Turbine trip | At the accident initiation |
| Loss of offsite power (LOOP) | Available (Non-LOOP) |
| Feedwater flow to steam generator (SG) | Maximum total flow only to broken side |
| Feedwater enthalpy | Maximum |
| Volume of reactor coolant system (RCS) | Maximum without tube plugging |
| Volume of feed and steam line | Maximum without tube plugging |

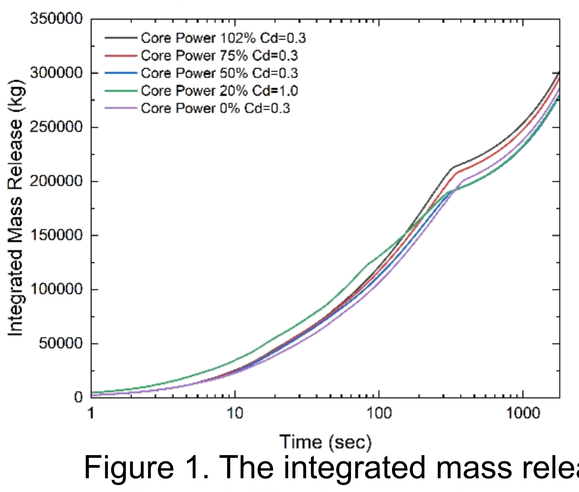
Table II. Initial conditions of the postulated MSLB accidents on APR1400

| Parameters | Values |
|---|---|
| Core power | 102%, 75%, 50%, 20%, and 0% of full power (FP, 3983 MWt) |
| PZR pressure | 16.03 MPa (2325 psia) |
| Core inlet temp. | 568.15 K (563 °F) |
| RCS flow rate | 95% |
| PZR water level | 60%(102%FP), 55%(75%FP), 50%(50%FP), 40%(20 and 0%FP) |
| SG water level | 52% narrow range (77.75% wide range) |
| Break type | Double-ended (guillotine) |
| Break size | Discharge coefficient (Cd) 0.1, 0.2, 0.3, 0.4, 0.5, and 1.0 |
| Single failure | MSIV failure and loss of containment cooling (LCC) |

## Results

### Mass and Energy Release of MSLB Accidents

- The M/E release of the postulated MSLB accidents on APR1400 was analyzed for various initial core power conditions, break sizes, single failures.
- The MSIV failure case with core power 102% and Cd 0.3, which has the highest peak containment pressure, released the largest amount of the M/E from the accident initiation to the end of the accident.
- The integrated energy of the LCC case with core power 102% and Cd 0.1, which has the highest peak containment pressure, exceeded that of case with 75% and Cd 0.2.



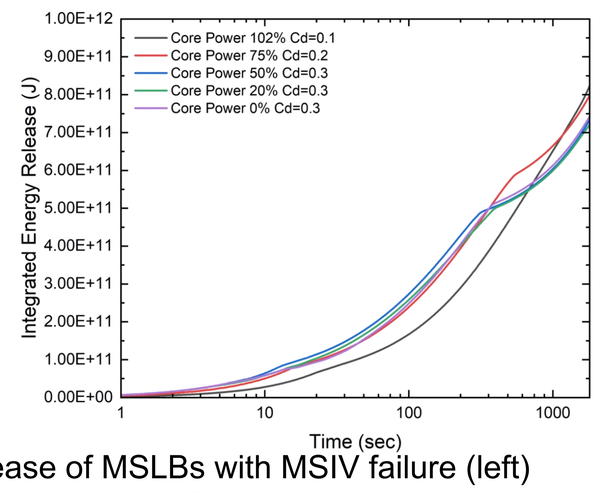
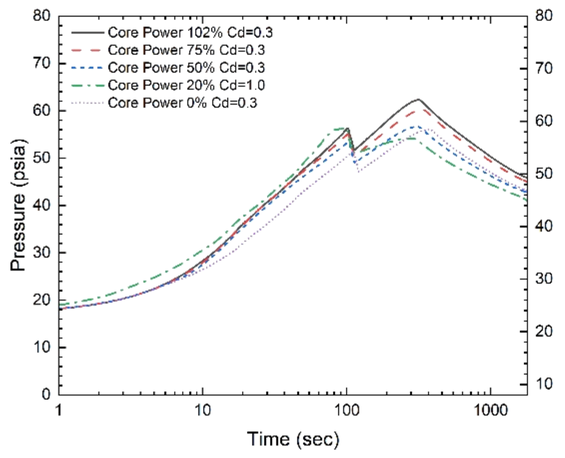




Figure 1. The integrated mass release of MSLBs with MSIV failure (left)
Figure 2. The integrated energy release of MSLBs with LCC (right)

### Containment Pressure and Temperature of MSLB Accidents

- The most limiting peak containment pressure and temperature:
  - MSIV failure: 62.30 psia at 315 seconds (102%FP and Cd 0.3) (see Fig. 4)
  - MSIV failure: 366.9 °F at 69 seconds (102%FP and Cd 1.0) (see Fig. 5)
  - LCC: 62.23 psia at 1800 seconds (102%FP and Cd 0.1) (see Fig. 6)
  - LCC: 366.8 °F at 63 seconds (50%FP and Cd 1.0) (see Fig. 7)



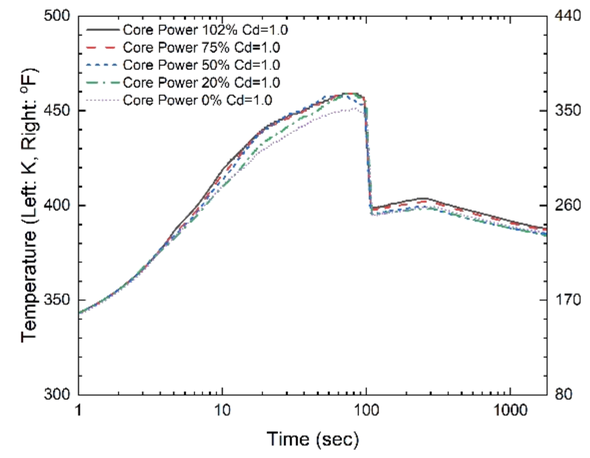
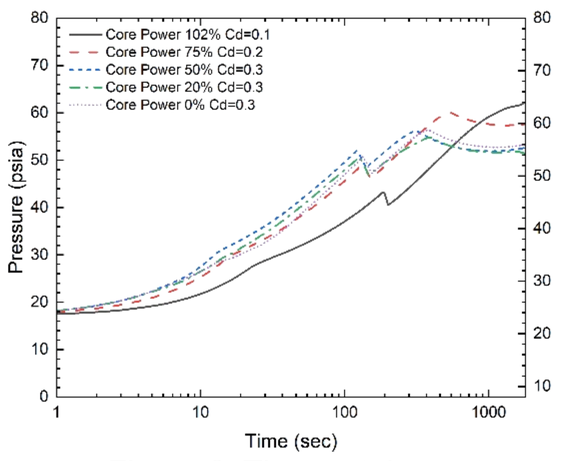




Figure 4. The containment pressure during the MSLBs with MSIV failure (left)
Figure 5. The containment temperature during the MSLBs with MSIV failure (right)



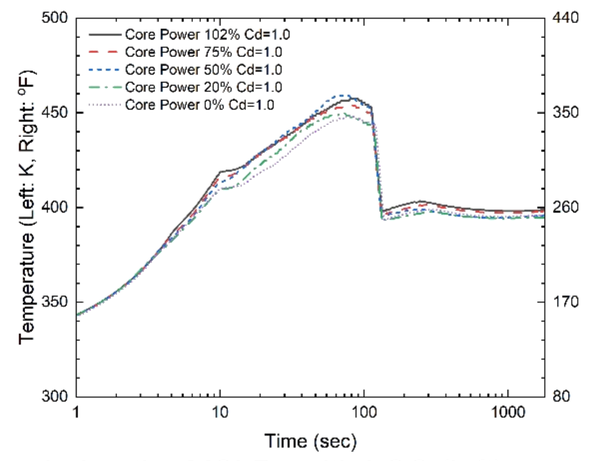




Figure 6. The containment pressure during the MSLBs with LCC (left)
Figure 7. The containment temperature during the MSLBs with LCC (right)

### Comparison with the Previous Methodologies

- The maximum peak pressure of containment, which is 62.30 psia, obtained by SPACE-ME methodology tends to be lower comparing with that of others.
- In contrast, the maximum peak temperature of containment, which is 366.9 °F, is relatively inclined to be higher than that of others.

Table III: The summary of the most limiting MSLB accident for the containment peak P/T By the various M/E release analysis methodologies

| Comparison of Methodology | | MSIV Failure | | LCC | |
|---|---|---|---|---|---|
| | | Press.(psia) | Temp.(°F) | Press.(psia) | Temp.(°F) |
| **APR1400 (SKN3&4) FSAR** | Peak | 63.1 at 378 sec | 328.6 at 112 sec | **64.6 at 428 sec** | **336.2 at 125 sec** |
| | Power /Size | 75% Cd 1.0 | 102% Cd 1.0 | 75% Cd 1.0 | 102% Cd 1.0 |
| **APR1400 KIMERA[2]** | Peak | 60.86 at 500 sec | **329.8 at 102 sec** | **65.84 at 1,040 sec** | 329.5 at 130 sec |
| | Power /Size | 50% Cd 0.4 | 102% Cd 0.3 | 50% Cd 0.2 | 20% Cd 0.3 |
| **APR1400 SPACE-ME (This study)** | Peak | **62.3at 315 sec** | **366.9 at 69 sec** | 62.23at 1,800 sec | 366.8 at 63 sec |
| | Power /Size | 102% Cd 0.3 | 102% Cd 1.0 | 102% Cd 0.1 | 50% Cd 1.0 |

## Conclusions & Future Works

- In SPACE-ME methodology, the maximum peak pressure of the containment in postulated MSLBs on APR1400 appears at 62.34 psia, which is less conservative than that of previous methodologies.
- However, more conservative maximum peak temperature of the containment is obtained at 366.9 °F.
- In the future, further studies for the establishment of SPACE-ME methodology are required.

### References

[1] Korea Electric Power Corporation Engineering and Construction Company Inc. “KOPEC Improved Mass and Energy Release Analysis Methodology”, KOPEC/NED/TR/06-005, Rev. 0, 2007.
[2] Korea Electric Power Corporation Engineering and Construction Company Inc. “Applicability Assessment of KIMERA to APR1400 Nuclear Power Plants”, KEPCO-E&C/TR/12-008, Rev. 0, 2012
[3] S. H. Jee, S. Y. Kim, J. W. Cho, E. J. Lee, and S. J. Park. “Introduction to SPACE-ME Methodology for Containment Design”, Korean Nuclear Society Autumn Meeting, Changwon, 2022.
[4] S. H. Jee, S. Y. Kim, J. W. Cho, E. J. Lee, and S. J. Park. “Preliminary LOCA M/E Release Analysis using SPACE-ME Methodology”, Korean Nuclear Society Autumn Meeting, Changwon, Korea, 2022.
[5] Korea Hydro & Nuclear Power Co., Korea Electric Power Corporation Engineering and Construction Company Inc., Korea Atomic Energy Research Institute, and Korea Electric Power Corporation Nuclear Fuel Co. “SPACE 3.22 Manual”, Vol. 1~6, 2019.
[6] Korea Hydro & Nuclear Power Co. “CAP 3.0 Manual”, Vol. 1~2, 2019.