THREE-DIMENSIONAL NEUTRONIC ANALYSIS OF THE ITER IN-VESSEL COILS

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ITER vacuum vessel (VV) has Edge-Localized Mode (ELM) and Vertical Stabilization (VS) in-vessel coils. The main function of the ELM coils is to minimize the high power deposition in the divertor induced by ELM heating, as well as to control moderately unstable Resistive Wall Modes (RWM). The VS coils provide for the fast vertical stabilization of the plasma. In each VV sector there are three ELM coils for a total of twenty seven coils. The two VS coils are toroidal rings positioned above the upper port and below the lower ELM coil and each has four independent conductor turns. The recent option for both in-vessel coils consists of Stainless Steel Jacketed, Mineral Insulated Conductor (SSMIC) cooled by water circulating inside the hollow copper conductor. The two sets of coils are installed between the blanket modules and the outboard inner wall of the VV.

The assessment of the radiation fluxes and nuclear loads in in-vessel coils is important for their design and could be critical because the shielding provided by first-wall and blankets modules could be insufficient to guarantee their structural integrity and proper operation. The conditions are particularly severe in the parts of the coils behind the gaps between the first wall and blanket modules due to neutron streaming. One of the most critical issues is the damage induced by neutron irradiation on the insulator: the absorbed dose to insulator must be low enough to avoid degradation and the replacement within the whole life of the machine. For this reason high radiation resistant insulation materials such as compacted MgO powder or Spinel are under consideration. Moreover, neutrons induce the activation of the components and this is an important safety concern for radioactive waste management.

In the present study a complete neutronic analysis has been performed for the design of the in-vessel coil systems using the MCNP5 Monte Carlo Code in a full 3-D geometry. A detailed geometry of ELM and VS coils based on the last design specifications has been integrated into the last 40° ITER MCNP model (Alite-4). Reference volumetric DT plasma source has been used. Detailed spatial maps of nuclear heating and helium production of the coils, absorbed dose of the insulators, dpa and transmutation of copper-alloy and neutron fluxes have been calculated. Neutron spectra in 175 energy groups have been used as input for an activation analysis performed with FISPACT inventory code for the waste classification.

Implications of the results on the design of the systems and on safety issues are also discussed.