



Performance Assessment and Integration of Different Tritium Extraction Technologies in the Outer Fuel Cycle

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The outer fuel cycle (OFC) of a fusion power plant (FPP) is a fundamental component that allows retrieving the bred tritium to permit D-T plasma operations. Moreover, this system plays a fundamental role for the safety of workers and population, acting as a physical barrier that delimits the tritiated circuit, and extracts tritium from the system, thereby diminishing the tritium inventory both in the BB and in ancillary systems. The open-source TRITium Object-oriented and Modular Analysis (TRIOMA) code is a Python package the analysis of OFCs in FPPs. The code leverages on pre-built classes and functions to build an intuitive, object-oriented framework. Its 0-dimensional analytical formulation enables fast calculation of the extraction efficiency and of integral parameters, including tritium inventory and losses, under steady-state conditions, for each component of the OFC, enabling rapid design iterations for OFC optimization. Both molten salt and liquid metal breeders, which have different analytical formulations due to different solubility laws [1], [2], [3], are included in TRIOMA. The code can be easily employed to make the preliminary design of an OFC, to analyze feasibility and sensitivity on input properties, to observe start-up transients, and pulsed plasma operations. Moreover, due to the flexibility of the Python environment, the integration with other open-source tritium transport tools and data analysis is facilitated.

The presented work employs TRIOMA to design and compare different tritium extraction technologies within the same OFC circuit. In particular, the comparison involves the Permeator Against Vacuum (PAV), the Gas Liquid Contactor (GLC) based on a packed tower column, and the Liquid Vacuum Contactor (LVC) technologies. These are the main selected tritium extraction technologies for PbLi liquid breeders foreseen in the WCLL breeding blanket module. In particular, the PAV mock-up experiment is based at ENEA Brasimone [4] in the TRIEX facility [5], as well as the GLC mock-up, while the LVC technology is tested in CIEMAT laboratories.

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