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A CINEMA Code Analysis of the Simplified ERVC Loop in the SMART

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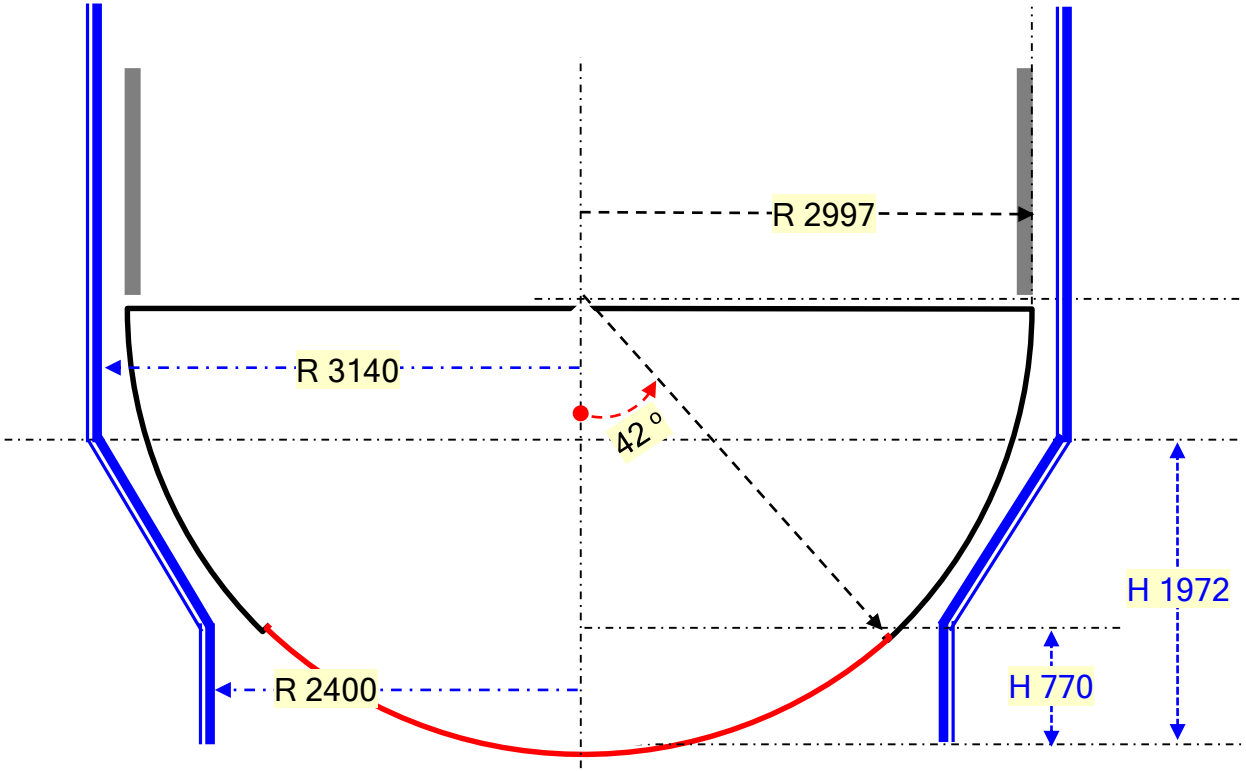
1. Geometry of the ERVC (inner channels)

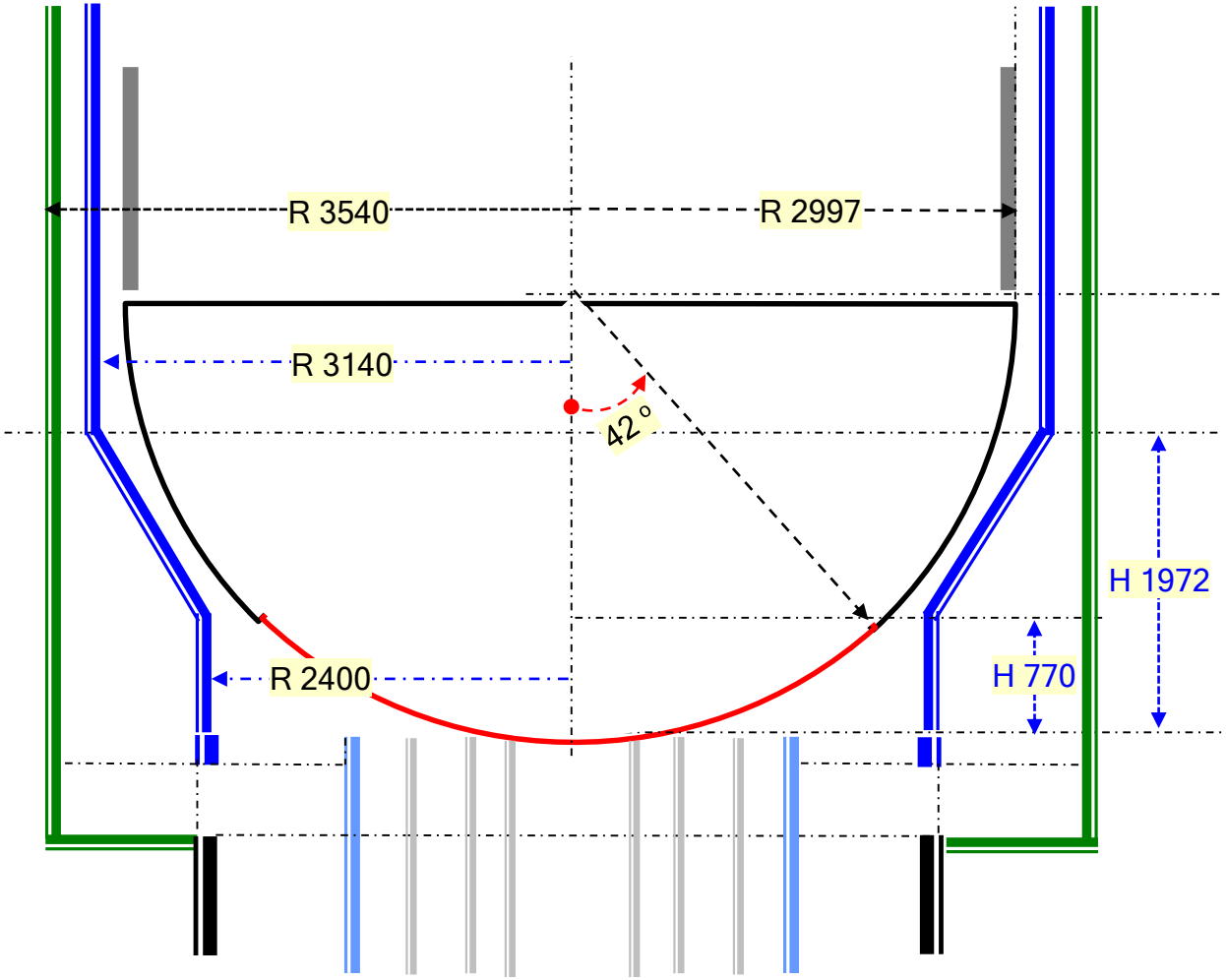


Inner channel:

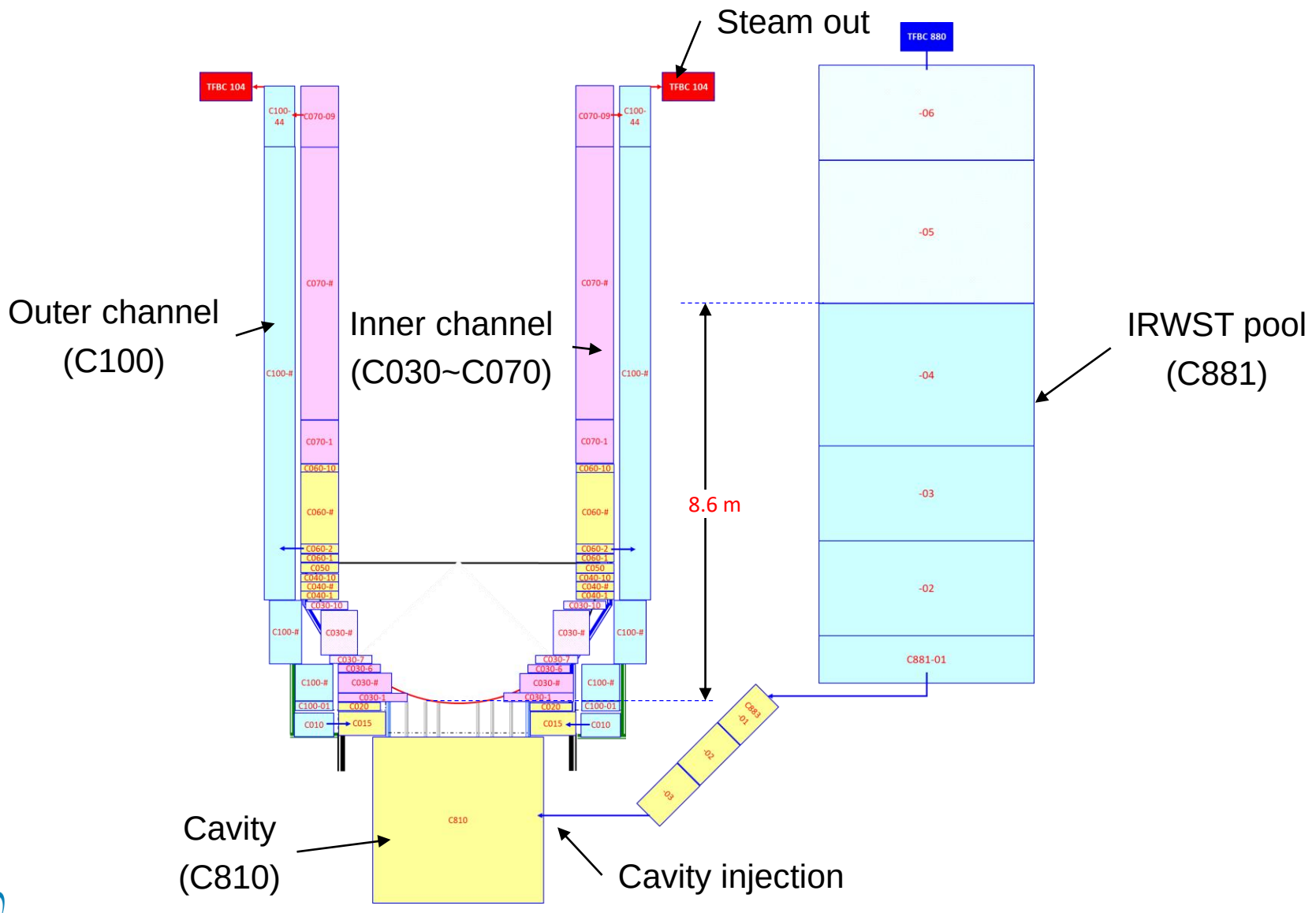
0 ~ 42° : Ri= 2400 mm

~90° : Ri= 3140 mm

1. Geometry of the ERVC (outer channels)



2. Nodalization of the ERVC



3. IC & BC

❑ IC and BCs are set to simulate SMART operation conditions

Location	Parameter	Value
Heated wall	Thermal power	2.82 MW
ERVC channel	Initial inventory	0 (empty)
Outlet (to containment)	Pressure	1.0 bar
IRWST	Initial level	8.0 m
	Initial head*	8.6 m
	Temperature	50°C
	Pressure	1.55 bar
Cavity	Opening time of injection valve	2,000 sec.

* From bottom of RPV to top of IRWST water

4. Calculation Results

❑ IRWST injection

❍ Injection starts after 2,000 sec (with opening valve)

- ⏩ Max. flow about 150 kg/sec
- ⏩ Flow becomes nearly stagnant at ~ 10,000 sec

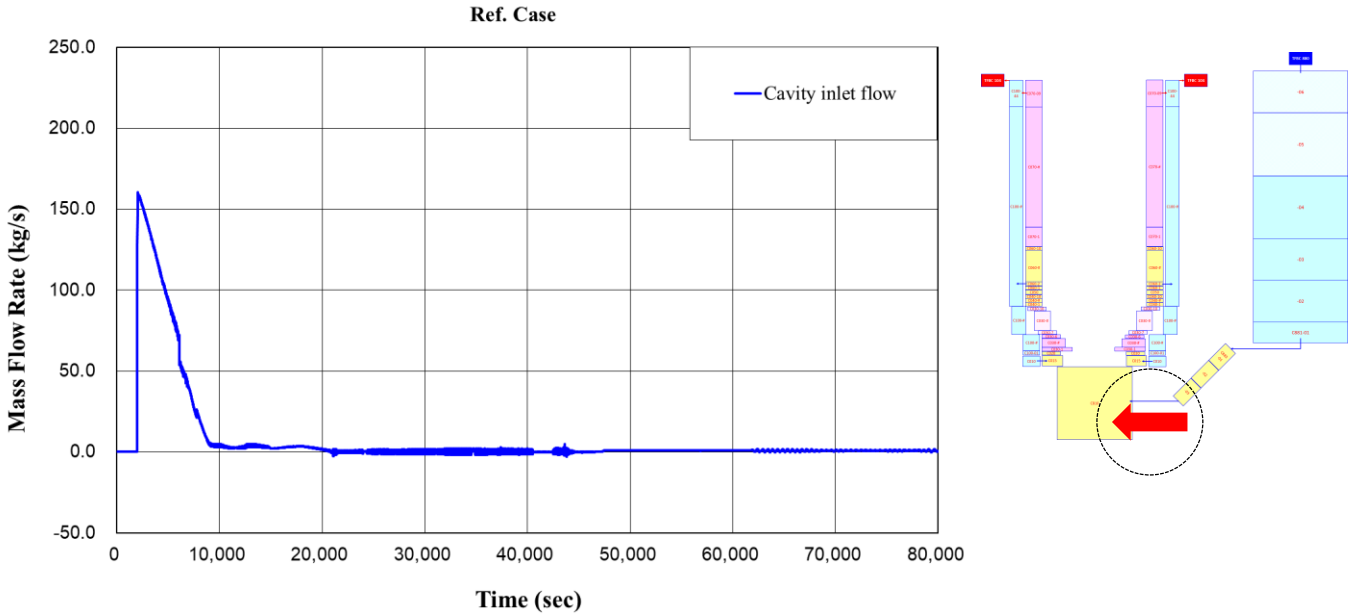


Fig. <1> Cavity injection from IRWST

❑ IRWST water level

- ❍ Level is rapidly decreased from 2,000 sec (valve opening time) to 10,000 sec
- ❍ Small decrease rate from 50,000 sec (flow balance btw. Inlet and outlet flows in the ERVC channel)

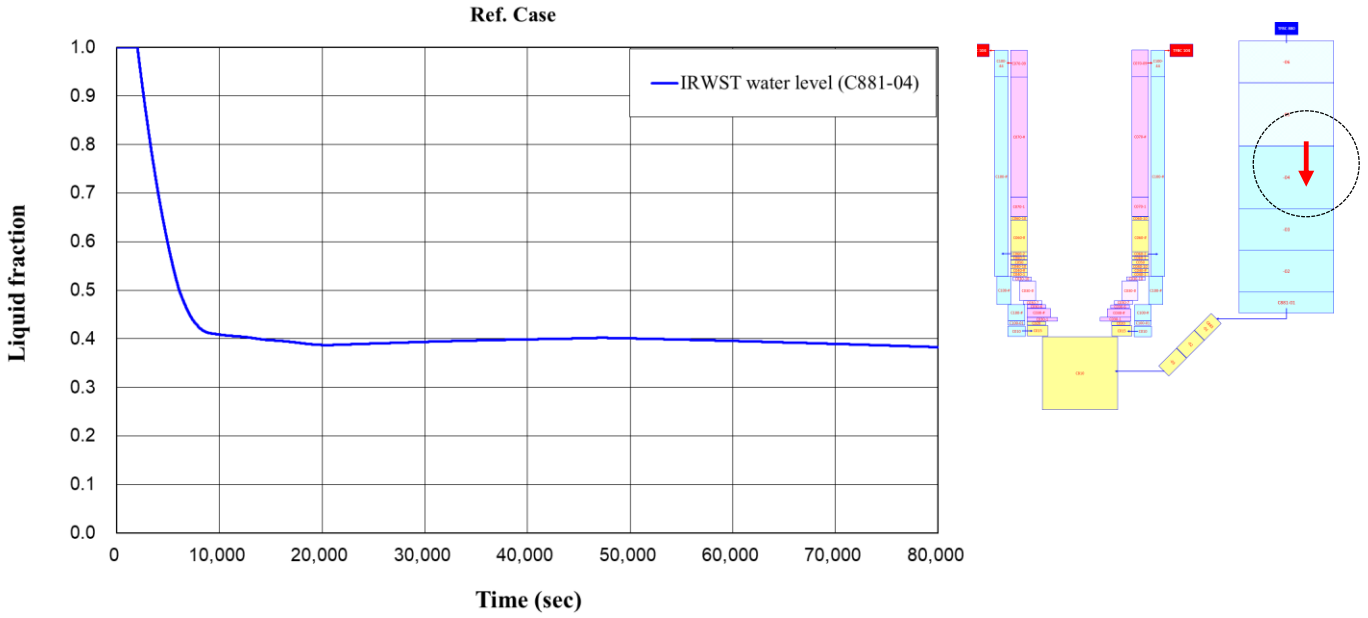


Fig. <2> Time variation of IRWST water level

❑ Flow circulation btw. inner and outer channels

❍ Steady flow about 600 kg/sec

⏩ Natural circulation is stabilized after saturation condition (~50,000 sec)

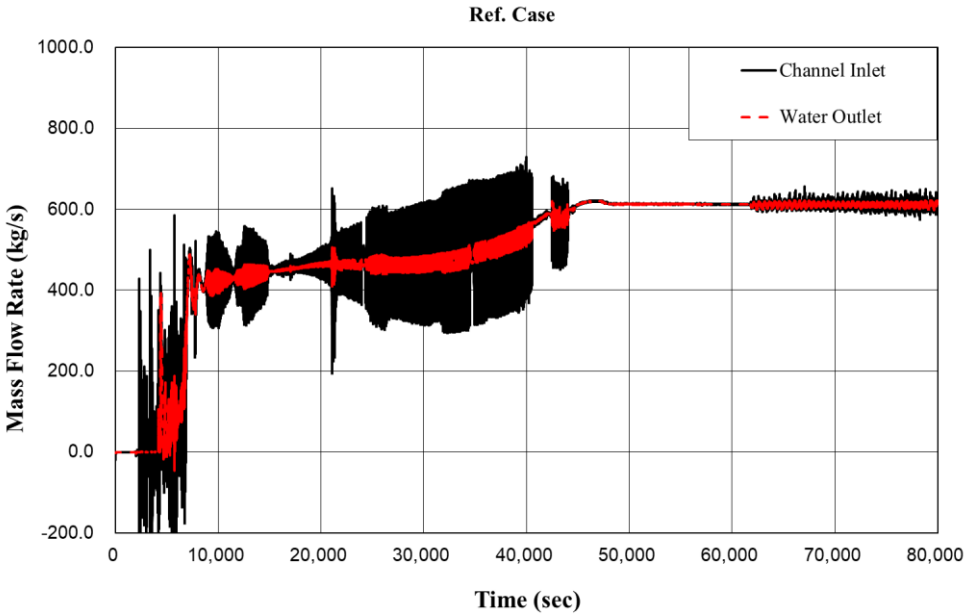


Fig. <3> Time variation of ERVC channel flows

❑ Steam venting to the containment

- ❍ Boiling of ERVC channel produces 1 kg/sec of steam flow rate
- ❍ Cavity inlet flow is little smaller than steam outlet flow
  - ⏩ The difference of flow is nearly constant, so channel level is continuously and linearly decreasing after 50,000 sec (see the next figure)

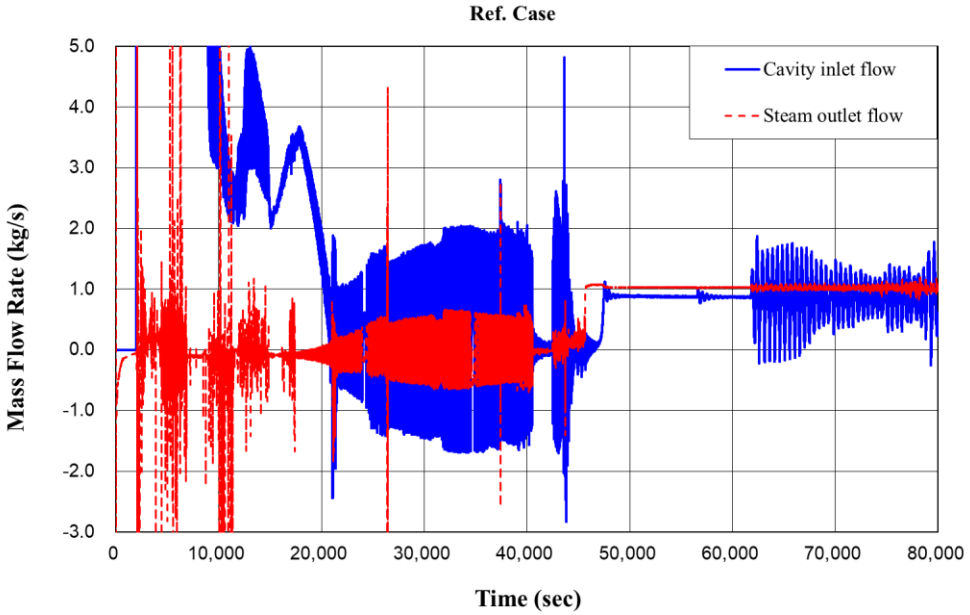


Fig. <4> Comparison of inlet and outlet flows in the ERVC channel

❑ Water level in the ERVC channel

- ❍ The water level is rapidly increase up to 10,000 sec. (max. ~5.8 m)
- ❍ The level is linearly decreasing after 50,000 sec.
  - ⏩ The inventory is continuously lost during the boiling period

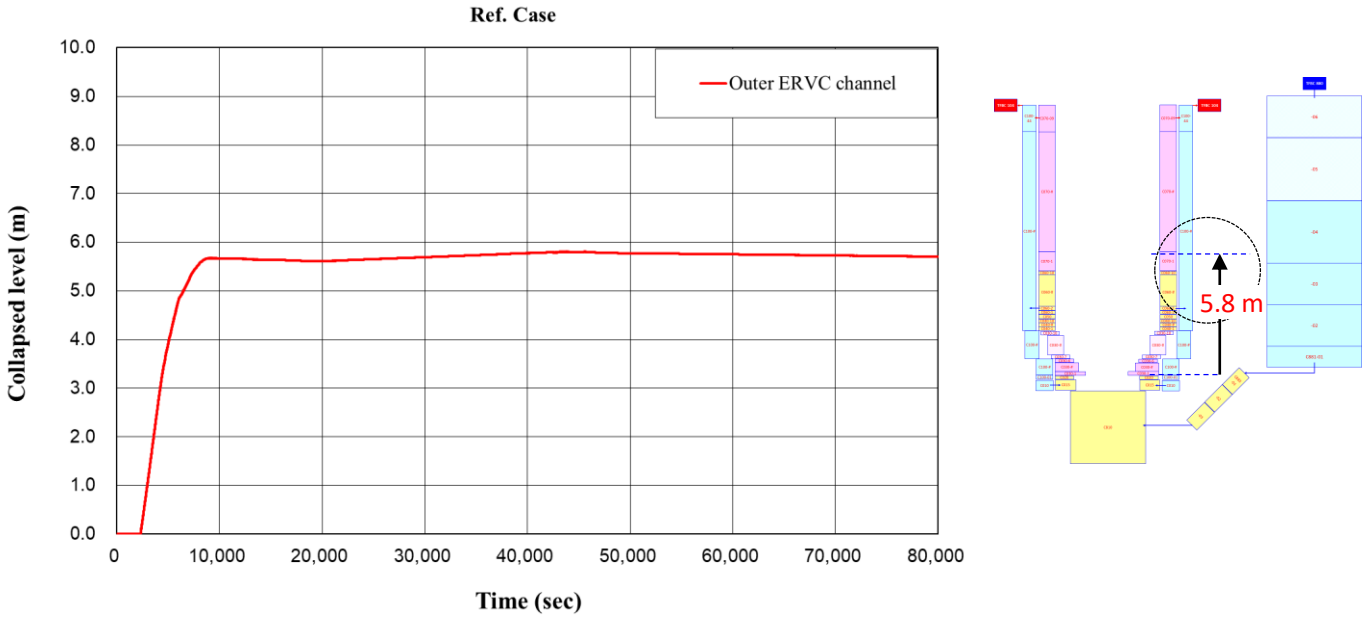


Fig. <5> Time variation of water level in the ERVC channel

❑ Pressure in the channel

- ❍ **Pressure rapidly increased and fluctuating during subcooled boiling, and stabilized after saturation boiling**
- ❍ **Pressure difference mostly by hydraulic head for each elevation**
  - ⏩ **Steam pressure in the upper part of the channel approaches 1.0 bar (outlet pressure BC)**

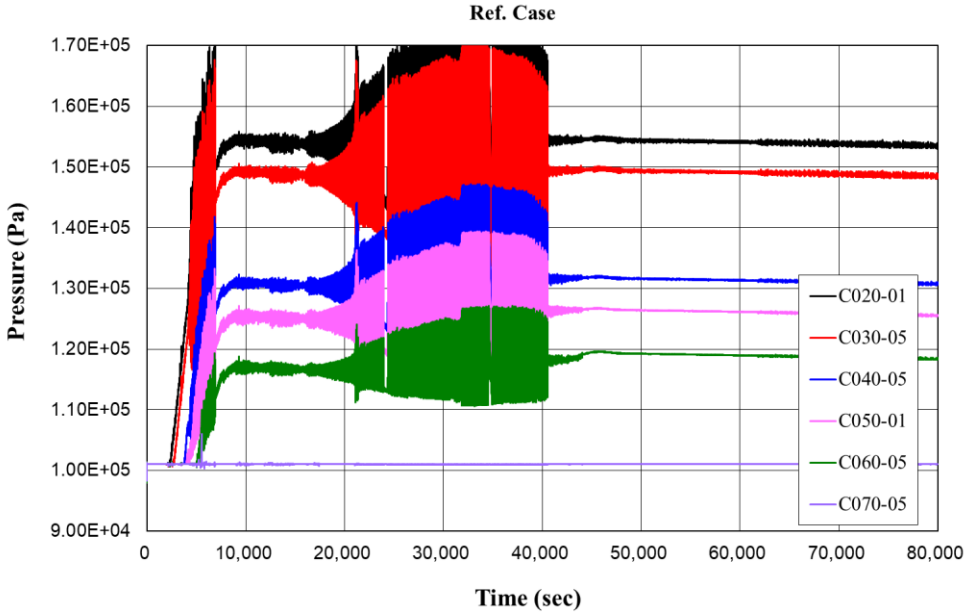


Fig. <6> Time variation of pressure at different elevations of the ERVC channel

❑ Temperature in the channel

❍ Initially subcooled water (323 K) is fulfilled and its temperature is increasing up to saturation temperature

⏩ Saturation conditions reaches at about 50,000 sec.

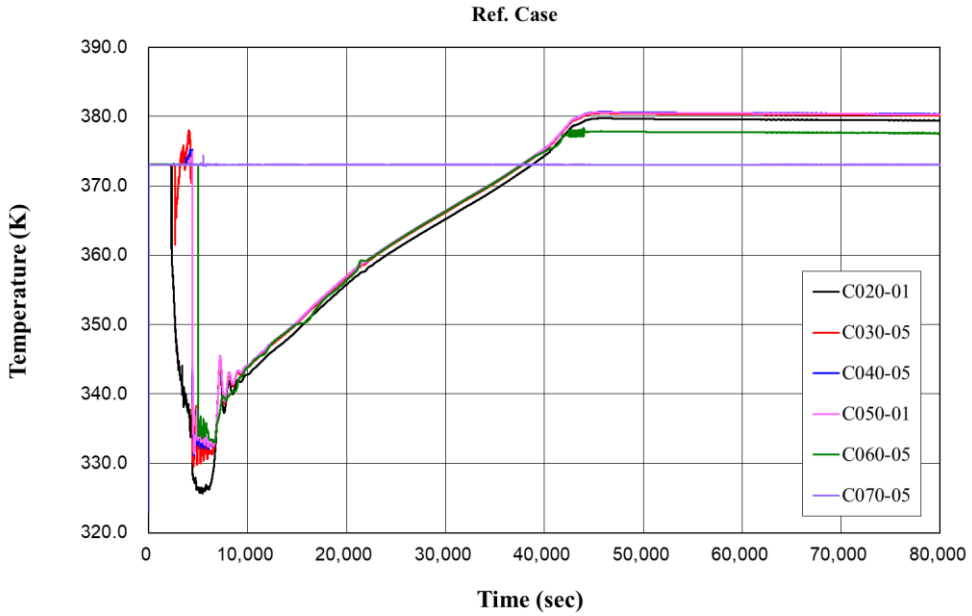


Fig. <7> Time variation of pressure at different elevations of the ERVC channel

5. Summary and Conclusions

- Simplified ERVC loop is modeled with assumptions of geometry conditions, IC, and BC from SMART design and severe accident management strategy
- The SPACE code (ver. 3.0, SVN 193) is used to simulate the performance of ERVC in the SMART
  - Cavity flooding by gravity driven flow from IRWST
  - Heat removal by natural circulation in the ERVC channel
  - Channel voiding and continuous steam venting to containment
- It is concluded that thermal-hydraulic flow conditions are stabilized after saturation boiling in the ERVC channel
  - Steam release to containment is about 1 kg/sec
  - Long term cavity flow is small but sustains the cavity flooding
- For future works, the ERVC loop model should be extended to overall plant calculations for inner vessel and containment analysis
  - Establishment of SMART-CINEMA version for ERVC modeling
  - Application to CINEMA-SACAP analysis for SA scenarios