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Finalization of the conceptual design of the auxiliary circuits for the European test blanket systems

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ABSTRACT

In view of the ITER conceptual design review, the design of the ancillary systems of the European test blanket systems presented in [1] has been updated and made consistent with the ITER requirements for the present design phase. Europe is developing two concepts of TBM, the helium cooled lithium lead (HCLL) and the helium cooled pebble bed (HCPB) one, having in common the cooling media, pressurized helium at 8 MPa [2]. TBS, namely helium cooling system (HCS), coolant purification system (CPS), lead lithium loop and tritium extraction/removal system (TES–TRS) have the purpose to cool down the TBM and to remove tritium to be driven to TEP from breeder and coolant. These systems are placed in port cell 16 (PC#16), chemical and volume control system (CVCS) area and tritium building. Starting from the pre-conceptual design developed in the past, more mature technical interfaces with the ITER facility have been consolidated and iterative design activities were performed to comply with design requirements/specifications requested by IO to conclude the conceptual design phase.

In this paper the present status of design of the TBS is presented together with the preliminary integration in ITER areas.

1. Introduction

Fig. 1 presents the adopted breakdown [3]. The subsystems of the EU TBSs (HCPB and HCLL concepts integrated in equatorial port #16) can be divided in three parts: specific SubSystems (SSs) for the HCPB, specific SSs for the HCLL TBS and common SSs [1,2].

The “HCPB specific SSs” are the HCPB helium coolant system, the HCPB tritium extraction system, the HCPB coolant purification systems and the HCPB data acquisition and control system (DACS).

The “HCLL specific SSs” analogous systems are the HCLL HCS, the HCLL CPS and the HCLL DACS. To this list few HCLL specific SSs are added, namely the Pb–Li Loop and the Tritium Removal Systems, considering that the tritium extraction system is based on the circulation of lead lithium in a specific component named Tritium Extraction Unit.

2. Subsystems design description

2.1. HCS design

According to the current PBS, the HCS is the TBS subsystem that transports the heat deposited or generated inside the TBM from the blanket to the component cooling water system (CCWS) of ITER, at the same time, maintaining the coolant at pressure levels and temperatures that ensure the proper operation of the TBM [4].

In the case of the two EU-TBMs, helium has been selected as coolant. With around 1 MW of power to be transferred from the blanket to CCWS-1 cooling system, the HCS needs about 1.3 kg/s of helium at 8 MPa. In addition to that, the mechanical performances of the TBM structural material (EUROFER-97) as well as the breeding process determine a certain operating temperature window for

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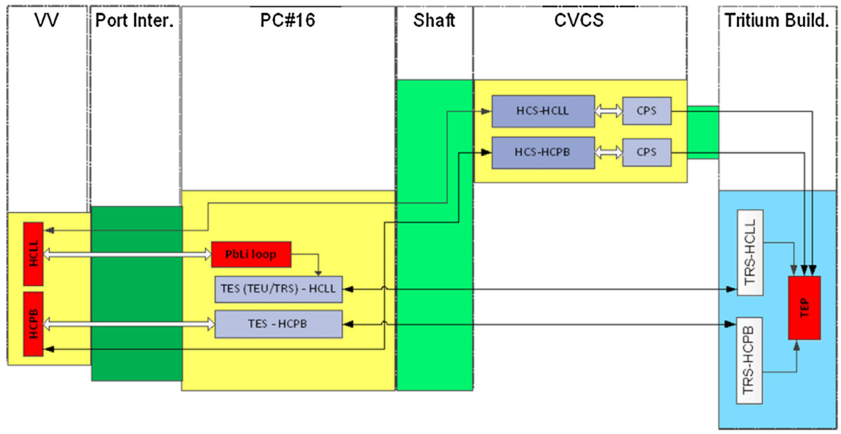

Fig. 1. Schematic view of HCLL and HCPB TBS.

the helium. For the EU-TBMs, this temperature window is defined between 573 K (TBM inlet) and 773 K (TBM outlet).

For the HCS, the reference structural material is austenitic stainless steel AISI 316L. The PFD of HCLL/HCPB HCS is shown in Fig. 2.

The loop has the shape of an “eight” with the TBM installed on the high temperature side and the helium circulator on the low temperature branch. A cooler (HX-1001), located before the helium-circulator, reduces the helium temperature to a level that ensures the proper operation of the circulator (50 °C). At the same time, the cooler acts as heat sink for the whole HCLL TBS.

In order to increase the reliability and availability of the loop, the current design foresees two identical helium-circulators (PB-1001-2) operating in parallel. Each of the two circulators is designed to provide the requested flow rate for cooling the TBM independently. In addition to this, in order to reduce the risk of fouling and erosion inside the circulator, the design foresees the installation of two dust filters directly at the inlet of the circulators.

The current design of the TBM requires around 1.3 kg/s for the cooling of the FW while for the cooling of the internals (stiffening grid and breeder units) only a fraction of this flow (∼60%) is

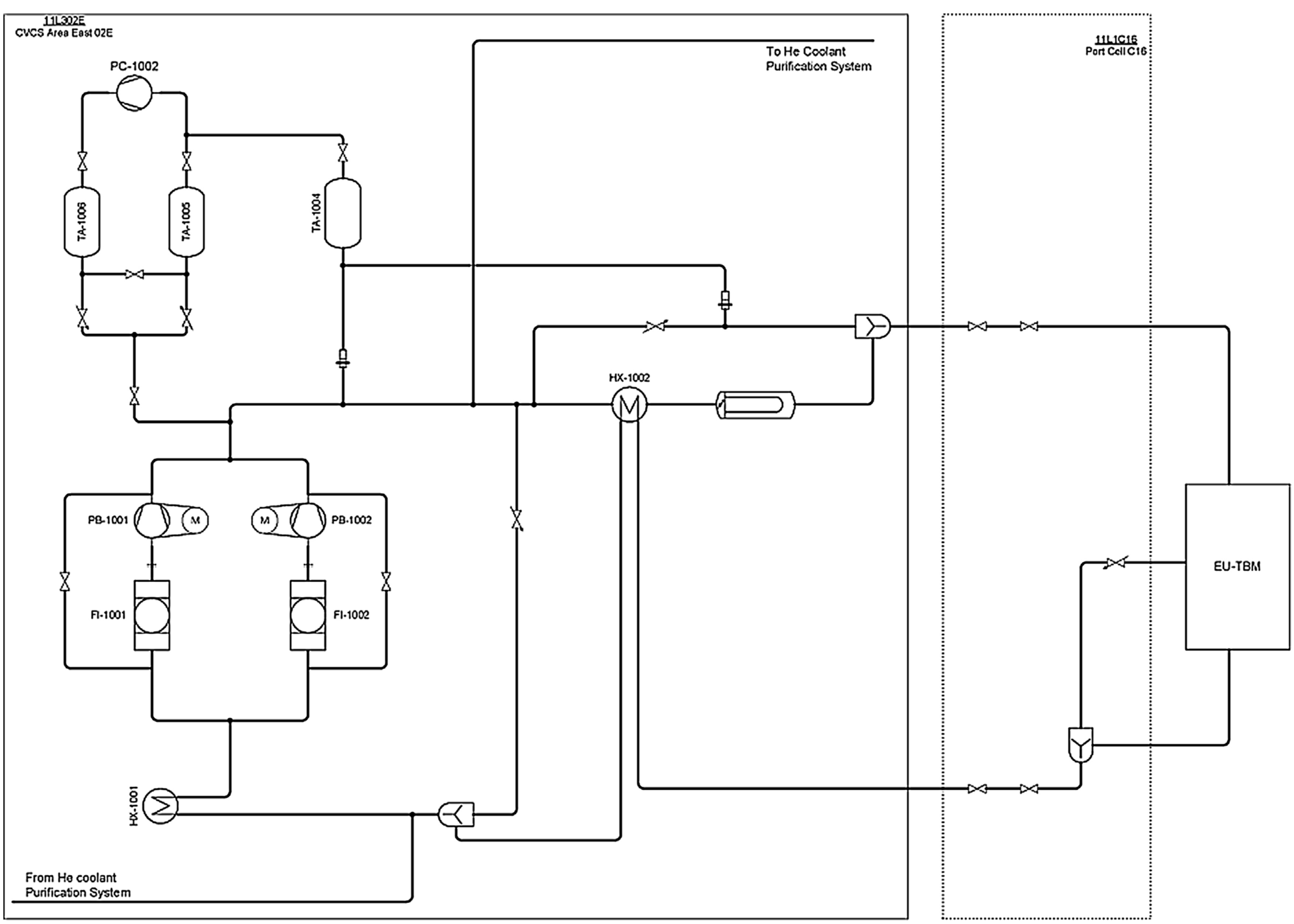

Fig. 2. HCS process flow diagram.