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Isotope separation systems for a european DEMO

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Large-scale isotope separation in a DEMO tritium plant poses significant challenges. Alternatives to distillation and palladium-based adsorption (used in the tritium fuel cycle for JET) remain elusive, despite the disadvantages: Cryodistillation is energy intensive and lacks inherent safety due to the high tritium inventories in the liquid phase, that inevitably expand to vapour in the event of a cooling failure. Palladium-based packings are expensive, and the systems are limited in scale by the heat transfer required to liberate hydrogen from the metal hydride. This presentation will outline the approach taken to tackle these challenges by the European DEMO Tritium Matter Injection and Vacuum work package, and highlight the most interesting results.

Firstly, a candidate list of potential technologies was generated. The isotope separation requirements created by each system block in the fuel cycle was considered, and potential mass balances for different scenarios defined. This work has identified approaches to the plasma fuelling requirements which could reduce isotope separation requirements, and opportunities to integrate isotope separation requirements within the fuel cycle.

The combination of requirements and mass balances has then been used to assess each technology option qualitatively and, where possible, quantitatively. This has led to surprising results in the size of systems required and the feasibility of both older and novel separation technologies for two distinct sets of isotope separation requirements: isotope rebalancing and protium removal for the inner fuel cycle, and trace tritium recovery for the outer fuel cycle. Studies have established that cryodistillation and temperature swing adsorption type processes (such as TCAP) are feasible within the inner fuel cycle, while gas chromatography is less attractive. Work is on-going to assess thermal diffusion, membrane separations, and pressure swing adsorption, and the suitability of technologies for trace tritium recovery in the outer fuel cycle.

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