# §3. Tritium Control for Flibe/V-alloy Blanket System

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Reduced Activation Ferritic/Martensitic Steel (RAFM) and molten salt Flibe was used in FFHR blanket design. On the other hand, the use of vanadium alloys (V-4Cr-4Ti) can increase the maximum operation temperature and $\Delta T$ of the coolant Flibe in the blanket, which is significantly beneficial for reducing viscosity of the fluid and enhancing thermal efficiency of the plant.

However, combination of high partial pressure of $T_2$ in Flibe and high tritium solubility of V-alloy structure would result in large tritium inventory in the blanket structural components. As a solution to this issue, it was proposed to dope $MoF_6$ or $WF_6$ into Flibe for corrosion protection of the wall surfaces by precipitation of Mo or W, and for reduction of the tritium inventory by enhancing the reaction from $T_2$ to TF which is more soluble in Flibe.

Fig. 1 is a schematic illustration of the REDOX control by $WF_6$ doping into Flibe. The reaction of the doped $WF_6$ with $T_2$ results in extremely biased equilibrium of TF over $T_2$. At the wall surface, the reaction of $WF_6$ with V results in dissolution of V into Flibe and plating of the wall surface with W. The W plating is thought to be effective as a corrosion barrier for the wall. In addition, the plating has a self-healing capability. The present study investigated possible tritium management scenario by quantitative thermodynamic calculations.

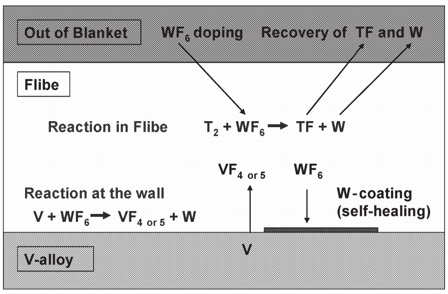


Fig. 1 Schematic illustration of REDOX control of Flibe by doping $WF_6$.

The reaction of $WF_6$ with $T_2$ is given as follows.

$$1/6\ WF_6 + 1/2\ T_2 = 1/6\ W + TF \quad (1)$$

For this reaction, the chemical equilibrium equation at temperature T is given by

$$\Delta G_f^o = -RT \ln P_{TF}/P_{WF6}^{1/6}P_{T2}^{1/2} \quad (2)$$

here $\Delta G_f^o$, R, $P_{TF}$, $P_{WF6}$ and $P_{T2}$ are the difference in the free energy for fluoride formation, gas constant, partial pressure of TF, $WF_6$ and $T_2$, respectively.

For evaluation of tritium inventory in the V-4Cr-4Ti, the blanket structure of FFHR-FV was assumed, where the breeding blanket is composed of 700 tons of V-4Cr-4Ti structure, 1140 tons of Flibe, and neutron/thermal shield.

Fig. 2 shows partial pressure and tritium molar fraction of TF and $T_2$ in various levels of $MoF_6$ or $WF_6$ doping into Flibe. In the figure, tritium inventory in V-4Cr-4Ti structure and in Flibe were also indicated assuming FFHR-FV blanket structure. It should be noted that the tritium inventory in V-4Cr-4Ti structure and in Flibe are dominated by the partial pressure of $T_2$ and concentration of TF in Flibe, respectively.

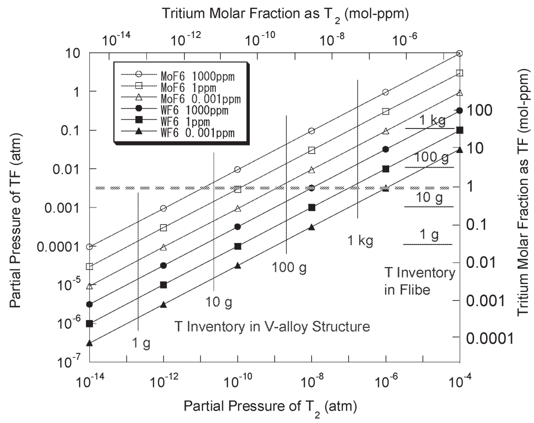


Fig. 2 Partial pressure and tritium molar fraction of TF and $T_2$ in Flibe for various levels of $MoF_6$ or $WF_6$ doping into Flibe at 1000K. Tritium inventory in V-4Cr-4Ti structure and in Flibe were also indicated assuming FFHR-FV blanket structure.

The level of TF in Flibe is a key parameter for the tritium management in the system. The tritium inventories in 700 tons of V-4Cr-4Ti structure and 1140 tons of Flibe in the blanket area were compared in Fig. 3 as a function of the tritium molar fraction as TF in Flibe in two cases of $MoF_6$ and $WF_6$ doping.

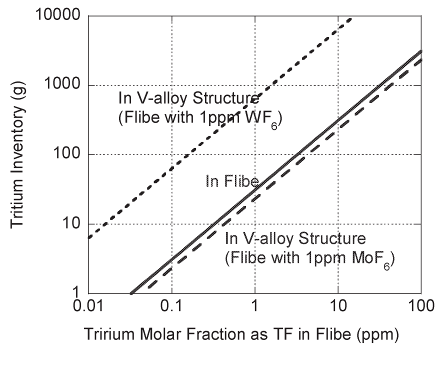


Fig. 3 The tritium inventories in V-4Cr-4Ti structure and Flibe in the blanket area as a function of the tritium molar fraction as TF in Flibe at 1000K. The blanket structure of FFHR-FV was assumed, which is composed of 700 ton of V-4Cr-4Ti structure and 1140 ton of Flibe.

Assuming the guideline of the total tritium inventory in the blanket area of 100g, the acceptable maximum level of TF in Flibe can be estimated to be ~3 ppm and ~0.1 ppm for $MoF_6$ and $WF_6$ doping, respectively. According to the previous analysis of tritium management, in which tritium level in Flibe was designed to be ~0.1 ppm, the $WF_6$ doping seems to be feasible for the tritium management.