EUROfusion

Download me!

22-27 September 2019 Budapest, Hungary ISFNT14

P2-010

Analysis of the Effects of Primary Heat Transfer System Isolation Valves in case of In-Vessel Loss-Of-Coolant Accidents in the EU DEMO

Antonio Froio[1], Luciana Barucca[2], Sergio Ciattaglia[3], Fabio Cismondi[4], Laura Savoldi[1] and Roberto Zanino[1]

[1]NEMO group, Dipartimento Energia, Politecnico di Torino, Torino, Italy
[2]Ansaldo Nucleare, Genova, Italy
[3]PPPT Department, EUROfusion Consortium, Garching bei München, Germany
[4]IFMIF Unit, Fusion for Energy, Garching bei München, Germany

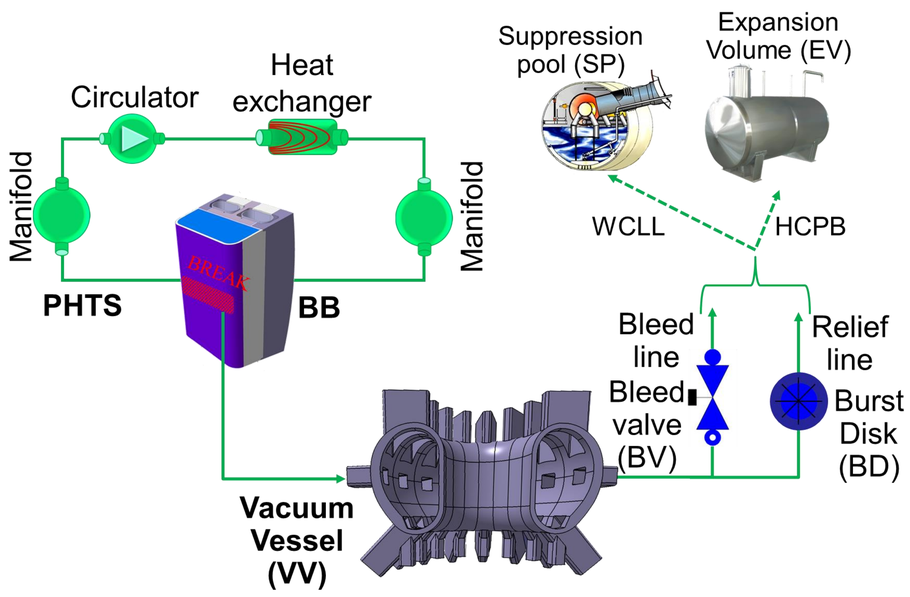
BACKGROUND

- In-vessel break in BB PHTS causes VV pressurization
- Released coolant evacuated to an Expansion Volume
- Amount of released coolant determines EV size + affects pressure peak and radioactivity releases
- Isolation Valves (IVs) as a mitigation measure

AIM OF THE WORK

- GETTHEM code [1-5] applied to investigate the effects of IVs
- Step 1 → determine EV size w/o IVs
- Step 2 → sensitivity analysis w/ IVs:
  - Valve position (on manifolds or on hot/cold legs)
  - Closure time (0.1÷3 s for HCPB, 2÷8 s for WCLL)

EU DEMO VVPSS layout

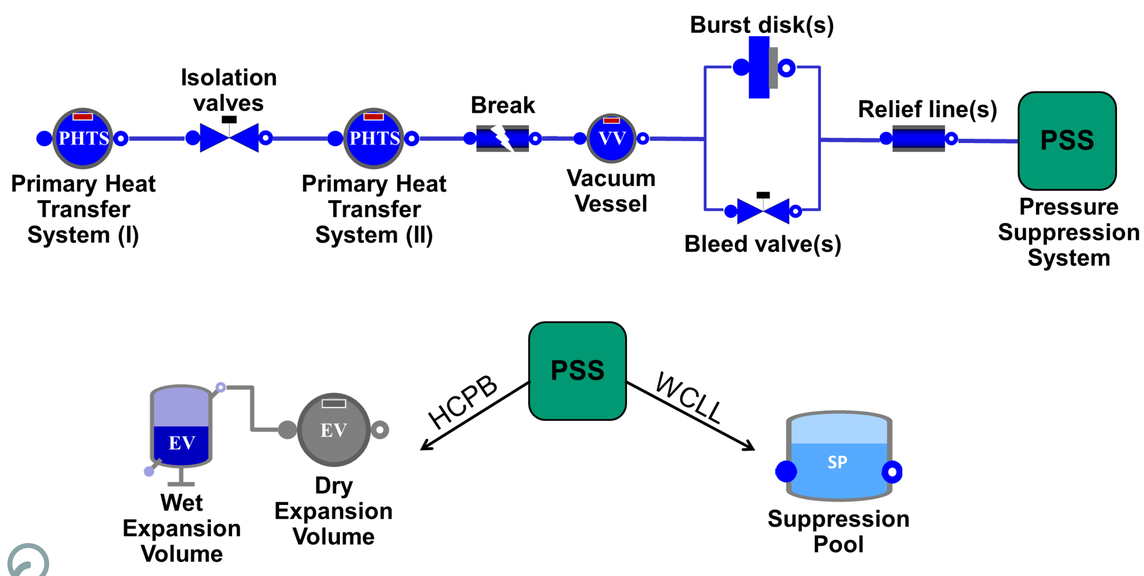


VV	Pressure limit	2 bar
HCPB	Inventory	431.0 m³
	PHTS temperature	300-520 °C
	VVPSS size	50000 m³ (0.2 % water)
	VVPSS temperature	20 °C
WCLL	Inventory	138.0 m³
	PHTS temperature	295-328 °C
	VVPSS size	2600 m³ (60 % liquid)
	VVPSS temperature	20 °C

All data from [M. T. Porfiri and G. Mazzini, EU DEMO BB Safety Data List v4.1, EFDA_D_2MF8KU]

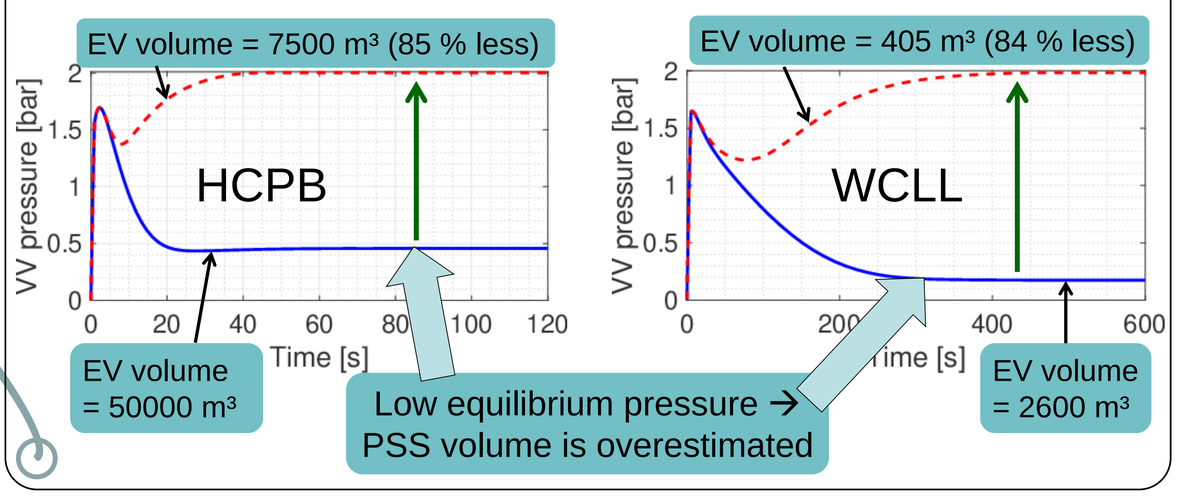
GETTHEM VVPSS model

0D/1D mass and energy conservation equations



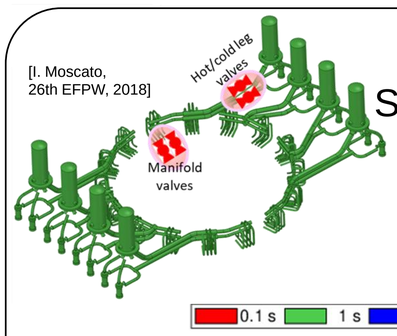
STEP 1:

Reduction of VVPSS size without IVs

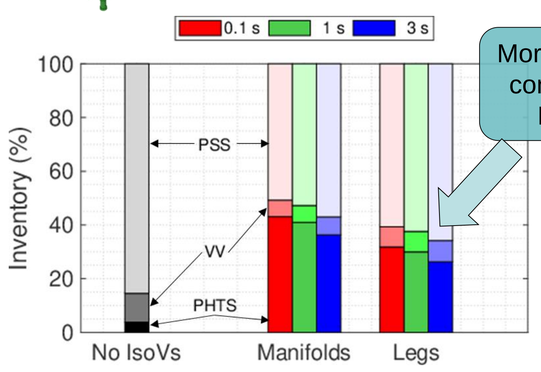


STEP 2:

Sensitivity to IVs position and closure time



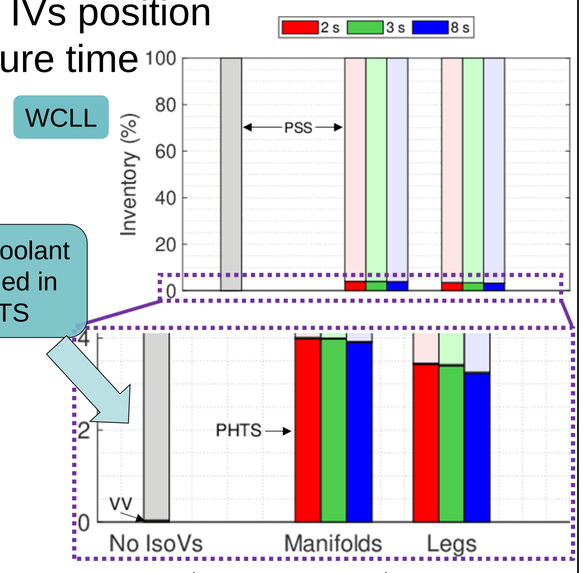
HCPB



IV position	IVs on manifolds			IVs on legs		
Closure time (s)	0.1	1	3	0.1	1	3
p_{peak} (bar)	1.69	1.69	1.69	1.70	1.70	1.70
$p_{equilibrium}$ (bar)	1.09	1.15	1.28	1.34	1.39	1.50
Inventory reduction (%)	46	43	36	33	30	24
Minimum VVPSS volume (m³)	2900	3200	3800	4000	4200	4700

More coolant confined in PHTS

WCLL

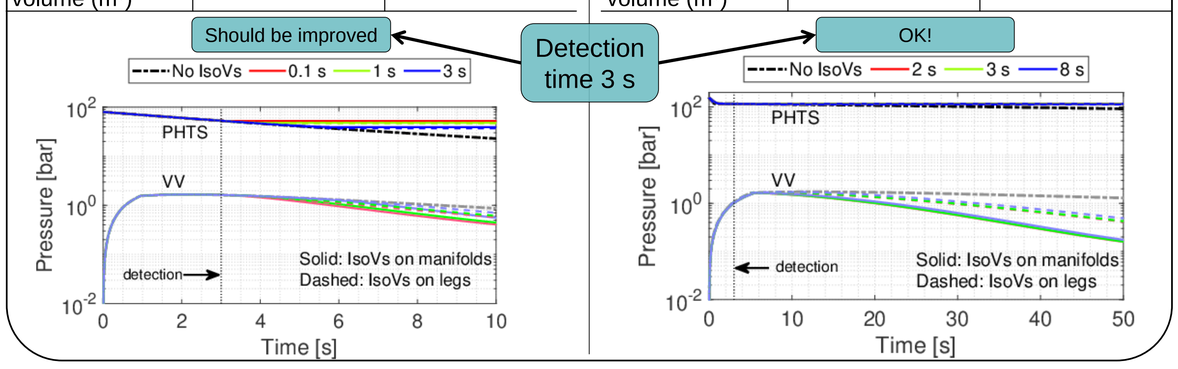


IV position	IVs on manifolds			IVs on legs		
Closure time (s)	2	3	8	2	3	8
p_{peak} (bar)	1.56	1.56	1.56	1.59	1.59	1.62
$p_{equilibrium}$ (bar)	0.23	0.23	0.24	0.37	0.38	0.43
Inventory reduction (%)	78	77	76	65	64	61
Minimum VVPSS volume (m³)	57	58	64	107	110	122

Should be improved

Detection time 3 s

OK!



ADDITIONAL REMARKS

- ❑ Pressure drop introduced by IVs: [M. Di Prinzio et al., EFDA_D_2MLY79 v1.0, 2018]
  - HCPB: 0.2÷0.6 bar (+7÷36 %) ⚠ Circulator power
  - WCLL: 2.6÷3.5 bar (+30÷36 %)
- ❑ IVs size:
  - On manifolds: DN-300 (WCLL) to DN-450 (HCPB)
  - On legs: DN-850 (WCLL) to DN-1300 (HCPB) ⚠ Feasibility

CONCLUSIONS and PERSPECTIVE

- ✓ Effectiveness of PHTS Isolation Valves for the mitigation of a LOCA has been assessed:
  - Acceptable for HCPB, excellent for WCLL
- ✓ Closure time not strongly affecting results
- ✓ IVs on manifolds are sensibly more effective than on legs

→ Benchmark among system codes and against CFD planned

[1] A. Froio et al., Dynamic thermal-hydraulic modelling of the EU DEMO HCPB breeding blanket cooling loops, *Prog Nuc Ene* 2016
[2] A. Froio et al., Dynamic thermal-hydraulic modelling of the EU DEMO WCLL breeding blanket cooling loops, *Fus Eng Des* 2017
[3] A. Froio et al., Benchmark of the GETTHEM vacuum vessel pressure suppression system (VVPSS) model for a helium-cooled EU DEMO blanket, *Safety and Reliability* 2017
[4] A. Froio et al., Modelling an in-vessel loss of coolant accident in the EU DEMO WCLL breeding blanket with the GETTHEM code, *Fus Eng Des*, 2018
[5] A. Froio et al., Thermal-hydraulic analysis of the EU DEMO helium-cooled pebble bed breeding blanket using the GETTHEM code, *IEEE TPS* 2018

POLITECNICO DI TORINO
Dipartimento Energia "Galileo Ferraris"

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.