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Multiscale Integral Analysis of Tritium Leakages in Fusion Power Plants

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Tritium leakages are a major concern regarding nuclear power plants, not only in commercial fission power plants, but also in future fusion power plants. 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, the need for preventing and containing tritium leakages, as it is done with any other contaminant, turns out to be a key issue.
The present work presents an integral methodology towards a standard for safety analysis regarding tritium leakages to the environment. The methodology is based on a multiscale analysis covering the whole tritium cycle within a fusion power plant, from a micro scale, analyzing key components where tritium is leaked through permeation, to a macro scale, considering its atmospheric transport.
Advection, diffusion, recombination and deposition processes 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 and later conversion to organic bound tritium (OBT) have to be taken into account. A final aspect of this work is the dosimetric analysis of the contamination through: inhalation, re-emission and ingestion. Early and chronic doses are also evaluated.
An example of a multiscale integral analysis of a tritium leakage at a fusion power plant is presented, illustrating when, where and how different scale analysis interface with each other, in order to provide accurate and reliable results and give valuable insights from the design, operation and safety point of view.
Keywords—tritium, system codes, CFD, safety, atmospheric transport , multiscale modeling

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