Remarks on FNSF base blanket choices and designs

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Criteria for the selection of base blankets for FNSF:

A) **Excellent safety and environmental features,**

B) **Minimum impact on the reliable operation of the facility,**

C) **Minimum extrapolation of present status of technology required,**

D) **Sufficiently high tritium breeding rate,**

E) **Allows testing of key features of the DEMO blankets,**

F) **Down time for the replacement of the base blankets minimized.**

Candidate blanket concepts for use as base blanket in FNSF:

Assumption: **FNSF should go into operation by 2025**

A) Liquid breeder blankets, based on ferritic steel as structural material

a) Helium cooled lead-lithium blanket (HCLL blanket)

b) Dual Coolant Lead-Lithium blanket (DCLL blanket)
(Self-cooled breeding zone, helium cooled FW/blanket structure, SiC flow channel inserts as thermal and electrical insulator)

B) Helium cooled ceramic breeder blankets (HCCB blanket) with beryllium as neutron multiplier

a) With austenitic steel as structural material

b) With ferritic steel as structural material

Pre-selection between the candidate blanket concepts:

A) Between the two liquid breeder concepts, the DCLL blanket is preferred because

- The high circulation leads - together with a permeator based tritium extraction system - to an extremely low T partial pressure in the LM.
- Cooling of the FW and the steel structure is nearly identical in both concepts. However, the arrangement of the cooling surfaces outside the VV in case of the DCLL makes the design of the blanket itself simpler and increases the reliability.
- With the DCLL blanket, a low LM exit temperature can be chosen at the begin of the operation, leading to large margins in regard to compatibility and stress limits. The performance of the blanket can be increased later to allow more DEMO relevant testing.
- Such a low temperature operation would allow the use of steel sandwich FCI's instead of the SiC-composite if the development of suitable SiC-material takes more time.
- The MHD pressure drop in the meander shaped LM flow in a HCLL blanket is at least as large as the pressure drop in a DCLL blanket.

Pre-selection between the candidate blanket concepts: (continued)

B) For the ceramic breeder blanket concept, ferritic steels are preferred over austenitic steels because

- Thermal conductivity is considerably lower and thermal expansion coefficient considerably higher for austenitic steel, leading in general to much higher thermal stresses.
- The development of fission fast breeder reactors has shown that austenitic steels start to swell at a rather high rate already at ~ 10 dpa if not cold worked by at least 25 %. This swelling rate is strongly temperature dependent (risk of differential swelling!).
- The large Ni-content in austenitic steels leads to considerably higher activation (waste issue!)

Since the issues of more difficult PWHT and impact of ferro-magnetismus of ferritic steels has to be solved in any case prior to power plant applications, these issues should be addressed already in FNSF.

Comparison of the two selected candidate concepts

Dual Coolant Lead-Lithium blanket
versus
Helium cooled ceramic breeder blanket

Issues to be considered in this comparison:

a) Safety and environmental impact
b) Reliable operation of FNSF
c) Required extrapolation of technology
d) Sufficiently high tritium breeding
e) Potential for testing of DEMO blankets
f) Required down time for blanket replacement