

Overview Summary – CQ5

SUMMARY OF SNOWMASS CHAMBER SCIENCE AND TECHNOLOGY KEY QUESTION NUMBER 5: RE-EVALUATION OF THE USE OF LOW ACTIVATION MATERIALS IN WASTE MANAGEMENT STRATEGIES FOR FUSION

Materials choice has long been recognized as a key factor in realizing the full safety and environmental potential of fusion power. Because the materials are de-coupled from the fusion energy source (the plasma), the long-term neutron-induced activation of components can be tailored by proper selection of materials to avoid generation of waste that would require deep geological disposal. Thus, the idea of “low activation” materials was conceived for the US fusion program with the hope that such material could be disposed of as low level waste (e.g., shallow land burial) and would not pose a burden to future generations.

The environmental impact of waste material is, however, determined not only by the level of activation, but also the total volume of active material. A tokamak power plant is large, and there is a potential to generate a correspondingly large volume of activated material. Fusion's waste volume is a direct environmental concern. Fusion's waste volume and mass is ~ 3 times that of fission wastes for similar net electric power. Furthermore, the public believes low level waste is bad and high level waste is even worse. The radiotoxicity hazard of the waste depends on the release risk, which is understood only by technical experts.

Some materials may become candidates for recycling, and others may be cleared from regulatory control by meeting prescribed criteria that have yet to be agreed upon internationally. Recently these concepts of recycling or clearance have been recognized as options for reducing the volume of radioactive waste from a fusion power plant. Determining if a material can be recycled or cleared from regulatory control depends largely on our ability to limit the induced activation of the component. Thus, there is a need to explore new and innovative concepts that can substantially reduce the activation of the large ex-vessel components that contribute significantly to the overall volume of activated material and to extend the capability of conventional conceptual fusion designs with proper optimization to achieve the same goal. The impact of these parameters on other aspects of plant performance must also be considered.

The results of our discussion suggest that the waste management strategy for fusion needs to be modified slightly. While low activation materials do reduce the long-term activation hazard of the waste, their use in and of itself does not necessarily reduce the volume of activated material and the subsequent amount of radioactive waste arising from the plant. Furthermore, the current waste management strategy of ensuring that all material can be disposed of via shallow land burial may not be practical when large quantities of fusion waste are to be managed in the next century. Thus, a waste management strategy focused solely on low activation materials does not address the entirety of the radioactive waste picture for fusion. We recommend a strategy that is balanced with respect to minimizing both the hazard (via low activation materials) and the volume (via reduction of ex-vessel activation). As such we propose the following minimum design goals:

- To reduce the overall radioactive waste volume by limiting vessel/ex-vessel activation so that the bulkier large volume components be cleared or recycled for re-use.
- To minimize activated material in a fusion plant that cannot be cleared or recycled

There are many opportunities to address the implications of this strategy in the next decade. There is a need to better understand the tradeoffs associated with this dual strategy of minimizing both hazard and volume. Systems and power plant studies should examine in a systematic manner the tradeoffs associated with changing blanket and shield materials to meet these new design goals relative to changes in the radial build of the machine, cost of energy, performance impacts and reduction of radioactive waste volume.

Recycling can clearly reduce the volume of radioactive waste needing disposal. However, a serious study of the economics and technical tradeoffs and the environmental impact associated with recycle is needed to determine the efficacy of this approach and the impact on the environmental picture for fusion. Such a study should examine the economics of recycling and the criteria used for recycling. It is also important to understand the tradeoffs associated with volume reduction via recycling versus increasing the hazard of the waste because of buildup of certain impurities via reuse in a fusion machine.

In addition to their improved performance potential via high wall load and high efficiency, high power density/high wall load concepts offer important advantages relative to the overall volume of activated waste in a fusion machine. The higher wall load produces a more compact machine, which in turn reduces the volume of the bulkier activated components (e.g., shield, VV, and magnets) by 30 to 50%. Finally, other fusion technology innovations such as stir friction welding and improved radiation resistant magnet insulation could allow reduction of the radial build of a fusion machine and hence reduce the volume of activated material.