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BB LOCA analysis for the reference design of the EU DEMO HCPB blanket concept

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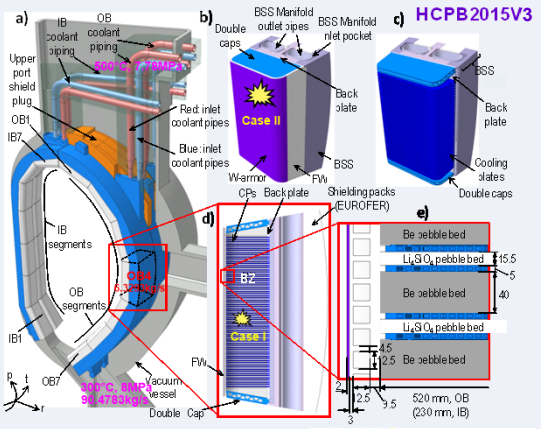
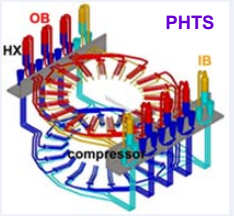
Accident sequences and assumptions

LOCA case					I (in-BB)		II (in-vessel)	
Failure condition					CP in BZ		FW	
Scenario					Ia	Ib	IIa	IIb
Assumptions	Failed cooling channel				1	32 (1 CP)	1	10
	A_b (m²)				3.0e-5	9.6e-4	3.125e-4	3.125e-3
	He ingress into				PG		VV	
	Bleed line / RD				p_{PG} > 0.5MPa		p_{VV} > 90kPa / 150kPa	
	A_PG / A_VV / A_RD (m²)				1.3254e-2		0.05 / 1.0	
Time evolution (s)	Steady state / LOCA				1000			
	HTC = 0.0				> 1000			
	compressor shutdown				1003			
	Plasma shutdown condition	FPSS	Plasma disruption (0.5 GJ)	(1) no	1004		1004	
					(casela1)	(caselb1)	(casella1)	(casellb1)
				(2) 100 ms	1004 ~ 1004.1		1004 ~ 1004.1	
					(casela2)	(caselb2)	(casella2)	(casellb2)
				(2') 10 ms	-		1004 ~ 1004.01	
							(casella2')	(casellb2')
		(3) Soft plasma shutdown (60 s)			1004 ~ 1064		-	
					(casela3)	(caselb3)		

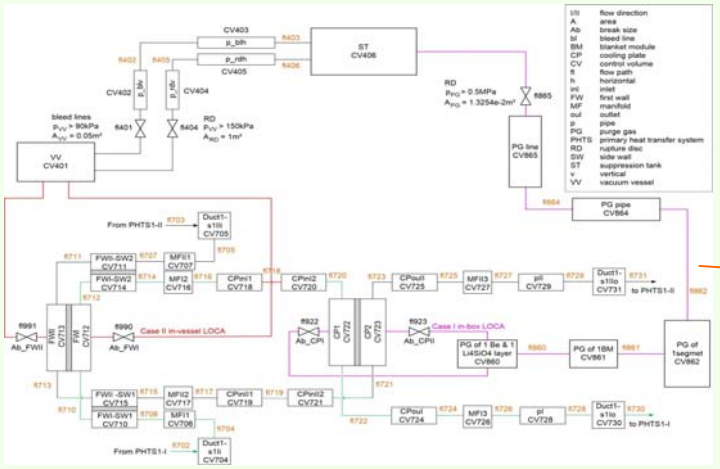
Reference design for DEMO2015 with 18TFs

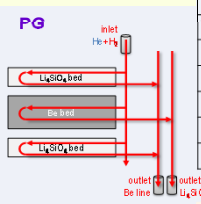


Item	V [m³]	T [°C]	p [kPa]
VV	2502	300	0.1
ST (He)	50000	20	4.5
Bleed line (v)	1.1	20	4.5
Bleed line (h)	2.5	20	4.5
RD pipe (v)	22	20	4.5
RD pipe (h)	32	20	4.5

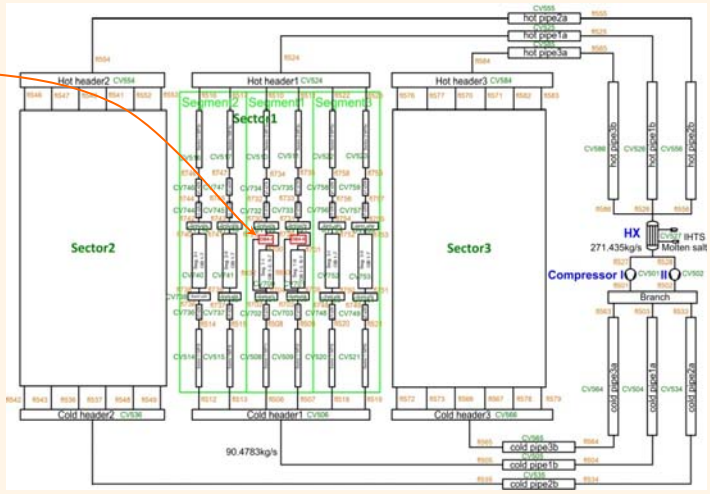


OB4 model and LOCA conditions using MELCOR186 for fusion

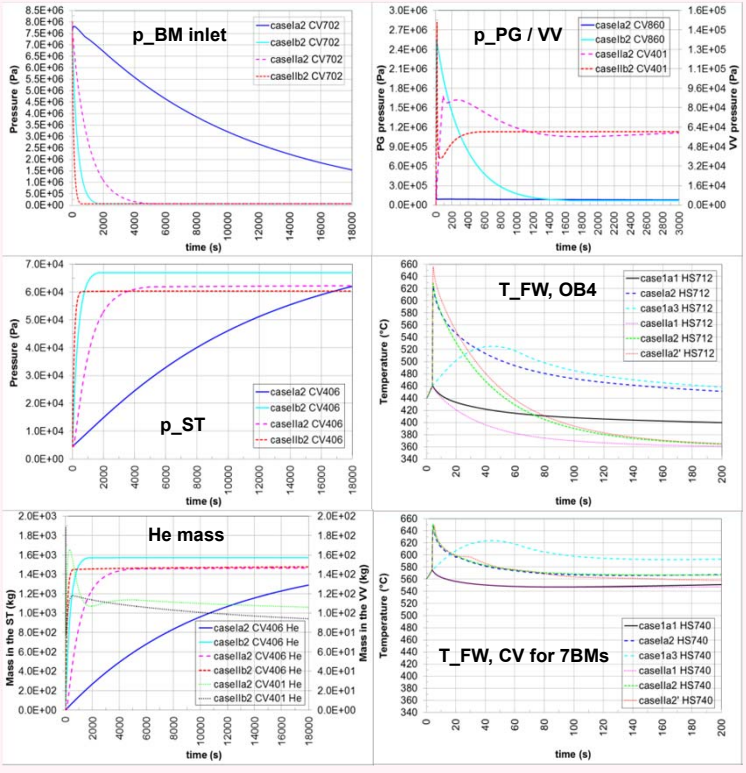




MELCOR modelling for one OB loop with the integrated OB4



LOCA



Conclusion

- **The model for one OB loop including 3 OB sectors results comparable He flow behaviour to the blanket design in normal operation.**
- **He inventory of one loop is 1.5848e3kg ⇒ 9.5090e3kg for 6 OB loops ⇒ challenge for the dimensioning of the pressure relief systems in case of in-vessel, in-BB or ex-vessel LOCA.**
- **The break size has impact on the He ingress with respect to the time evolution of the mass flow rate, pressure, temperature and mass:**
  - *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 plasma shutdown condition has impact on the FW temperature:**
  - *The high heat flux load* caused by short disruption time *leads to high temperature peak exceeding the design limit.*
- **The in-vessel LOCA affects the VV, while the in-BB LOCA can affect the tritium extraction removal (TER) system potentially.**
- **In caselIb, the final pressure at equilibrium (p_{fin}) is ~60kPa with V_{ST} of 50000m³. To reach p_{fin} at 200kPa (p_{VV_limit}), V_{ST1} is 12476m³ ⇒ 74856m³ for 6 OB loops.**
- **To reduce V_{ST}:** *add subcooled water in the ST & heat exchange to the environment.*
- **Investigation of 3D thermal analysis for T_FW, and loop update for new design.**

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