Prediction of neutron source, tritium production and activation for long-pulse operation of the ITER Neutral Beam Test Facility

S J Cox, A Emmanoulidis, T T C Jones and M J Loughlin

EURATOM/UKAEA Fusion Association, Culham Science Centre, Abingdon, Oxfordshire, OX14 3DB, United Kingdom. Email: timothy.jones@jet.uk

As part of the safety analysis of the Neutral Beam Test Facility foreseen for ITER, a quantitative assessment of neutron production, component activation and tritium formation/accumulation is necessary. These key radiological factors determine the radiation shielding parameters, the hands-on maintainability of beamline components, and dictate the requirements for eventual licensing of the facility. Since a possible approach to the NBTF is to consider the beamline and ancillary equipment as parts of the first ITER injector, it is also important to be able to assess the transportability of the main components.

A Local Mixing Model (LMM)[1] has been utilised to compute the evolution of the hydrogen isotope content within the implantation zone of the CuCrZr target material of the beam-stopping elements, together with the beam-target fusion reaction rate calculated by taking account of the slowing-down of the 1MeV incoming projectile ion within the implantation layer. An important modification of the LMM code is to treat the tritium reaction product ions, resulting from D-D reactions, as a constituent of the incident beam. This is reasonable since the most probable tritium birth energy is close to 1MeV, the deuterium beam acceleration voltage, and this approach allows the source rate of 2.5 MeV and 14MeV neutrons to be estimated simultaneously. Although the treatment of tritium in the LMM is not ideal, it will be shown how this and other simplifying assumptions may be made which either do not significantly affect the predictions or ensure conservatism in the results. For example, it is shown that T→D “beam-target” reactions always dominate over those of D→T, which overcomes the problem of uncertainty, in the model, of the distribution of tritium trapped within the implantation layer; in contrast there is little uncertainty that this region will rapidly approach deuterium saturation for long-pulse (≤ 1hr) operation. Using the computed sources as input, neutronics and activation calculations for the NBTF components have been carried out using the MCNP/FISPACT codes both by UKAEA (in the present work) and by ENEA. As expected, long-pulse operational requirements lead to neutron activation and tritium production levels which have non-negligible but manageable radiological consequences.

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[1] H-D Falter *et al*., Proc. 17th Symposium on Fusion Technology, Rome (1992) p.481