The ITER Tungsten First Wall

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1 Introduction

At the heart of the ITER 2024 baseline is a switch of the armour material of the First Wall (FW) from Beryllium to Tungsten and the introduction of a new “Start of Research Operations” (SRO) phase with an inertially cooled First Wall [1][2][3]. This paper reviews the associated engineering tasks and challenges in the ITER First Wall that are incurred as a result of the new ITER baseline.

2 Introduction of the Temporary First Wall

To enhance the robustness of the ITER machine, a ‘Start of Research Operations (SRO)’ will include the installation of a passively cooled First Wall. This allows a learning phase to early ITER operations that is more forgiving to disruptions, resulting in reduced risk of a water leak in-vessel that would hinder subsequent DT operations. This “Temporary First Wall” (TFW) will mimic the actively cooled First Wall in material, geometry and interfaces, with a shape and structure that is intentional alike to its successor in later ITER operations of DT-1 and DT-2 (see Figure 1). This new system, like the FW, will experience different loading depending on its position in the machine. Correspondingly, the TFW design includes a mixture of potential plasma-facing design types, including bulk Tungsten blocks, Tungsten heavy alloy, and Tungsten-coated steel (see Figure 2). The Tungsten coating on steel will be a relatively novel technology for fusion application with up to 300 m^2 of exposed surface area to the plasma. A robust coating qualification plan is therefore underway: first by cyclic transient loading and high heat flux testing (via electron beam), and second by ITER-relevant loading of large areas in tokamak(s). A considerable design challenge for the TFW will be its tolerance to the anticipated high expected transient loads of the SRO phase, especially in the current quench phase during disruptions and runaway electron events. Modelling of these loads and their impact is underway to assist in the design development of the TFW that can enable successful completion of the ITER research plan for SRO [5] while providing investment protection for the project.

3 Transition to a Tungsten First Wall for DT operation

The First Wall armour material change from Beryllium to Tungsten facilitates many positive consequences (such as elimination of beryllium specific toxicity, lower erosion rate, and higher melting temperature) [4]. However, the advanced state of the Blanket System design, qualification, and manufacturing, requires careful efforts and re-development to integrate the new armour into the final design.

The change of material is also accompanied by a desire to resolve a long-standing concern of runaway electron damage, for which a thicker armour layer is proposed in the impacted areas. This material change together with the increased (local) thickness requires an adaptation in the design of each panel type to re-align all panels to a new position. As more than half of all the shield blocks, on which the first wall panels mount, are fully manufactured, the re-alignment of panels is done by the addition or removal of thickness in the FW panels (see example in Figure 3). The change to tungsten has as well benefits to the design, with a considerably higher melting temperature relative to beryllium, and as well a theoretically more robust bond between the armour and the copper alloy heat sink. These together permit potential design simplifications and demand a re-evaluation of the tolerance requirements of all panels, which are all based on a beryllium armour. While several full-scale prototypes of the beryllium First Wall panel have been completed, work is now underway for re-production of similar tungsten-armoured representative mock-ups to demonstrate the performance of newly developed technology. This qualification work is proceeding in parallel with on-going factory manufacturing of stainless steel and copper alloy parts of the First Wall, making the finalization of the Tungsten First Wall a delicate balance to design, qualify, and manufacture simultaneously.

4 References

[1] P. Barabaschi et al. , submitted to Fusion Eng. And Design 2025.
[2] R. A. Pitts et al., Nuclear Materials and Energy **42** (2025) 101854
[3] P. Barabaschi et al., this conference.
[4] A. Loarte et al., this conference.
[5] S. Deshpande et al., this conference.

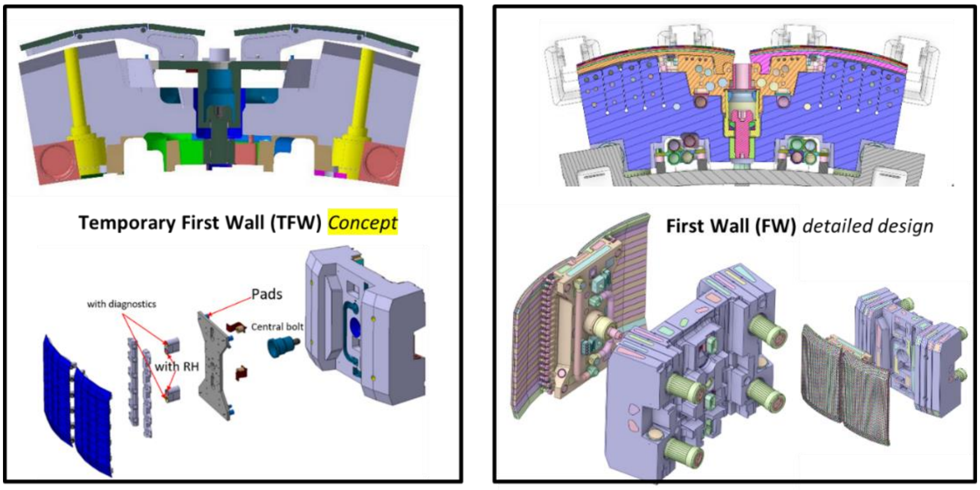

Figure 1. An early design concept of the Temporary First Wall (at left) compared to the actively cooled First Wall (at right).

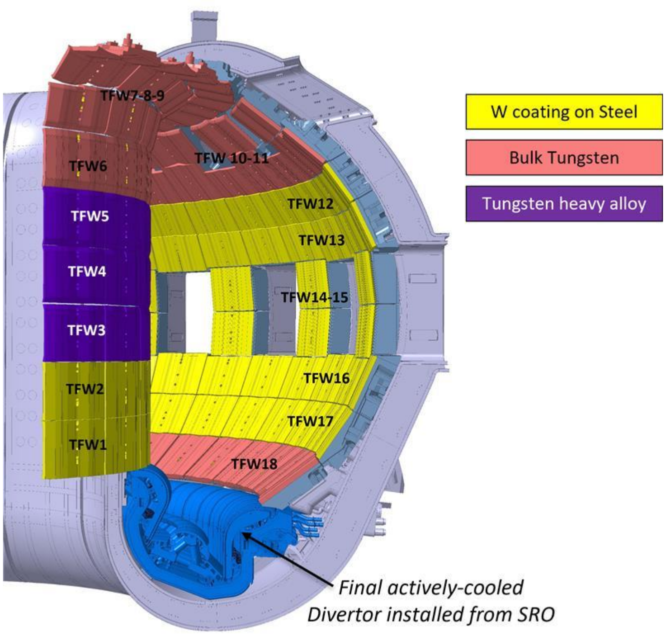

Figure 2. The Temporary First Wall, installed for the Start of Research Operations, color-coded by the expected design types of bulk tungsten, tungsten heavy alloy, and tungsten coated steel.

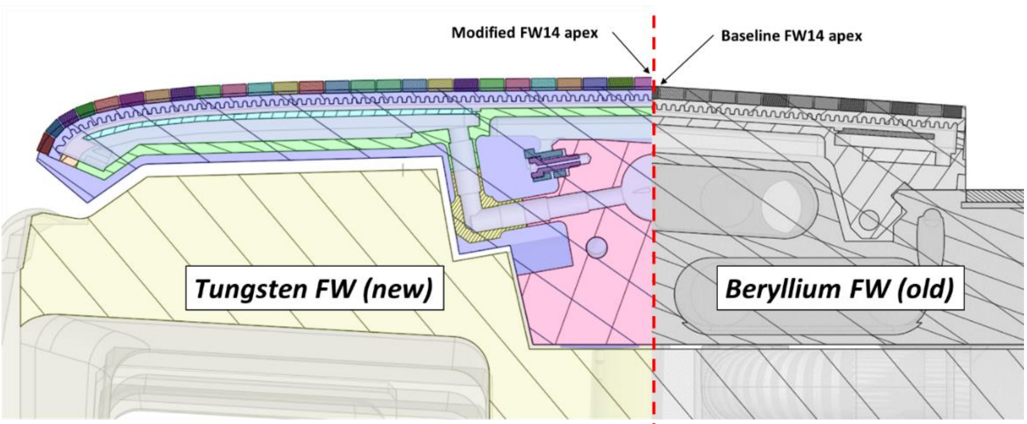

Figure 3. An example design modification of an actively cooled First Wall panel to adapt to combined changes of armour material, armour thickness, and