Fusion Engineering and Design 87 (2012) 1347–1351

Contents lists available at SciVerse ScienceDirect

Fusion Engineering and Design

journal homepage: www.elsevier.com/locate/fusengdes

Progress in the integration of Test Blanket Systems in ITER equatorial port cells and in the interfaces definition

R. Pascal[a,*], S. Beloglazov[a], S. Bonagiri[a], L. Commin[b], P. Cortes[a], L.M. Giancarli[a], C. Gliss[a], M. Iseli[a], R. Lanza[a], B. Levesy[a], J.-P. Martins[a], J.-C. Nevière[a,c], L. Patisson[a], D. Plutino[a], W. Shu[a], H.L. Swami[d]

[a] ITER Organization, Route de Vinon sur Verdon, 13115 Saint Paul Lez Durance, France
[b] CEA, IRFM, Cadarache, France
[c] Comex-Nucleaire, 13115 Saint Paul Lez Durance, France
[d] Institute for Plasma Research, Bhat, Gandhinagar 382428, India

ARTICLE INFO

Article history:
Available online 10 May 2012

Keywords:
Breeding blanket
TBM
TBS
ITER

ABSTRACT

In the framework of the TBM Program, three ITER vacuum vessel equatorial ports (#16, #18 and #02) have been allocated for the testing of up to six mock-ups of six different DEMO tritium breeding blankets. Each one is called a Test Blanket System (TBS). A TBS consists mainly of the Test Blanket Module (TBM), the in-vessel component facing the plasma, and several ancillary systems, in particular the cooling system and the tritium extraction system. Each port accommodates two TBMs and therefore the two TBSs have to share the corresponding port cell. This paper deals with the design integration aspects of the two TBSs in each port cell performed at ITER Organization (IO) with the corresponding definition of interfaces with other ITER systems. The performed activities have raised several issues that are discussed in the paper and for which design solutions are proposed.

1. Introduction and definitions

The design, manufacturing, installation and operation of 6 Test Blanket Systems (TBSs) in ITER machine is part of the TBM Program as it is described in detail in ref [1,2]. The ITER Members TBM Teams are responsible for the definition of the testing plan, the definition of the technical specifications, design, manufacturing and delivery of the TBSs. For the functional and physical interfaces with other ITER systems and buildings, the IO is in charge of the design integration [3]. Within the ITER project, a TBS is defined as the Test Blanket Module (TBM), the in-vessel component facing the plasma and producing tritium, and several ancillary systems (such as cooling systems, tritium extraction systems, coolant purification systems, and instrumentation and control (I&C) systems).

Three ITER equatorial ports (#16, #18 and #02) will host a TBM port plug (PP), which includes two TBM-sets. Each TBM-set consists of one TBM and one TBM-shield associated with each TBM. Both TBM-Sets are attached to a thick water-cooled stainless steel structure called TBM frame, which is plugged into the vacuum vessel port extension. The TBM frame and both TBM-shields close the vacuum vessel and therefore are part of the ITER first safety barrier and also ensure neutron shielding.

Each TBM-shield is crossed by all inlet and outlet fluid pipes feeding its associated TBM and tube(s)/cable(s) for TBM diagnostics. From the back side of the TBM, the pipes cross the TBM-shield and they go to the port cell (PC) where they are connected to the corresponding components located in the so-called Ancillary Equipment Unit (AEU). Several pipes leave the AEU and run to the other cooling system components and tritium system components located in other parts of the tokamak complex building.

Since two TBSs share one port, both TBSs must share the area of the PC taking into account the presence of other IO systems components. Each PC is divided in two parts by the bioshield plug: (i) inside the bioshield, the port interspace (PI) that is crossed by the TBSs pipes arranged in a component called Pipe Forest (PF), and (ii) outside the bioshield, the remaining part that hosts the TBS AEU, see Fig. 1.

Following the various plasma operation phases, several versions of each TBM are planned to be tested with different testing objectives. During the long term maintenance (LTM) shutdowns, about 8 months of duration, the AEU, bioshield plug and PF are disconnected and moved from the PC to the hot cell facility (HCF) in order to clear the path for the remote handling (RH) cask movements. Indeed, the RH equatorial transfer cask system (ETCS) needs access to the back of the TBM PP for removing it and bringing it to the HCF. Then, the RH cask brings back from the HCF a new TBM PP and plugs it into the VV Port [4]. AEU, bioshield plug and PF are then reconnected. Because of the planned regular TBM PPs replacements, the AEU, bioshield plug and PF need to be removable, see Fig. 2.

* Corresponding author. Tel.: +33 442176969; fax: +33 442257366.
E-mail address: romain.pascal@iter.org (R. Pascal).

0920-3796/$ – see front matter © 2012 ITER Organization. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.fusengdes.2012.03.010

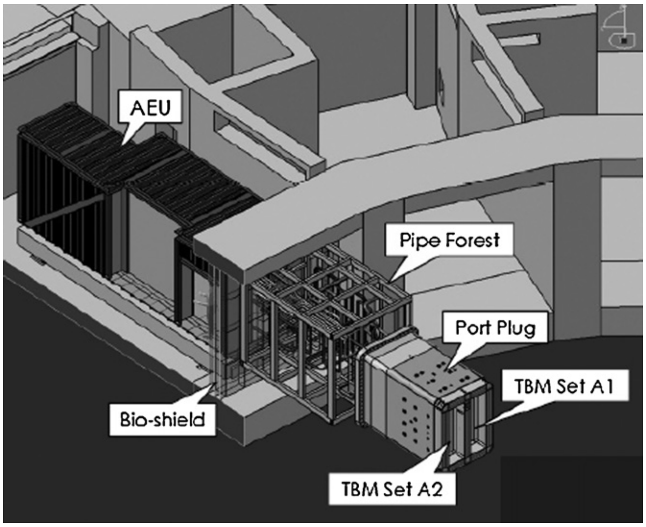

Fig. 1. View of the AEU, bioshield plug, PF and of the TBM PP.

In the next section, the PF and bioshield plug designs are addressed, their interfaces with building concrete as well. Then, the integration and design of the AEU is presented. Some additional integration items around the AEU are detailed. In the second section, the issue related to management of the heat and tritium in the TBM port cell is described. Main driver keys for the studies needed for solving this issue are presented.

2. Integration of the 2 TBS in the port interspace area

The design of some ITER systems interfacing with TBSs is in advance of the TBSs design and the design of ITER buildings is also completed. Therefore, most of the TBSs interfaces have to be defined and fixed, in particular those with the tokamak complex building and the liquid and gas systems. For this purpose, IO has developed in the ITER machine digital mockup the integrated design of the AEU, bioshield plug and PF. The same design principle and choices are applied to all the TBM port cells, even is some specificities (e.g. the number of pipes) will be added at a later stage for each of them.

2.1. PF and bioshield plug design

The PF is an assembly made of a self-supporting frame and a bundle of pipes/tubes feeding two TBMs. The pipes are supported on the structure and are surrounded by a thermal insulator to limit the heat release due to their high temperatures ranging between 280 °C and 500 °C. The PF frame is made of bolted and welded steel beams and steel plates at the bottom to sustain pay loads, see Fig. 2.

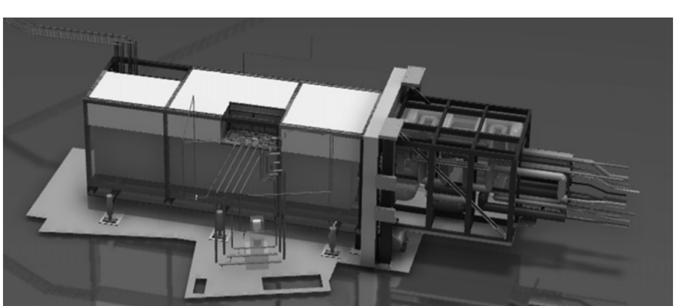

Fig. 2. Close view of the AEU, bioshield plug and PF and some interfaces in the port cell.

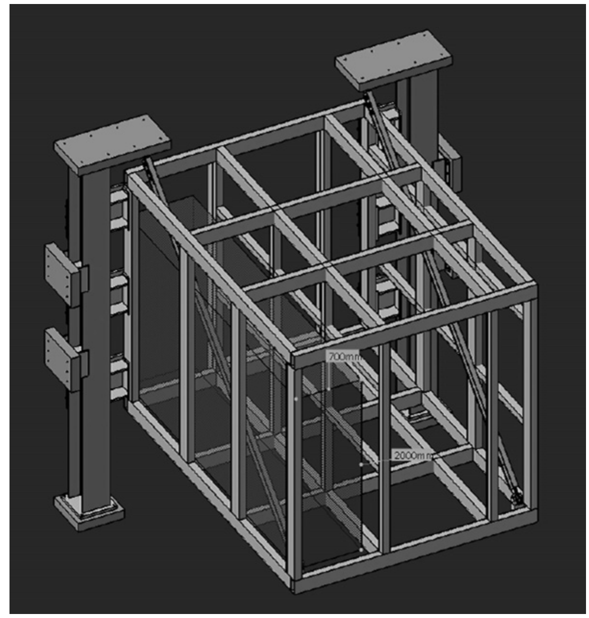

Fig. 3. View of the cantilevered PF frame, access corridor in the PF and PF supports.

Within the PF frame a corridor of 2 m height and 0.7 m width is reserved for human access in order to perform maintenance operations (e.g. installation of hands-on assisted automatic tools, cleaning, move of a robotic arm, etc.), see Fig. 3. The dimensions of the access corridor are compliant with the today nuclear industry practices.

The PF frame is fixed cantilevered with 6 attachments to two vertical steel beams that are bolted to 8 steel plates, which are embedded into the building concrete. The two beams are permanent components that will therefore be submitted to the ITER lifetime neutron fluence, see Fig. 4. The seismic loads (SL-2 level) induced by the PF on the embedded plates through the vertical beams have been conservatively estimated in order to define the corresponding loads to the building. It has been assumed that the

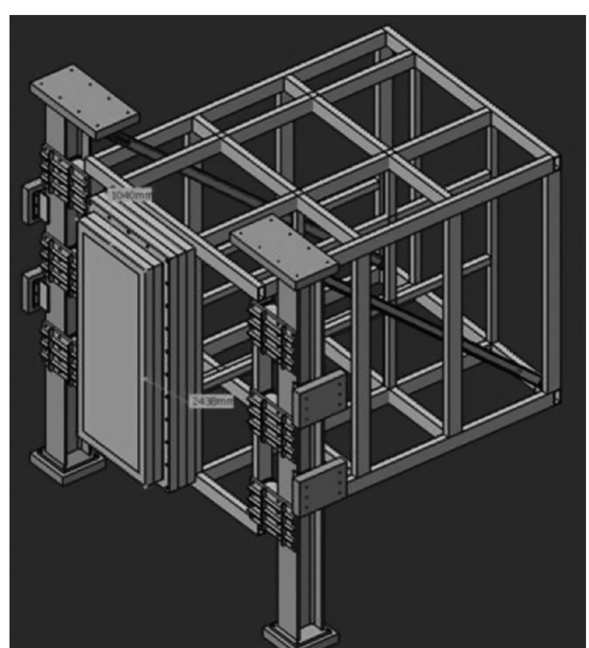

Fig. 4. View of the PF frame and part of the bioshield plug.