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Nuclear analysis towards a spherical tokamak for energy production: analysis approaches and measurement experience derived from JET DT operations

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Predictions of fusion's radiation fields and associated nuclear quantities are fundamentally needed to serve a range of performance, safety and regulatory criteria - at all stages of the plant lifecycle, ranging from conceptual design to decommissioning. Radiation fields comprise the spatial, energy and temporal distribution of neutron and photon fluxes throughout the fusion device in various phases of operation. These also extend to several associated derived quantities, for example, nuclear heating, damage, dose and radionuclide production rates in those materials comprising the technology. Nuclear analysis, encompassing radiation transport methods, inventory codes, nuclear data, geometric-material models, and computational analyses, constitutes the framework for predicting these responses.

Confidence in neutronics predictions for a fusion power plant depends primarily on: i) the specific knowledge of design and operations to be analysed; ii) the quality of the nuclear data and validation base, rooted in current and historical nuclear experiments; and iii) the validity of computational methods. This work examines UKAEA's neutronics methodologies tailored to a spherical tokamak based on a design from the STEP programme. A parametric approach is employed to assess on-load neutron and photon fields as well as residual photon radiation fields and waste arisings through pulsed and steady-state operating scenarios.

This work discusses underpinning experiments through post-irradiation nuclear measurements derived from unique deuterium-tritium operations at JET, supported by international verification and validation efforts, including those within the SINBAD and JADE frameworks, and the IAEA FENDL nuclear data library.

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