Plasma Stabilization Conducting Shells and Their Impact on TBR and Activation in CLiFF Design

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Plasma kink mode stabilization and plasma elongation are best achieved by keeping a stabilizing shell as close as possible to the plasma. In CLiFF design, a 2-cm-thick flowing liquid layer (Flibe) is placed in front of a solid FW and was thought to be used as an active conduction shell. On the other hand, higher conductance is achieved by solid shells (e.g. Cu, Al, FS, W, V alloy). The adverse effect of this shell on TBR is highly system-dependent. Among the design features that quantify this effect are: the type of breeder and structure, the degree of Li-6 enrichment, the material of the shell, and whether or not there is a front beryllium multiplying zone in the blanket. Placing W shell at the FW in a system that does not deploy beryllium will have lesser adverse impact on TBR (~-8-10%) if Flibe breeder uses natural lithium. However it improves TBR by ~+2-3% if 25%Li-6 enrichment is used. It is obvious that placing the conducting shell deeper in the blanket will have marginal adverse effect on TBR. A front 10-cm thick beryllium zone (60%Be, 30%Flibe, 10% SiC) is most likely to be adopted in CLiFF design. Natural lithium gives the largest local TBR (~1.5). Without the convective layer (TBR=1.54), using W shell gives the largest adverse impact on TBR (up to ~-30% for shell thickness d=2 cm) and tritium self-sufficiency condition can not be met. Copper is the next element that has an adverse effect on TBR. The drop is ~ 20% at d=2cm. The corresponding drop with FS is ~ 15%. The least impact is with V and Al conductors (TBR drops by~-12% for 2 cm shell).

Activation analysis is performed to determine the levels of activity and decay heat generated in the different proposed shells. Tungsten shell produces the highest level of decay heat. A shell made of V alloy generates the least decay heat. The activation results are also utilized in radwaste classification. Tungsten and aluminum shells will not qualify for disposal as Class C low level waste (LLW) according to Fetter limits. On the other hand, the copper shell will not qualify for disposal as Class C LLW according to the NRC 10CFR61 limits.