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Re-evaluation of NUPEC M-7-1 Hydrogen Experiment using MELCOR 1.8.6

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1. Introduction

Evaluation of hydrogen distribution in containment building is still of keen interests. KINS is evaluating the hydrogen risk for the continued operation of Kori-1 and also for the new reactors like Shin-Kori-1,2, Shin Wolsong-1,2 etc. Considering these needs and also that the code used in KINS is moving from MELCOR 1.8.5 to MELCOR 1.8.6, we have evaluated the NUPEC hydrogen test M-7-1 using MELCOR 1.8.6. The NUPEC test was chosen just because it is the only available data we have. We will continue to evaluate other experimental data of hydrogen once they are available.

In NUPEC's Hydrogen Mixing and Distribution Test M-7-1, steam/helium mixture was released into the lower region of a simplified 1/4 scale model of large dry containment of 4-loop PWR(fig.1) to simulate break of a steam generator (SG) system.(fig.2) Total helium volume was decided by volumetric scaling of hydrogen released due to 100% Zr-H_2O reaction.

At the same time, containment spray was also activated to simulate the impact of spray water. Test containment had 25 compartments and 66 paths, and each compartment had measuring instruments for temperature (wall/air), pressure and helium concentration.

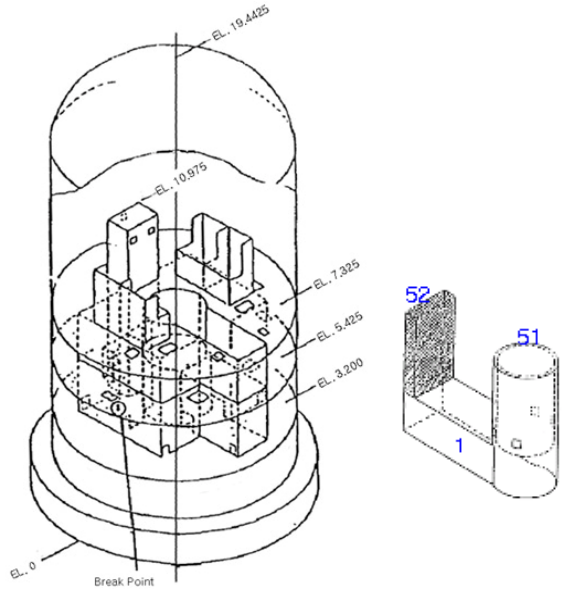

Figure 1. NUPEC Test Containment bird eye view

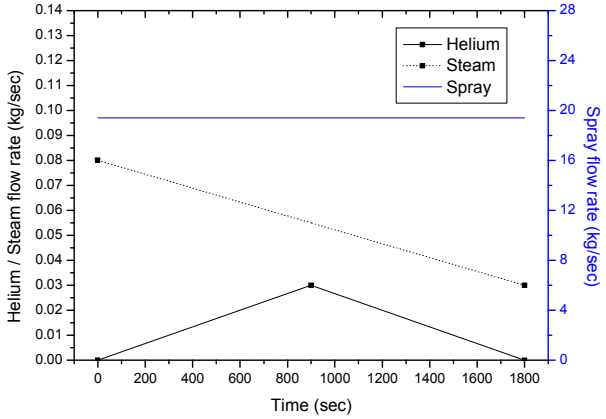

Figure 2. Helium, Steam and Spray flow rate injected

2. Modeling of NUPEC Test Facility

Test containment has been modeled by 29 nodes and 70 paths(fig.3). Almost nodes correspond with compartments except 51, 52, 105, 106. Flow loss coefficients and heat structure properties are determined by analytic calculation.

Compartment 1 had complicated geometry and had so many paths to other compartments. So compartment 1 is divided to 3 nodes of cylinder (51), vertical (52) and lower node (1) (fig.1).

Containment drain tank had been omitted in ISP-35 specification. But in M-7-1 experiment, actually containment spray water accumulated in the first floor was flushed to the drain tank and removed from it with the same rate of spray (19.4kg/s). Drain tank is modeled by node 105, 106.

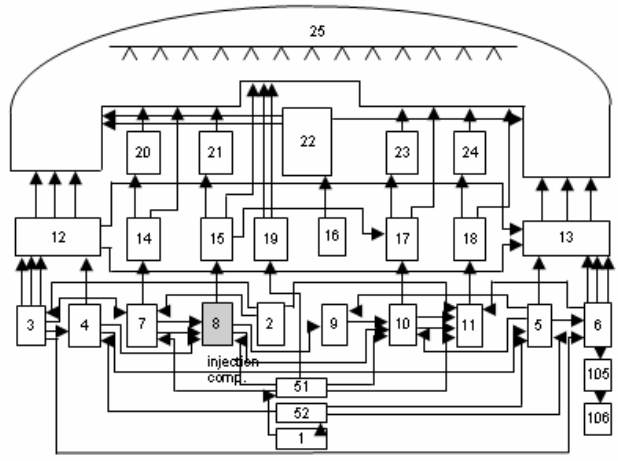

Figure 3. Nodes and Paths

3. Results

3.1. Helium concentration

Most important variable of NUPEC experiment is concentration of helium. Mixing and distribution behavior of helium has been observed at break point (node 8) and at dome (node 25).

Helium concentration is increasing linearly until 900sec, and it matches well with experimental result. But after 900sec, MELCOR is underestimating the experimental result.(fig.4,5)

Because all the helium mass injected into the containment was not removed out of the containment at all, the reason of this underestimation seems to be due to the overestimation of partial pressure of steam and air. The overestimation of partial pressure of steam and air should come from the heat transfer of hest structures in the containment.

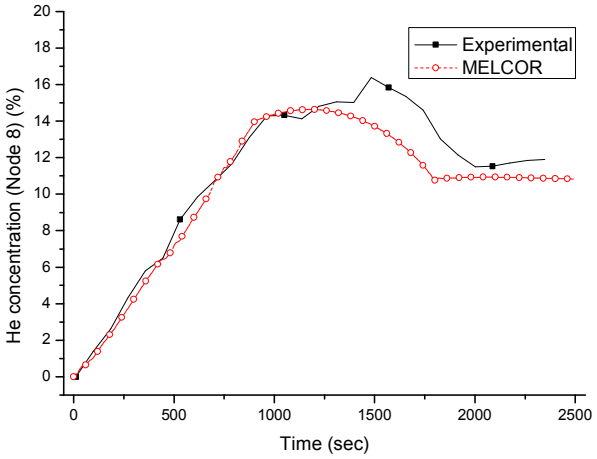

Figure 4. Helium concentration of break point node

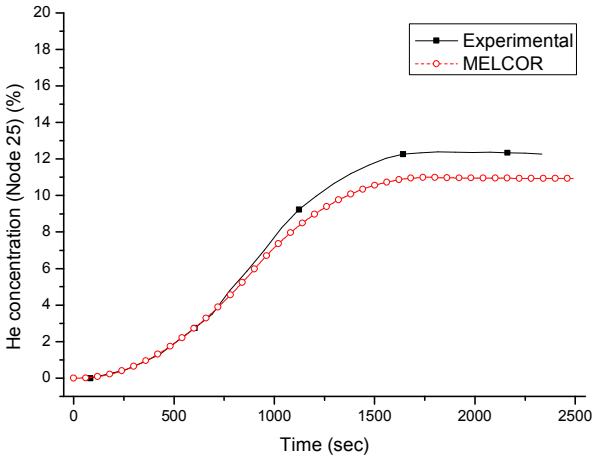

Figure 5. Helium concentration of dome node

3.2. Pressure

In dome compartment (node 25), MELCOR simulates containment pressure within 4% of error. Comparatively speaking, the result of calculation using MELCOR1.8.6 shows low pressure at early phase and high pressure after the end of containment spray (1800sec).(fig.6)

It seemed that the effect of containment spray was more sensitive to analytic result than experiment.

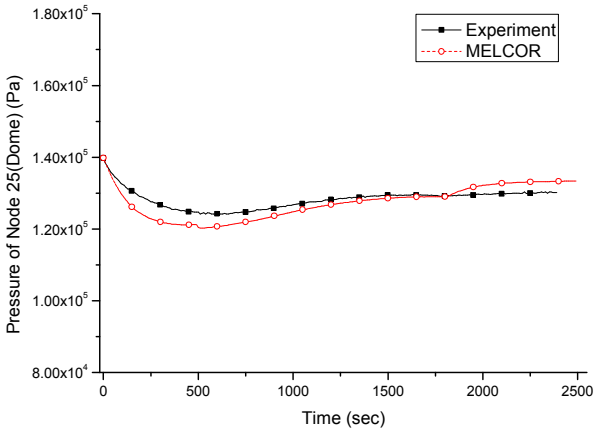

Figure 6. Pressure of dome node

4. Conclusions

We have evaluated the NUPEC hydrogen distribution test M-7-1 using MELCOR 1.8.6. The primary purpose was to evaluate the code. MELCOR 1.8.6 have adequate capability for thermal hydraulic calculation of containment in severe accident condition. And also have capability for hydrogen mixing and distribution behavior, but calculation result of helium concentration shows some sensitivity to some thermal input conditions like heat transfer coefficient or containment spray injection time.

Acknowledgement

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