Understanding and modeling tritium transport under irradiation at LIBRETTO-4 in-pile tests

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Demonstration of tritium self-sufficiency and tritium control are major scrutiny issues in nuclear fusion technology. Predictive modelling of tritium transport behaviour in fusion materials represents an unavoidable step for such self-sufficiency demonstration in the pathway through ITER Test Blanket Modules towards DEMO.

Libretto (Liquid Breeder Experiment with Tritium Transport Option), experiments were designed and accomplished in order to study the effect of neutrons on the tritium permeation through pre oxidized ferritic-martensitic steel EUROFER tube filled with lead lithium eutectic. For LIBRETTO-4 the two experiments (-4/1, -4/2) were almost identical but operated at two different temperatures (300-350, 500-550 ºC) providing in-pile continuous and comparable data. The plenum of the liquid metal tube is also continuously swept and measured and from these two measurements an in-pile tritium permeation percentage can be obtained and free surface desorption directly measured.

The present work focuses on the numeric modelling approaches to reproduce tritium release-rate data, both permeation and desorption at LIBRETTO-4 capsules.
Different numeric strategies have being investigated starting from a 1-d model in TMAP7 (today the tool with ITER QA) a finite difference tool [1] implementing the complete physics of a tritium release-rate model and pedigree for tritium transport assessments.

On the base of the quality of fitting/understanding obtained diverse tritium transport under irradiation is validated: (1) diffusion coefficients in lead-lithium eutectic and in EUROFER; (2) Sieverts´ constants, (3) tritium mass transfers across a lead-lithium free swept surface, (4) finite mass exchange coefficients at interfaces and (5) release-rate constant at surfaces.

Transport values obtained are reported and discussed.