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Activation, Decay Heat, and Waste Classification Studies of the European DEMO Concept

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Inventory calculations have a key role in designing future fusion power plants because, for a given irradiation field and material, they can predict the time evolution in chemical composition, activation, decay heat, gamma-dose, gas production, and even damage (dpa) dose. For conceptual designs of the European DEMO fusion reactor such calculations can provide information about the neutron shielding requirements, maintenance schedules, and waste disposal prospects; thereby guiding future development.

Extensive neutron-transport and inventory calculations have been performed for a reference DEMO reactor model with four different tritium-breeding blanket concepts. The results have been used to chart the poloidal variation in activity and decay heat from different regions of the same component, such as the vacuum vessel (VV) or divertor, and as a function of time since shutdown. Results demonstrate that the shielding performance of the four blanket concepts will differ significantly. The decay heat values can be summed across the cells (used to define the neutron-transport model) of the same component to produce time-evolving total decay heat, which can then be used to assess how long a component, such as a divertor cassette, will require active cooling after shutdown, or when it will become sufficiently cooled to be manipulated and removed from the vessel.

Detailed nuclide inventories for the VV and divertor, focussing on the dominant radionuclides, have been produced by averaging results across all relevant cells. They reveal which radionuclides are the most problematic, potentially suggesting how changes in material composition (including isotopic tailoring) could help to reduce activity. Minor impurities in the raw composition of W used in divertor tiles, for example, are shown to produce long-lived radionuclides.

Finally, using a simple waste classification, based on UK regulations, and a recycling potential limit, the simulations can be used estimate the time-evolution in waste masses for both the entire vessel and individual components, and also suggest when a particular component might be suitable for recycling. The results indicate that the large mass of the VV will not be classifiable as low level waste on the 100-year timescale, but the divertor will be, and that both components, on the other hand, will be potentially recyclable within that time.

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