ITER-like Thermal sensors for the Beam Line Components in MITICA and ITER HNB

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MITICA, the full-scale prototype of the NBI for ITER, is under procurement and is going to be installed and operated in Padova at the Neutral Beam Test Facility at Consorzio RFX.
MITICA will be equipped with several diagnostics to assess and optimize the beam production in the beam source and the beam transport in the beamline components of the ITER HNB injectors, which will have a reduced set of these diagnostics. Among this set, the thermal diagnostic is the main in vessel measurement for the protection and calorimetry of the Beam Source (BS) and the beam line components (BLCs).
About 700 thermal sensors will be mounted in MITICA with different technologies: thermocouples for distributed measurements on the in vacuum components, fiber Brag gratings (FGSs) as thermal sensors on high voltage biased panels of the BLCs. The full set of the thermocouples can be split into two groups: one foreseen only in MITICA and another one, called ITER-like and subject of this paper, common to both HNB and MITICA. In fact, the requirements about the vacuum compatibility and the radiation hardness to be satisfied in ITER NBIs are more constraining than in MITICA and hence the technical solutions adopted in the design of such sensors have been severely investigated.
The ITER-like thermocouples with isolated junction are Type N (Nicrosil-Nisil) without ferromagnetic materials to avoid errors due the strong magnetic fields expected in ITER. The tolerances are accordingly to the class 1 limits for the IEC 60584 standard. Mineral Insulated Cables (MICs) with MgO as insulating material and Inconel 600 for the metal sheath are mandatory to survive to the high neutron and gamma fluxes. These thermocouples are realized with an Ultra High Vacuum (UHV) compatible termination with ceramic/metallic bushing leak tight tested through helium bombing technique accordingly to 10-9mbar l/s, consistently with the large number of sensors and in accordance with the ITER requirements. The diameter of the MIC is 0.5mm with a sheath thickness of 0.08mm to get a reliable mechanical robustness, compact cabling and compliance with the requirements for remote handling operations.
The paper reports the technical specifications for the procurement of the full set of ITER-like sensors. All the manufacturing details are presented and all the tests carried out by Metrologie Srl, an accredited testing and calibration laboratory, are widely described and the results reported demonstrating that the majority of the ITER requirements are satisfied.