*Transactions of the Korean Nuclear Society Autumn Meeting*
*Yeosu, Korea, October 24-26, 2018*

# GAMMA-FR validation against LOVA experiments

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## 1. Introduction

KAERI (Korea Atomic Energy Research Institute) Nuclear Fusion Technology Development Division has been developing in-house computer program for safety analysis of nuclear fusion systems, which is called GAMMA-FR (General Analyser for Multi-component and Multi-dimensional Transient Application-Fusion Reactor) code [1]. KO TBM team uses this code for safety analysis of the HCCR TBS which is going to be installed in ITER. ITER safety division provided list of validation requirements which should be satisfied for the quality assurance of safety analysis code. Many verification and validation items of GAMMA-FR have been performed by KAERI [2-4] and this paper is about validation against LOVA(Loss Of Vacuum Accident) experiment.

## 2. Experimental Apparatus

A schematic of the LOVA experimental apparatus and GAMMA-FR nodalization of vacuum vessel for breach T1 are shown in Figure 1. The main components are a toroidal test section (vacuum vessel) with six breach ports, a purge gas system, and a vacuum pump. The VV is constructed from stainless steel and is mounted on a weight measuring system. The VV is initially filled with helium (air-He experiments), a 100-mm diameter butterfly valve is used.

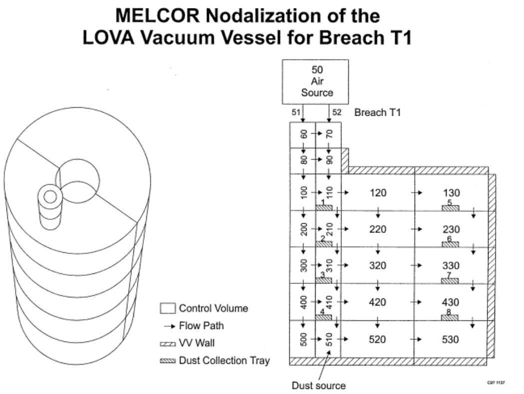


Figure. 1 Schematics and nodalization of the LOVA experimental apparatus (Breach port - T1)

The VV was initially evacuated. When the butterfly valve opened, the VV rapidly filled with air until the two pressures equilibrate. Due to high wall temperature, a buoyancy-driven, counter current flow was established at the breach, with cool (high-density) air flowing into the VV and warm(low-density) air flowing out. Three cases were analysed according to the specifications given in Table 1. The ambient air temperature was assumed to be 20℃ (actual air temperatures were not provided).

| Abbreviation | Breach Port | VV Wall Temperature | VV Pressure | Ambient Air Temperature |
|---|---|---|---|---|
| T1Vac100 | T1 | 99℃ | 1Pa | 20℃ |
| S1VacRT | S1 | 15℃ | 1Pa | 15℃ |
| S1Vac100 | S1 | 96℃ | 1Pa | 20℃ |

Table. 1 Validation Cases

## 3. Results

In figure 2, VV pressure during the test T1Vac100 is presented. Results from GAMMA-FR code, MELCOR code and experimental data are compared and it shows good agreement with each other. Figure 3 is mass accumulation in the VV and agreement is good. On the other hand, higher mass flow rate of MELCOR at early stage of the accident was observed at the leak path (Figure 4), which experimental data is not available.

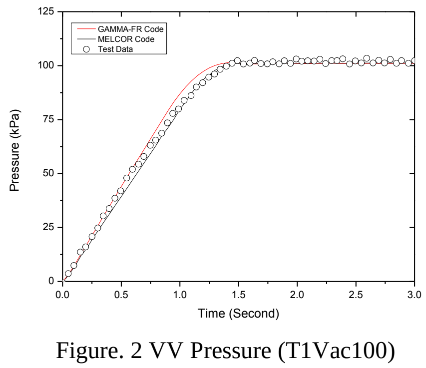


Figure. 2 VV Pressure (T1Vac100)

VV wall temperature (99℃) is a boundary condition of the test. Heater and heat sink are installed at inlet of the breach in the MELCOR input deck, which control wall temperature and it affects gas temperature and density of the fluid. But heating method of each code is different, therefore, it is hard to achieve complete match of VV wall temperature of the codes. In terms of average temperature, calculation result of each code successfully captures the physics of fluid temperature.

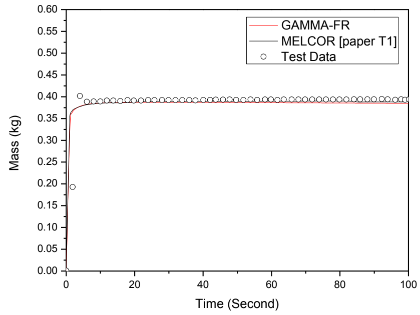


Figure. 3 Mass accumulation in the VV (T1Vac100)

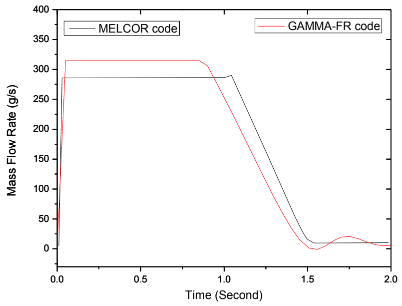


Figure. 4 Mass flow rate at leak path (T1Vac100)

In figure 5 and 6, VV pressure build-up and fluid mass during the test S1VacRT are presented. Results from GAMMA-FR code, MELCOR code and experimental data are compared and it shows good agreement, however, it has larger deviation among data than that of T1VacRT test.

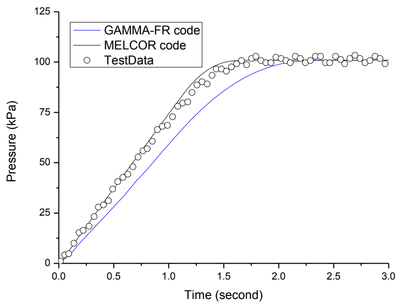


Figure. 5 VV Pressure (S1VacRT)

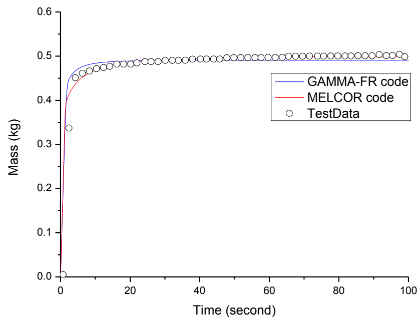


Figure. 6 VV Pressure (S1VacRT)

In figure 7, VV pressure during the test S1Vac100 is presented. Results from GAMMA-FR and MELCOR code are compared and it shows good agreement, however, experimental data is not available for this test. Based on comparison of the other tests, reasonably good agreement is expected.

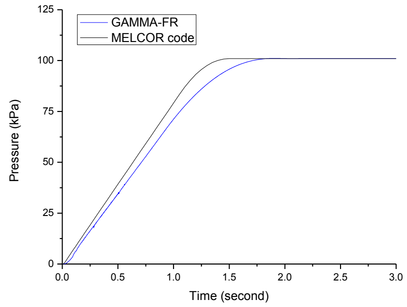


Figure. 7 VV Pressure (S1Vac100)

## 4. Conclusion

These results show good agreement among GAMMA-FR, MELCOR predictions and experimental data, demonstrating GAMMA-FR's ability to predict the loss of vacuum accident of a nuclear fusion system. The slight differences sometimes visible are due to temperature boundary condition and heater and heat sink control in GAMMA-FR and MELCOR, which introduces some minor deviations in mass flow rate in leak path. No significant differences were found.

## 5. Acknowledgement

This work was supported by the R&D Program through the National Fusion Research Institute (NFRI) funded by the Ministry of Science and ICT of the Republic of Korea (NFRI-IN1803).

## 6. References

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