

Induced voltages and currents in copper and stainless steel core mineral insulated cables due to radiation and thermal gradients

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To reconstruct the shape and position of the plasma boundary of ITER, in-vessel magnetic coils will be employed, which will be exposed to radiation and temperature gradients. A study was undertaken to assess their impact on magnetic coil measurements and on other tokamak diagnostics employing mineral-insulated (MI) signal cables.

Thermally induced electromotive force (TIEMF) voltages in MI cables with Cu, stainless steel (SS) and Ni cores have been measured, before and after 16 hours' exposure to 305°C and 720°C. For the tests a scanning oven was used, establishing a well defined temperature profile (ranging from 20°C to 305°C). For fresh Cu core cables a fine structure in the TIEMF voltages was observed with amplitudes of a few μV ; for SS core cables, similar amplitudes were found, but the axial variations are smoother. The tested Ni core cables showed slow variations with amplitudes as large as 50 μV . After exposure at 305°C, hardly any change was observed. For Cu core cables exposed to 720°C, changes in Seebeck coefficient led to TIEMF voltage changes of the order of 1 μV . For the SS and Ni core cables, the changes appeared to be significantly larger.

Next, U-shaped sections of the Cu and SS core cables have been irradiated in the BR2 reactor up to a local thermal neutron fluence of about $1.5 \cdot 10^{20}$ n/cm². The cables were guided through a 25 cm long double wall tube to create significant temperature gradients during the irradiation.

The amplitudes of the various delayed contributions to the core-to-sheath currents can be attributed to the beta rays from activated Cu and Mn in the cables and their surroundings. The prompt current amplitudes depend strongly on the orientation of the rig inside the irradiation channel. During the first days of irradiation the prompt component amplitudes showed a drift. No correlation was observed between the core-to-core-voltages and the core-to-sheath current asymmetry.

Important core-to-core voltages were observed, which could be interpreted as due to the Seebeck effect with increasing Seebeck coefficients during the irradiation. For the Cu core cable the coefficient was found to increase proportionally to the neutron fluence, with a proportionality factor of $2.5 \cdot 10^{-21}$ ($\mu\text{V}/^\circ\text{C}$)/(n/cm²) which could be attributed to thermal neutron induced transmutation. For the SS core cable the coefficient saturated at a local fluence of about 10^{19} n/cm² and depended on the local temperature during irradiation.