SENSITIVITY AND UNCERTAINTY ANALYSIS FOR THE TRITIUM BREEDING RATIO OF A DEMO FUSION REACTOR WITH A HELIUM COOLED PEBBLE BED BLANKET

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The capability of a fusion reactor to breed enough tritium to reach self-sufficiency is described by the Tritium Breeding Ratio (TBR) which is estimated by means of Monte Carlo neutron transport calculations using codes like MCNP. These calculations utilize nuclear cross-section data which are associated with uncertainties. To propagate these uncertainties from the nuclear cross-section data to the final TBR uncertainty, sensitivity and uncertainty analysis is required. MCSEN, a patch to the MCNP code, employs such a method to the Monte Carlo transport technique. MCSEN has the capability to calculate the sensitivity of a specified nuclear response such as the TBR to multiple reaction cross-sections of an isotope in a single run. The sensitivity profiles provided in such a calculation and available covariance data are then used to calculate the TBR uncertainty with the Sandwich code.

For the Helium Cooled Pebble Bed (HCPB) concept, currently under development in the European Fusion programme as breeder blanket for DEMO, uncertainty analyses have already been performed for the tritium production in a mock-up of a single breeding blanket and a test blanket module designed for ITER. In this work, a TBR uncertainty assessment was performed for an entire fusion power plant of the European DEMO type.

To this end, a suitable 3D model of the DEMO reactor with HCPB blanket modules, as routinely used for blanket design calculations, was employed. The nuclear cross-section data were taken from the JEFF-3.2 data library. For the uncertainty analysis, the isotopes H-1, Li-6, Li-7, Be-9, O-16, Si-28, Si-29, Si-30, Cr-52, Fe-54, Fe-56, Ni-58, W-182, W-183, W-184 and W-186 were considered. The related covariance data were taken from JEFF-3.2 where available, and from FENDL-2.1 for Li-7, from EFF-3 for Be-9 and from JENDL-3.2 for O-16. For comparison purposes, covariance data from the TENDL-2014 library were used.

The analyses show an overall uncertainty of ±3.2% for the TBR when using JEFF-3.2 covariance data with the mentioned additions. The uncertainty is dominated by the uncertainties coming from the O-16, Li-6 and Li-7 cross-sections. When using TENDL-2014 covariance data, the uncertainty increases to ca. ±10%.