

**An almost exclusive focus on low activation materials may be leading us toward a non-competitive, unattractive system**

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**The material system of the fusion power technology (FPT) (divertor, first wall, blanket, vacuum vessel, and shield) must serve stringent functional requirements (provide vacuum, remove heat, exhaust plasma ash, assure tritium self sufficiency, provide radiation protection). It must also serve the goals of economic competitiveness and safety and environmental attractiveness. Economic competitiveness requires low cost, high power density, high temperature, low failure rate and fast maintainability. Safety requires low chemical reactivity, low decay heat, low stored energy, etc. Environmental attractiveness requires low use (or recycling) of limited resources, low routine releases, low long term activation, etc.**

**In the presence of neutrons, all materials will become radioactive. However, there is substantial difference in the magnitude of long-term (>100 years) radioactivity among materials. Two decades of research identified only three structural materials as low activation materials: ferritic steel, vanadium alloy, and SiC/SiC composites. None of these materials appear practical for divertors. Current first wall/blanket concepts based on these materials and current low activation strategy suffer from major flaws:**

**1) Non-competitive Economics**

**The neutron wall load becomes limited to  $< 2 \text{ MW/m}^2$ . The corresponding power density is a factor of 240 lower than PWR and 600 lower than LMFBR.**

**2) Feasibility Issues**

**Vanadium alloys work only with lithium coolant. Feasibility requires a self healing coating that has not yet been identified. R&D resources are focused on development of vanadium and none is directed toward finding a feasible insulator. SiC/SiC has a number of feasibility issues and is so brittle that no one knows how to design for it today a practical system.**

**3) Safety Issues**

**All these materials have relatively high decay heat levels that preclude passive safety. Lithium which is the only coolant compatible with vanadium has extreme chemical reactivity with water and air.**

**Material development must be a central part of fusion R&D provided that it is based on a prudent strategy to serve the goal of practical fusion power. Such a strategy should have among its principles:**

- 1) focus on material systems with compatible combinations of coolants, breeders, multipliers and structural materials**
- 2) highest priority must be given to feasibility issues and satisfying the FPT functional requirements**
- 3) economic competitiveness must be a key goal. This requires high power density capability (wall loads  $> 5 \text{ MW/m}^2$ ), high temperature, low failure rates, and fast maintainability**

- 4) **select only a combination of materials for which passive safety can be realized**
- 5) **include low activation as one of the many criteria for which tradeoffs are performed to select the most practical and attractive system**
- 6) **realize that selecting low activation structural material is not the only means, and it may be the least practical approach, to realizing low activation system. Thick liquid walls, for example, as proposed for IFE allow practically any structural material to be low activation. Furthermore, coolants, breeders, and multiplier materials have about ten times the material volume of structural materials and hence, their activation characteristics are as important as those of the structural materials.**