CRYOGENICS OPERATIONS 2008

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JT60 SA : Baking Scenarios Studies

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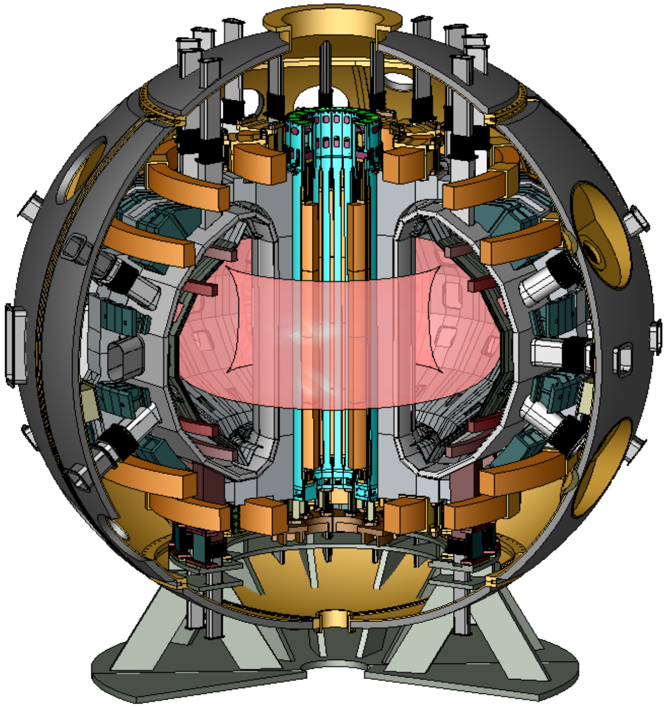
Outline



- **Baking for what ?**
- **Impact on the cryogenic system**
- **JT60 SA Baking**
  - » Baking conditions and constraints
  - » Plasma Operation State
  - » 3 scenarios : baking and associated cool down
- **Conclusion**

Baking for what ?

- **Plasma facing surfaces conditioning is an aspect of plasma operation necessary to obtain very low impurity release conditions that are essential for tokamak plasma operation in general and high fusion performance operation**

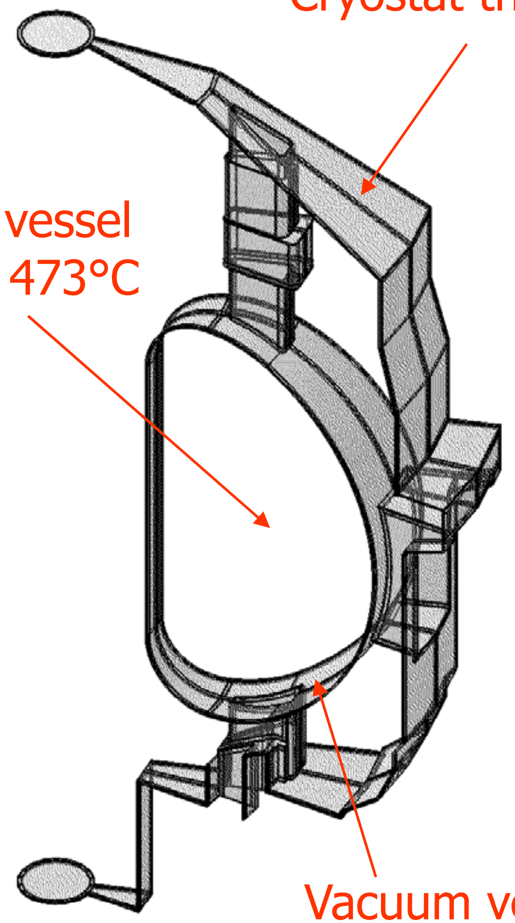
- **Baking of the vacuum vessel is one of the techniques used**

- **Baking is efficient in removing water, volatile hydrocarbons and hydrogen**

- **Vacuum vessel temperature is led and maintained to around 200°C (473K) during several days**

Impact on the cryogenic system

1/ 36 JT60 thermal shields



- **Radiation heat loads on thermal shields of vacuum vessel increase**
- **Helium mass flow to maintain thermal shields at 80K increases**
- **Baking can be sizing for the cryogenic system**

JT60 SA Baking

- **Baking conditions :**
  - » Vacuum vessel temperature = 313 to 473K, heat speed =10K/h
  - » Tinlet thermal shields = 80K
  - » Toutlet thermal shields ≤ 140K
  - » Magnets temperature ≤ 70K
  - » 5 days of baking every 3 weeks
- **Baking constraints :**
  - » baking must be a «non-sizing» operation state for the cryogenic system compared to the Plasma Operation State (POS)
  - » POS fixes maximum helium mass flow
- **3 scenarios :**
  - » baking phase
  - » associated cool down phase

JT60 SA Plasma Operation State

- **Heat loads at 4.3K = 6.23kW**

  Helium loops through a thermal buffer

  He mass flow = 460g/s

- **HTS current leads**

  He Mass flow (50K-300K) = 24g/s

} Return to low pressure

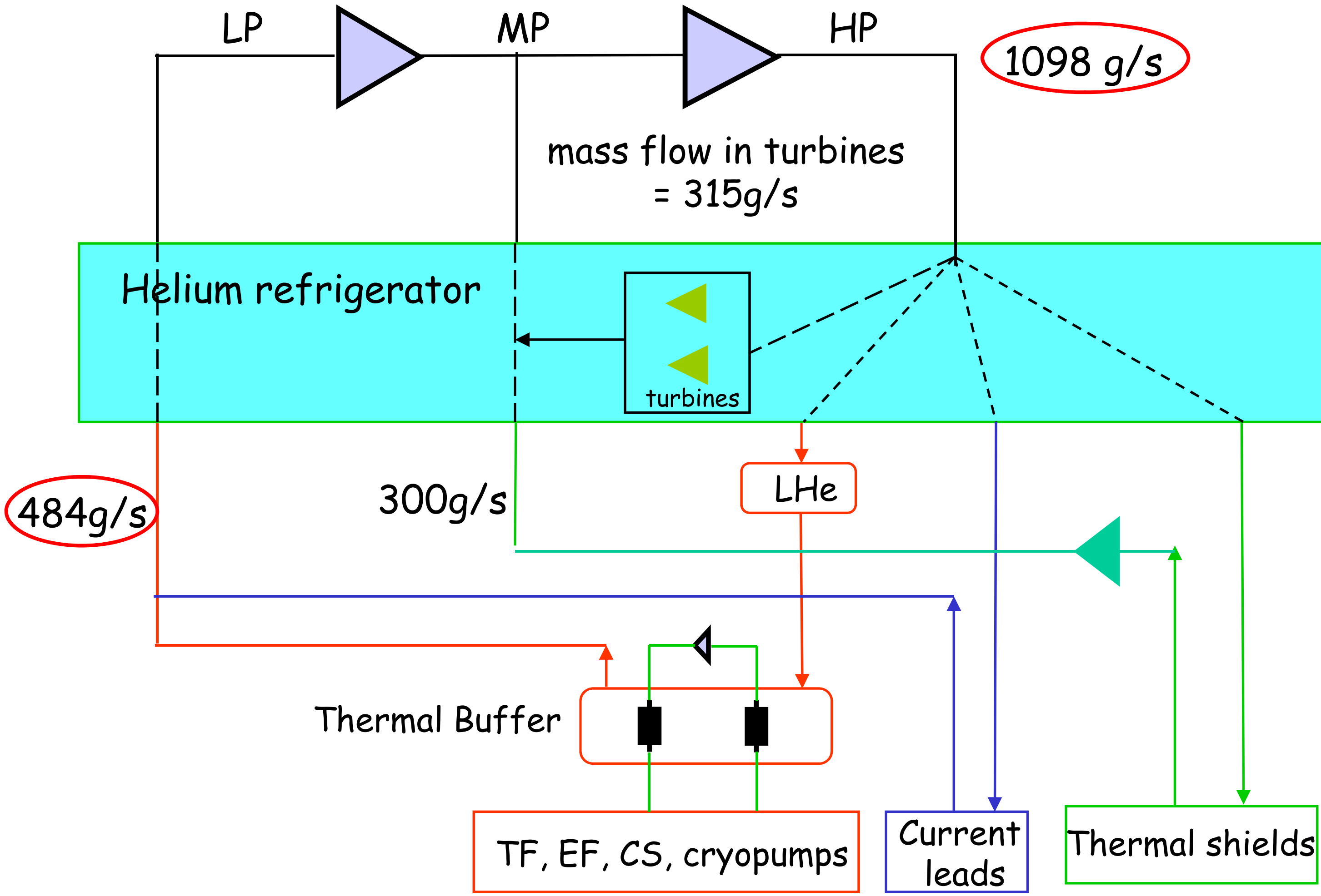
- **Heat loads at 80K = 32kW**

  (Radiation heat loads on thermal shields = 22.8kW)

  He Mass flow (80K-100K) = 300g/s ⇐ Return to middle pressure

JT60 SA Plasma Operation State

- **Scheme of the cryoplant**



Scenario 1

• Baking : thermal conditions

- Vacuum vessel temperature = 313 to 473K, heat speed = 10K/h
- Average temperature of thermal shields = 100K,
  Tinlet = 80K, Toutlet = 120K, heat speed = 1K/h
  Radiation heat loads on thermal shields = 117kW
- Magnets temperature = 4.5K
  Helium loops through thermal buffer in operation

⇩

Heat loads at 4.5K = 4.32kW

Helium loops in operation

Mass flow = 280g/s

Heat loads at 80K = 124kW

Radiation heat loads on TS = 117kW

Mass flow = 602g/s

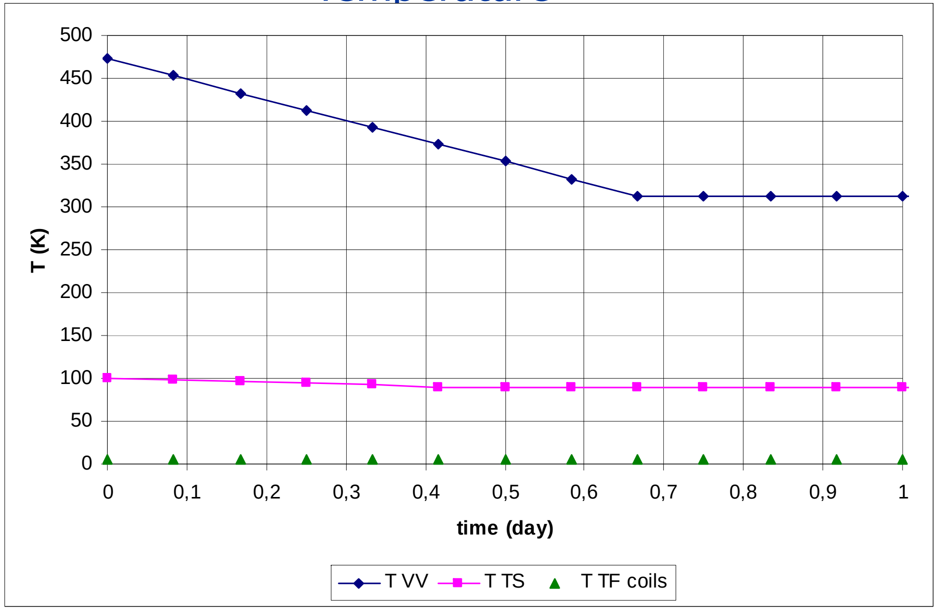
1st stage of compression = 280g/s

2nd stage of compression = 280+602+220 = 1102g/s

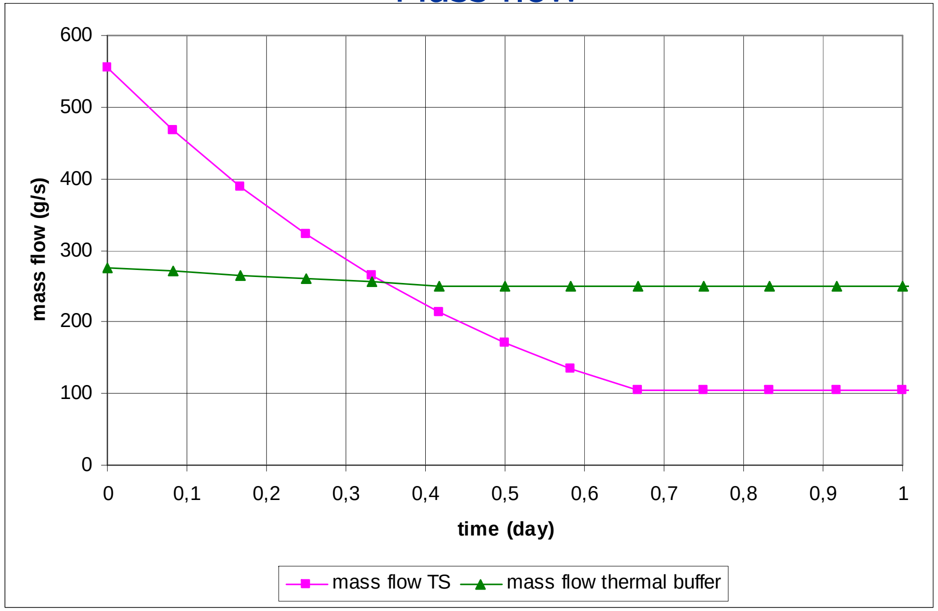
Scenario 1

- **Cool down after 5 days of baking**
  - Cool down speed of vacuum vessel = 10K/h from 473K to 313K
  - Cool down speed of thermal shields = 1K/h from 100K to 90K

Temperature



Mass flow



Thermal conditions of POS mode are restored after 0.7 day of cool down

Scenario 2

• Baking : thermal conditions

- Vacuum vessel temperature = 313 to 473K, heat speed = 10K/h
- Average temperature of thermal shields = 105K,
  Tinlet = 80K, Toutlet = 130K, heat speed = 1K/h
  Radiation heat loads on thermal shields = 117kW
- Magnets temperature = 4.5K
  Helium loops through thermal buffer in operation

⇩

Heat loads at 4.5K = 4.57kW

Helium loops in operation

Mass flow = 292g/s

Heat loads at 80K = 124kW

Radiation heat loads on TS = 117kW

Mass flow = 490g/s

1st stage of compression = 292g/s

2nd stage of compression = 292+490+220 = 1002g/s

Scenario 3

• Baking : thermal conditions

- Vacuum vessel temperature = 313 to 473K, heat speed = 10K/h
- Average temperature of thermal shields = 105K,
  Tinlet = 80K, Toutlet = 130K, heat speed = 1K/h
  Radiation heat loads on thermal shields = 117kW
- Magnets temperature free
  Helium loops stopped

⇩

Heat loads at 4.5K = 0kW

Mass flow = 0g/s

Heat loads at 80K = 124kW

Radiation heat loads on TS = 117kW

Mass flow = 490g/s

1st stage of compression stopped

2nd stage of compression = 490g/s

Scenario 3

Simulation

- **Baking**

➢ Vacuum vessel temperature increases from 313 to 473K with a heat speed = 10K/h

➢ Warm-up speed of thermal shields = 1K/h from 90K to 105K

- **Cool down after 5 days of baking**

➢ Cool down speed of vacuum vessel = 10K/h

➢ Cool down speed of thermal shields and TF coils = 1K/h

➢ Cool down of TF coils is performed by helium flow at high pressure

Scenario 3

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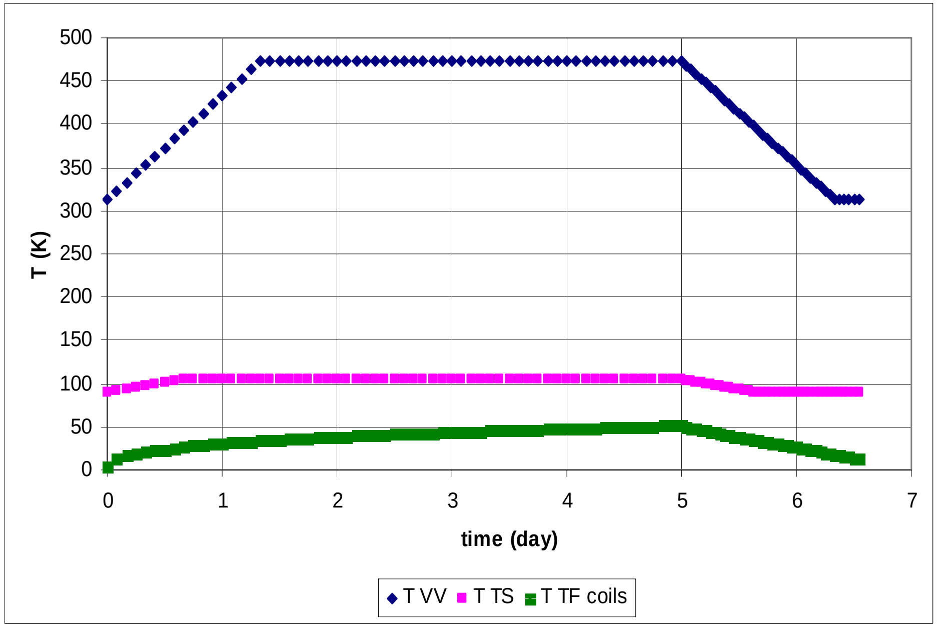
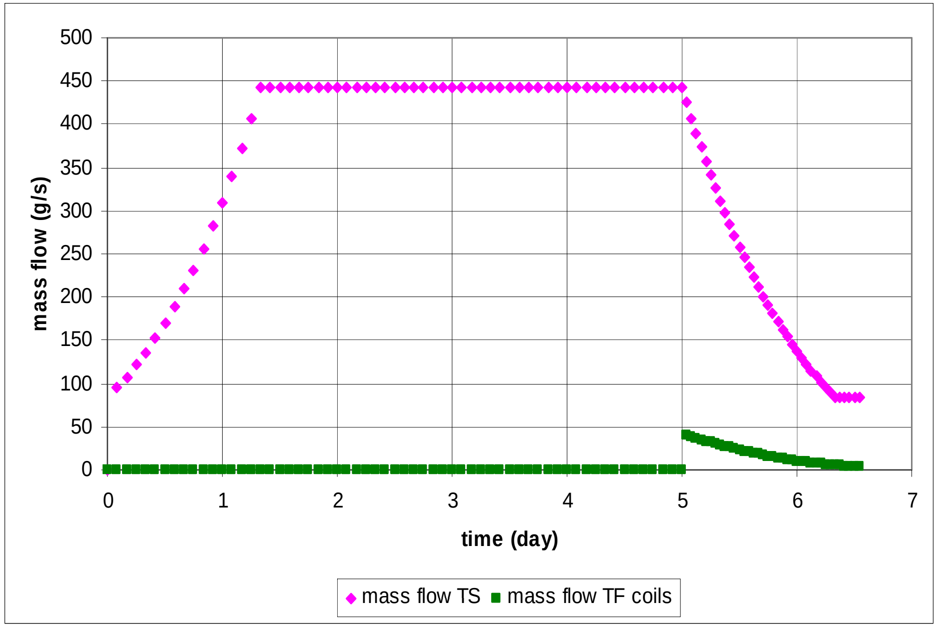
Temperature



Mass flow



- After 5 days of baking, TF coils reach 50K
- Thermal conditions of POS mode are restored after 2 days of cool down

CONCLUSION

• Comparison of the 3 scenarios

- **To compare the different scenarios, it is necessary to calculate theoretical electrical power for baking phase and associated cool down**
- **Low pressure is fixed at 1bar, middle pressure at 5bars and high pressure at 18bars**

	Baking (5 days)	Associated Cool Down	TOTAL	DURATION
	kW.h	kW.h	kW.h	day
Scenario 1	66650	7255	73905	5+0.7=5.7
Scenario 2	63234	7093	70327	5+0.7=5.7
Scenario 3	21748	8434	30182	5+2=7

To combine electrical consumption and availability of the machine, the scenario 3 remains the most efficient.