Conceptual design of a combined tritium extraction system with an intermediate heat exchanger and its leakage to the environment analysis for nuclear fusion reactors.

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Future fusion reactors, as for example those being studied in the ITER and NIF experiments, will breed tritium from other elements to use it as fuel. Hence, T production and recovery as well as the need for preventing and containing tritium leakages, as it is done with any other contaminant, turns out to be a key issue.

In this work, the conceptual design of a hydrogen isotopes extraction system from liquid lithium lead eutectic alloy by permeation, combined with an intermediate heat exchanger, is shown. The component has been designed based on a printed circuit heat exchanger. A set of modifications have been implemented in order to take advantage of coupled electromigration (EM), thermomigration (TM) and hydrogen permeation barriers. The extractor is modelled with Computacional Fluid Dynamics code OpenFOAM© which allows a 3D numerical study and the results analyzed from the efficiency point of view.

In addition a Tritium leakage by permeation through the proposed extractor to the environment, following an integral methodology based on a multiscale analysis, is exposed. Advection, diffusion and recombination and deposition process have to be considered in plant components as well as in the soil and vegetation to fully simulate the behavior of different chemical forms of tritium, including their reactions. In addition, penetration in the underground, re-emission to the atmosphere and later conversion to organic bound tritium have to be taken into account. A final aspect of this work is the dosimetric analysis of the contamination. All of pathways have been taken into account: inhalation, re-emission and ingestion. Early and chronic doses are also evaluated.