Ferritic-Martensitic Steel Test Blanket Modules: status and future needs for design criteria requirements and fabrication validation


DEN/DANS/DM2S/SERMA, CEA Saclay, F-91191 Gif-Sur-Yvette Cedex, France
Forschungszentrum Karlsruhe, P.O. Box 3640, D-76021 Karlsruhe, Germany
EFDA CSU Garching, Boltzmannstrasse 2, D-85748 Garching, Germany
CEA Saclay, DEN/CPT, F-91191 Gif sur Yvette, France
Kraftanlagen Nuklear Technik GMBH, D-69126 Heidelberg, Germany
ASSYSTEM, Energy&Nuclear, F-84120 Pertuis, France
CEA Grenoble, DRT/LITEN, F-38054 Grenoble, France

jfsalavy@cea.fr

One of the missions of ITER is to test mock-ups of DEMO-relevant breeding blankets, the so-called Test Blanket Modules (TBMs). Most TBMs proposed by ITER Parties make use of ferritic-martensitic steel as structural material. In this framework, Europe is developing two types of TBMs, a Helium-Cooled Lithium-Lead (HCLL) TBM and a Helium-Cooled Ceramic Breeder (HCCB) TBM, both using a 9%CrWVTa Reduced Activation Ferritic-Martensitic (RAFM) steel, called EUROFER, as structural material and Helium as coolant. From the structural point of view, these TBMs can be considered representative of all other RAFM TBMs proposed by the various Parties, covering almost all the operating conditions of these solid and liquid breeder concepts. The design of the TBMs is supported by detailed structural analyses. In parallel, a significant R&D program has been carried-out and is still on-going for the fabrication of the TBM steel box. These activities are mainly devoted to i) the fabrication using diffusion bonding of plates components with internal cooling channels and ii) the assembly by welding of those various plate components. The TBMs will be inserted in the ITER reactor and have to fulfil high standards of quality assurances required for reliable and safe ITER operation, in particular requirements in terms of Code and Standards (C&S). Moreover, TBMs will have to cope with French Regulations on Pressure Vessel Equipments, possibly in its nuclear extension. For example, the TBMs have to follow, when applicable, the ITER Structural Design Criteria for In-vessel Components (SDC-IC). Current SDC-IC version does not cover the manufacturing and inspection methods and the specific TBM structural material. After the presentation of the main features of the TBM designs, this paper reviews the status of the TBMs design and manufacturing with regards to the present SDC-IC. In particular, it identifies missing information (design rules, categories of welds, material properties, etc.). It also shortly reviews the bonding technologies (diffusion bonding, welding) under qualification or development, and the inspection and NDE techniques. It identifies existing standards (RCC-MR, EN, etc.) for qualification of these proposed techniques, necessary code cases. Finally, it preliminarily reviews the on-going R&D work on these subjects and identifies the remaining steps for qualification.