

UW Blanket Activity

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Preliminary Design Parameters



| | |
|-----------------------------------|---------------------------|
| Average OB heat flux | 0.7 - 1 MW/m ² |
| max OB NWL | 7 - 10 MW/m ² |
| max SiC/SiC temp. | 1100 – 1400 oC |
| Breeder exit temp. | ~ 1000 oC |
| SiC/SiC thermal conductivity | 20 – 30 W/mk |
| FW location at midplane – IB , OB | 3.5 , 6 m |
| Top/bottom FW radii – IB , OB | 3.5 , 4 m |

FW Design Characteristics

- FW design is still **evolving**
- **FW consists of array of bundles** overlapped toroidally to intercept surface heat flux
- **Horizontal cross sections** at midplane ($R = 6$ m) and at top/bottom ends ($R = 4$ m) are shown in Figs. 1 and 2
- **Single FW bundle** (shown in Fig. 3) consists of set of twisted tubes surrounding a straight central tube
- **Breeder** flows poloidally in SiC/SiC tubes.
- Tube **wall is 0.3 cm thick** and breeder tube diameter is 1 cm
- Number of tubes and dimensions will be optimized later
- Plasma facing FW surface needs **protective coating**. Few mm of SiC (or Be) coating could be sprayed on FW in factory or in-situ
- FW design is also **applicable to divertor** system

Fig. 1. IB or OB FIRST WALL AT MIDPLANE

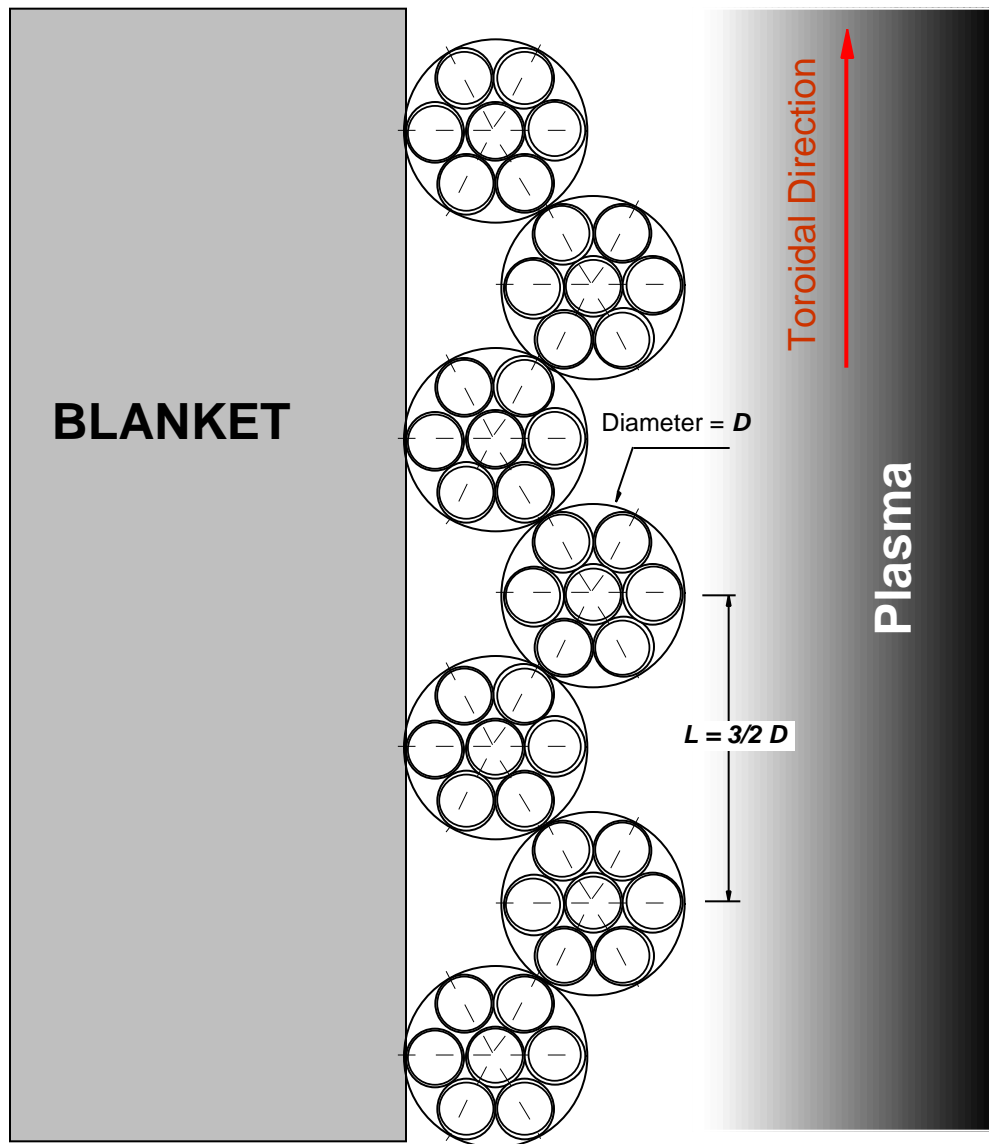


Fig. 2 OB FIRST WALL AT TOP/BOTTOM

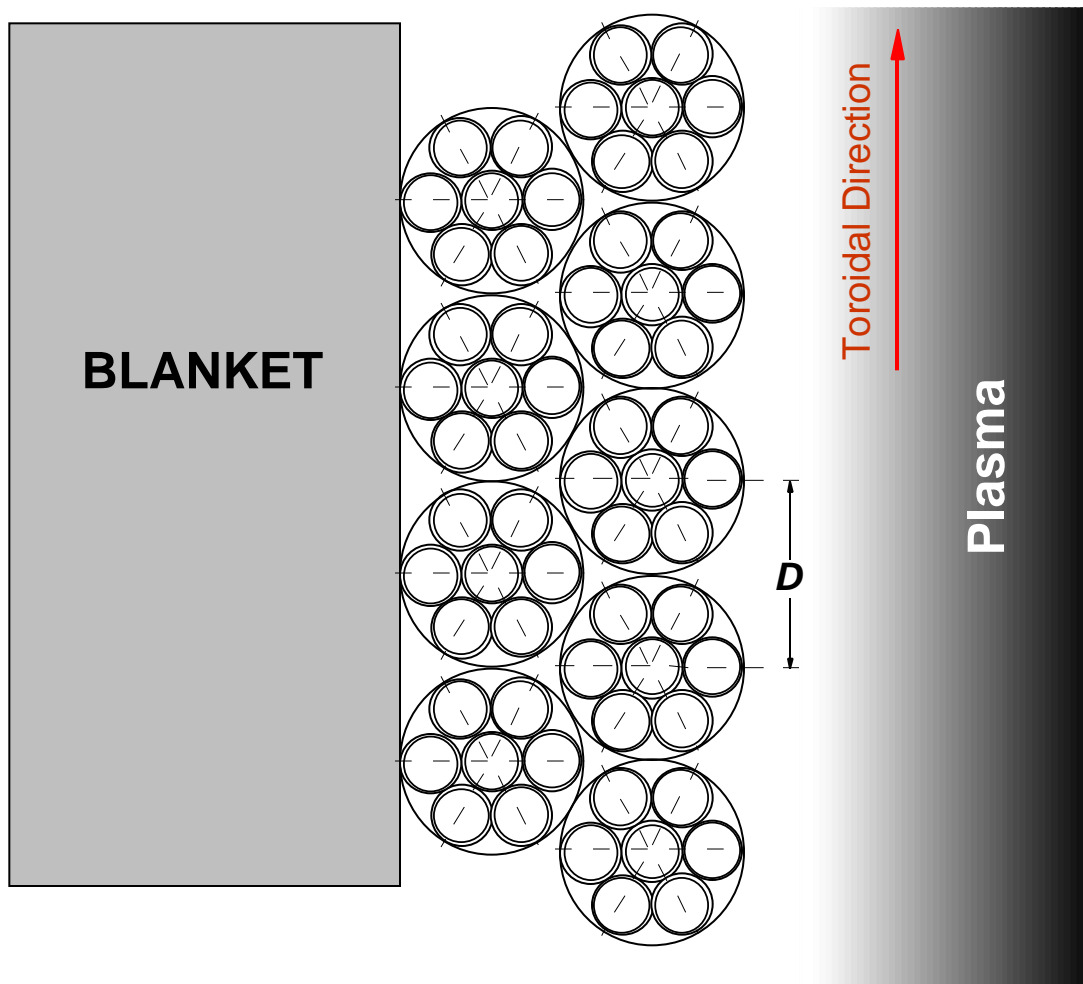
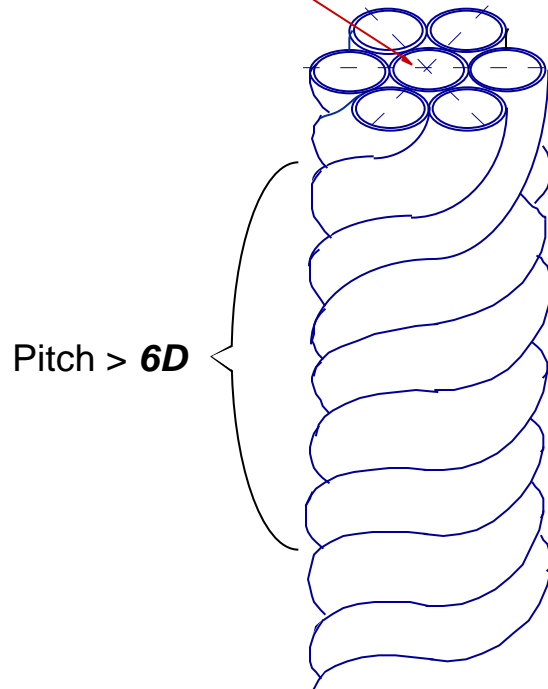


Fig. 3 Bundle of Twisted Tubes

Straight Central Tube



Blanket Design Characteristics

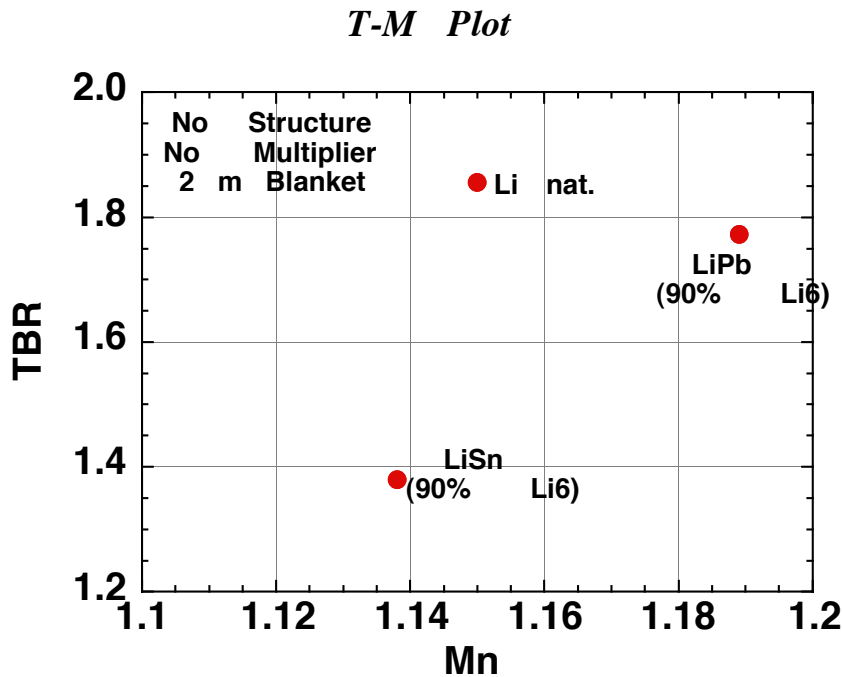
- Blanket design is at an **early stage** of development
- Currently investigating two blanket options:
 - Breeder **flowing** poloidally in square cells
(similar to ARIES-ST and Tauro designs)
 - **Stagnant** breeder pool with:
 - large bubbling of helium for tritium extraction
 - coolant flowing in SiC channels for heat removal .
- **No decision** has been made yet on preferred option.

FW/Blanket Design Issues

Expected values

- Heat flux handling capacity > 1 MW/m²
- Thermal conversion efficiency 50 – 60%
- Max temp. of SiC/SiC structure 1400 oC
- Max. temp. of breeder 1000 oC
- Optimum FW composition/dimension
- FW spray coating: SiC or Be
- FW outgasing
- Manifolding and attachments
- Accommodation of Kink stabilizing shell
- Blanket segmentation
- Flowing or stagnant breeder in blanket
- Compatibility of breeder with SiC at high temp.
- SiC content in blanket 10 - 20%
- IB blanket thickness 20 - 50 cm
- OB blanket thickness 50 - 80 cm
- Breeding capacity of candidate breeders
- Others ?

Breeding Potential of LiPb and LiSn Breeders



- Li₂₅Sn₇₅ has lower breeding potential than Li₁₇Pb₈₃
- LiPb and LiSn with natural Li have TBR of 1.6 and 0.5, respectively
- FW/Blanket structure, penetrations, and geometry will degrade overall TBR to 1.1 or less

Breeding Capacity of LiPb and LiSn in Realistic Design

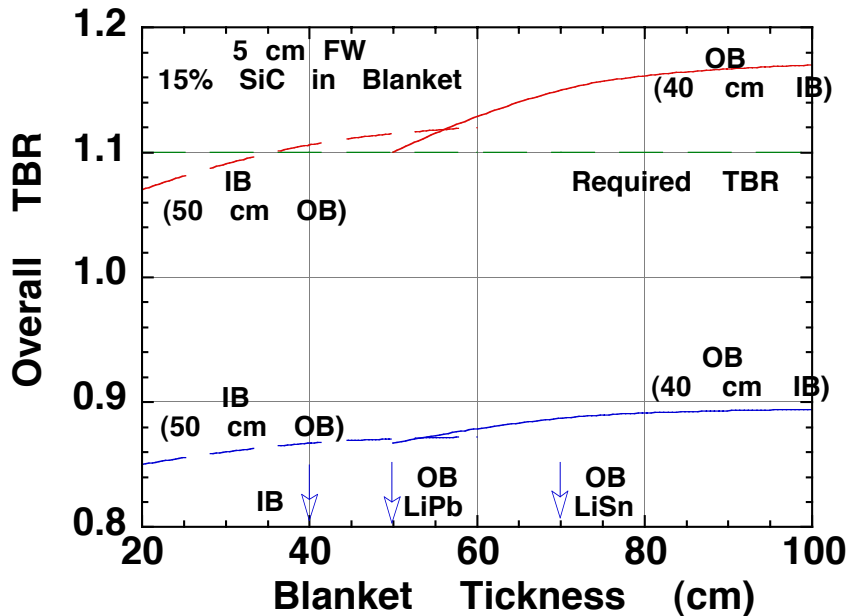


- **Starting dimension/composition:**
 - 20 cm thick IB blanket and 50 cm thick OB blanket (ARIES-RS type blanket)
 - 15 % SiC structure in blanket
 - 90% enriched Li
 - 5 cm thick FW (2 cm SiC, 3 cm LiPb)
- No breeding blanket behind divertor
- Breeder-cooled divertor and HT shield
- Required TBR = 1.1
- Results:

| Breeder/structure | <u>LiPb/SiC</u> (85/15) | <u>LiSn/SiC</u> (85/15) | ARIES-RS <u>Li/V</u> (90/10) |
|--------------------------|-----------------------------------|-----------------------------------|---|
| Overall TBR | 1.07 | 0.85 | 1.1 |

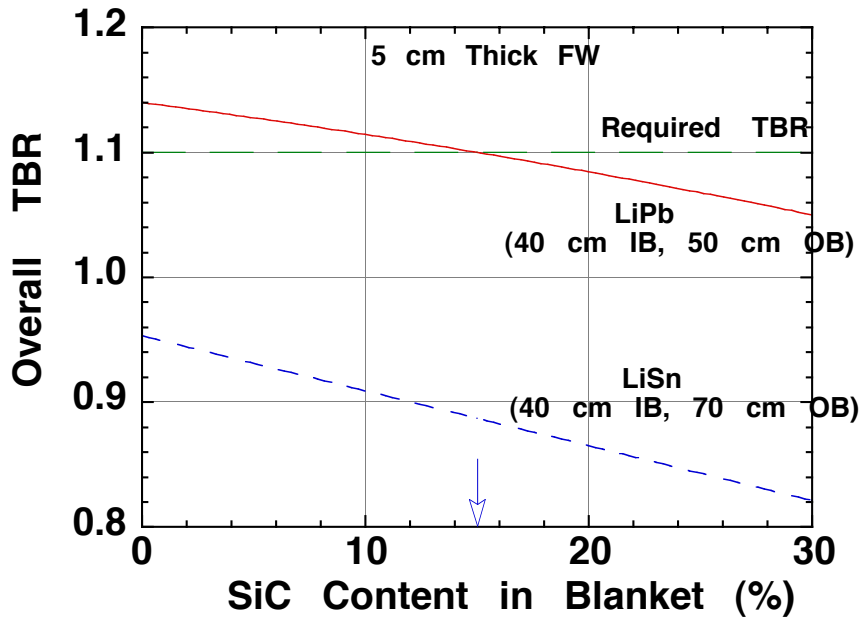
- **To increase TBR:**
 - Thicken blanket
 - Reduce SiC content in blanket
 - Reduce SiC content in FW

TBR of LiPb/SiC and LiSn/SiC Blankets



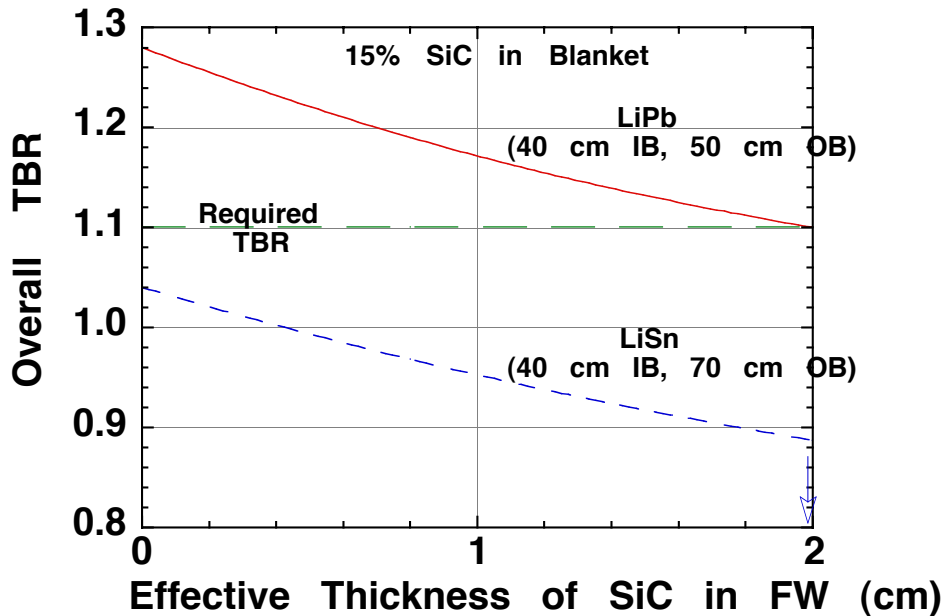
- **LiPb/SiC** blanket satisfies breeding requirements with:
 - 40 cm thick LiPb/SiC IB blanket
 - 50 cm thick LiPb/SiC OB blanket
 - 15% SiC structure in blanket
 - 5 cm thick LiPb/SiC FW
- **LiPb/SiC** blanket has ~5% excess breeding capability
- **LiSn/SiC** blanket does not meet breeding requirements. Thick blankets increase TBR to ~ 0.9:
 - 40 cm thick LiSn/SiC IB blanket
 - 70 cm thick LiSn/SiC OB blanket
 - 15% SiC structure in blanket
 - 5 cm thick LiSn/SiC FW

Sensitivity of TBR to SiC Content in Blanket



- If design calls for more (or less) SiC content than 15% in blanket, **LiPb/SiC** blanket thickness will be used to adjust TBR to 1.1
- **LiSn/SiC** blanket without SiC structure has TBR of 0.95

Sensitivity of TBR to SiC Content in FW



- SiC of FW has larger impact on breeding than SiC of blanket
- Each mm of FW SiC changes TBR by ~1%
- Lower SiC content in FW allows thinner OB **LiPb/SiC** blanket than 50 cm and/or higher SiC structure in blanket than 15%
- **LiSn/SiC** blanket will not breed unless SiC in BOTH FW and blanket is reduced to 1 cm.
- Is 1 cm SiC structure sufficient to support 40-70 cm thick LiSn blanket?

Conclusions

- Proposed FW/blanket design potentially offers high heat flux handling capability and high thermal conversion efficiency
- **LiPb/SiC** blanket satisfy breeding requirements (TBR = 1.1) with excess breeding capability
- **LiSn/SiC** will not meet breeding requirements unless SiC structure is limited to 1 cm or less in both FW and blanket
- **Beryllium** multiplier could enhance breeding potential of LiSn/SiC blanket
- **Overall Mn** will not exceed **1.1** for both breeders, meaning larger machine than ARIES-RS (Mn = 1.2) for same net output power.