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The ITER TBM Program: A Pathway Towards Tritium Breeding Blankets For D-T Power Reactors

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In ITER, two dedicated equatorial ports are allocated for the TBM (Test Blanket Module) Program in order to allow the operation and testing of Test Blanket Systems (TBS) that are relevant mock-ups of tritium breeding blankets systems for fusion power reactors, using operation parameters typical for power reactors. The ITER baseline 2024 foresees two phases, DT-1 and DT-2. During DT-1, the plan is to operate four TBSs [1], namely:
—TBS-1: water-cooled lithium-lead TBS procured by EU.
—TBS-2: helium-cooled ceramic pebble TBS procured jointly by Korea and EU.
—TBS-3: water-cooled ceramic breeder TBS procured by Japan.
—TBS-4: helium-cooled ceramic breeder TBS procured by China.

Each TBS is formed by an in-vessel component where tritium is generated, called TBM, and by several subsystems (e.g., coolant system, tritium-extraction system, measurement systems). The four TBMs are inside the equatorial ports # 16 and #18, directly facing the plasma (two TBMs in each port) and the corresponding subsystems are located behind the ports in specific areas of the Tokamak Complex (see Fig.1).

Other types of TBSs could be operated during DT-2, for instance a dual-coolant lithium-lead type, and other TBM designs using different structural and functional materials.

After a general description of potential breeding blanket systems and of the selected TBSs for DT-1, the presentation addresses some examples of on-going R&D and the associated technical information that can be obtained in support of DEMO breeding blankets development, such as, for instance, the development of the Reduced-Activation Ferritic/Martensitic (RAFM) steels as TBM structural materials, the development of codes and standards, the approach to pressure equipment implementation and to the tritium management, the development of specific measurements and control systems. These technical outcomes can be obtained already in the on-going TBS design phase to be completed by 2029 and continue during the manufacturing phase, until installation planned to start in 2035. The four DT-1 TBSs will start operation in 2039 and will operate for about ten years.

It will also be shown that TBS operations during DT-1 will allow to achieve the main top-level testing objectives for each TBS, provided that the ITER operational scenarios implement some minimal operational requirements specific for the TBM Program. Starting from the top-level testing objectives, several measurable “general Campaign Testing Objectives (gCTO)”have been identified. They cover each of the five DT-1 campaigns and are applicable to all TBSs. The achievement of these objectives will give useful information also for other types of TBSs and the corresponding results would be a useful support to the specific modelling activities that are under development for the characterization of tritium breeding blankets for DEMO reactors.

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