Strategy for the qualification of Eurofer97 structural material of the EU-TBM in ITER

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The structural material of the European test blanket module (TBM) is a reduced activation ferritic-martensitic (RAFM) steel namely Eurofer97 for both Helium Cooled Pebble Bed (HCPB) and Helium Cooled Liquid Lead (HCLL) concepts. These TBMs will be test in ITER project which is a nuclear facility and as such it needs to be licensed by the nuclear authorities. The design and the fabrication of the TBM are done following nuclear codes (RCC-MRx) and in accordance with the regulatory documents for (nuclear) pressure equipment (ESP/N).

With this development of ITER and the way toward such as IFMIF and DEMO, the material development has reached the next step that is the qualification of a new material for its integration in a nuclear design code such as RCC-MRx to facilitate the licensing procedure. One of its main achievements is the introduction of the Eurofer97 within the RCC-MRx 2012 edition and a dedicated material appendix A3.19AS already comprising few properties. The complete set of properties has to be integrated within this appendix and the related design rules identified in order to qualify the material and facilitated the licensing.

The qualification of a material such as Eurofer97 for a nuclear code necessitates broad testing campaigns to identify and to characterize its behaviour under large variety of conditions such as its physical properties, its mechanical strength, its time dependent properties like creep and fatigue behaviours, and its fracture toughness including the crack growth rate. All these properties have to be also identified under different neutron irradiation doses hence an important number of specimens required to be irradiated to take into account the substantial number of tests to be performed. Small Specimen Testing Technology (SSTT) becomes then essential for the qualification of Eurofer97 as the structural material of the TBM within ITER.

The development of the related design rules and codification necessitate first to identify the gaps in term of material properties and to define a development plan. Additionally the validity of the existing design rules of the code needs to be demonstrated for Eurofer97 and TBM components in the ITER fusion environment. Indeed the RCC-MRx code has been developed on the basis of austenitic steels. These rules have to be reviewed and possibly reconsidered and adapted to Eurofer97 because of its specificities such as low ductility, low cyclic softening, embrittlement and hardening with neutron irradiation. Also the TBM itself has its specific manufacturing and assembling techniques such as the use of HIP welding that need to be studied because they are not covered by the code.

The aim of this paper is to present the strategy and the work program of Fusion For Energy to achieve this qualification of the Eurofer97 structural material of the EU-TBMs with respect to the nuclear code RCC-MRx.