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# Preliminary safety analysis of LOCAs in one EU DEMO HCPB blanket module

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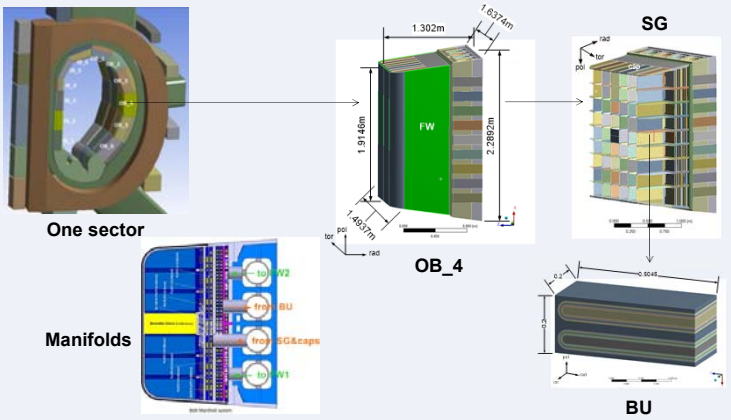
## Accident scenarios

- **Case I in-box LOCA to the breeding blanket (BB): failure of one horizontal plate**
  - ❑ **He as working fluid or noncondensable gas**
  - ❑ **MELCOR1.8.6 for fusion / MELCOR1.8.2 for fusion (ITER)**
- **Case II in-vessel LOCA: failure of 10 FW channels (~10%)**
  - ❑ **Impact of FW break sizes (case IIa: one channel, case IIb: two channels)**
- **Case III in-box LOCA to the purge gas system: failure of one CP in the BU**

## HCPB blanket 2014

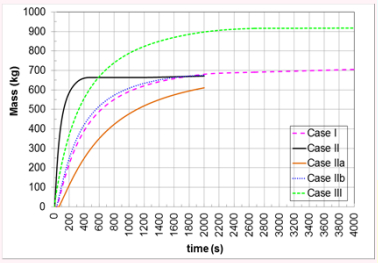



## Main design data

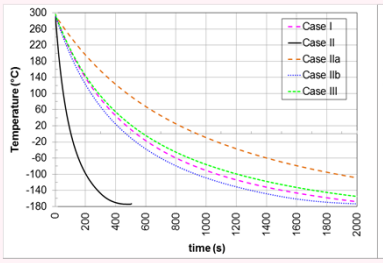
| Parameter | | | Value |
|---|---|---|---|
| OB_4 | Surface heat flux on the FW (MW/m²) | Front wall | 0.5 |
| | | BU to front wall | 0.06 |
| | | BU to side wall | 0.035 |
| | Neutron power (MW) | | 5.142 |
| | Mass flow rate (kg/s) | | 6.323 |
| | Pressure at inlet (MPa) | | 8.0 |
| | Temperature (°C) | Inlet / outlet | 300 / 500 |
| | FW | Cross section (mmxmm) | 10x15 |
| | | No. of channels | 95 |
| PHTS1 for 60 modules | Pressure (MPa) / temperature (°C) | | 8.0 / 300 |
| VV | Pressure (MPa) / temperature (°C) | | 5.0E-04 / 300 |
| EV | Pressure (MPa) / temperature (°C) | | 0.09 / 200 |

## Transient

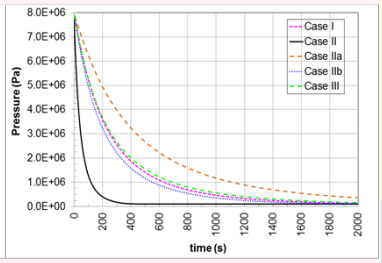
| Case | | Time (s) I | II | III |
|---|---|---|---|---|
| LOCA | | 0.0 | | |
| Pump shutdown | | 3.0 | | |
| Plasma shutdown (FPSS) | | 4.0 | | |
| Plasma disruption | | - | | |
| *Results* | p_CV778>1.0MPa | *1.0* | - | - |
| | p_CV401>90kPa | *38.0* | *7.9* | - |
| | p_CV865>0.5MPa | - | - | *1.4* |
| dt | | 5.0e-4 | | |




**He mass in the EV (CV405)**

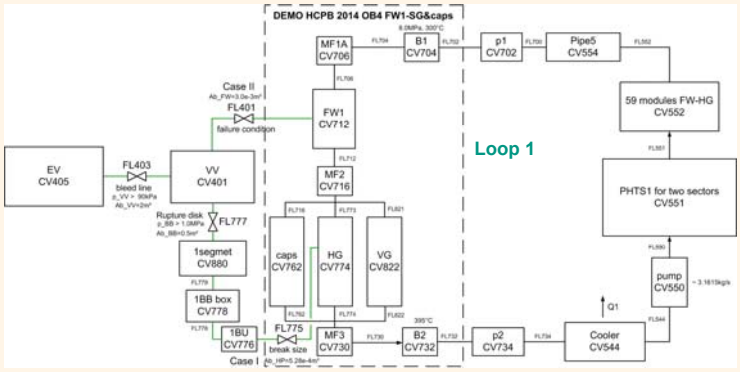



**He inlet temperature (CV704 / CV703)**

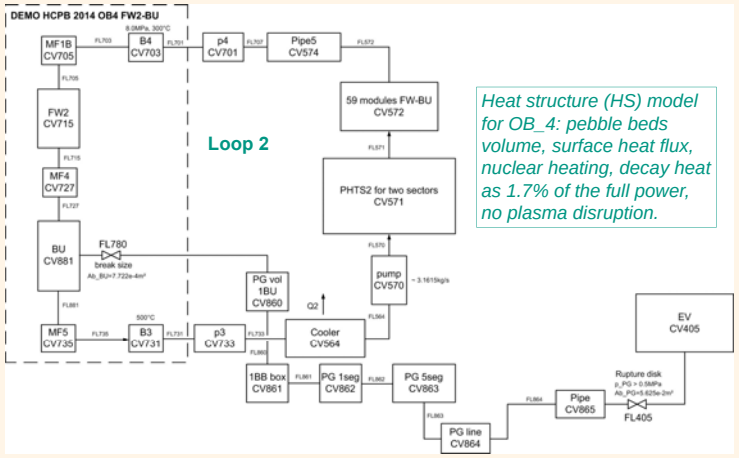



**Inlet pressure (CV706 / CV705)**

## Modelling using MELCOR1.8.6 for fusion




**Nodalization for case I / II**




**Nodalization for case III**

## Steady state

| Parameter | | | MELCOR1.8.6 Loop 1 | MELCOR1.8.6 Loop 2 | MELCOR1.8.2 Loop 1 | MELCOR1.8.2 Loop 1 |
|---|---|---|---|---|---|---|
| He | Flow | | Working fluid | | Noncondensable gas | |
| | Inventory of PHTS & 60 modules (kg) | | 1016.7 | 988.6 | 1035.0 | 1035.1 |
| FW | ṁ (kg/s) | | 3.1805 | 3.0707 | 3.2084 | 3.2096 |
| | p_inlet (MPa) | | 7.84 | 7.93 | 7.85 | 7.88 |
| | dp (kPa) | | 149.0 | 149.0 | 149.0 | 149.0 |
| | He | inlet (°C) | 294.2 | 296.7 | 294.5 | 296.8 |
| | | outlet (°C) | 364.6 | 371.7 | 364.1 | 366.9 |
| | EUROFER (°C) | | 621.8 | 818.7 | 621.1 | *3721.3* |
| | W (°C) | | 661.1 | 862.0 | 660.4 | *3765.0* |
| SG/BU | ṁ (kg/s) | HG / BU | 1.7143 | 3.0707 | 1.7295 | 1.7301 |
| | | VG | 0.6642 | - | 0.6701 | 0.6706 |
| | | Caps | 0.8020 | - | 0.8087 | 0.8089 |
| | He outlet (°C) | | 388.1 | 505.1 | 387.4 | 389.2 |

## Conclusion

- **FPSS without plasma disruption makes temperature decrease in the fluid and structure.**
- **Small FW break size decelerates the He loss speed, pressure drop and temperature decrease in the affected module, and He accumulation in the VV.**
- **The largest He amount accumulated in the VV is 279kg (case II), and 917kg in the EV (case III).**
- **Pressure increase in the BU (>7MPa) and temperature increase in the VV (>700°C) may have impact on their design.**
- **MELCOR1.8.6 for fusion provides upgraded results against MELCOR1.8.2 due to the double precision.**
- **He properties produce precise results against He as noncondensable gas.**

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