Technical Note for the Market Survey on the Final Design & Procurement of TAS & TES for the WCLL & HCCP TBSs

In preparation of Call for Tender

Contents

1. Scope of the document

Fusion For Energy (F4E) is launching a Market Survey in preparation of a Call for Tender (CFT) on the Final Design and Procurement of Tritium Extraction System (TES) & Tritium Accountancy System (TAS) of the Water Cooled Lithium Lead (WCLL) & Helium Cooled Ceramic Pebbles (HCCP) Test Blanket Systems (TBS).
The two Gloveboxes, one for WCLL-TBS and one for HCCP-TBS, are also included in the scope of this CFT.

This Technical Note provides supporting information so that interested companies can answer the survey with a minimum of background.

2. Description of TAS and TES, including the Gloveboxes

a. Introduction

The ITER project aims to build a fusion device, twice the size of the largest current devices, with the goal of demonstrating the scientific and technical feasibility of fusion power. Future fusion reactors (DEMO) after ITER will need to generate the tritium (T) consumed in the deuterium-tritium (D-T) reactions and to extract the thermal and neutronic power deposited in components surrounding the plasma. These functions will be ensured by a so-called Tritium Breeding Blanket (TBB) covering the inner side of the vacuum vessel and directly facing the plasma. These TBBs will be tested in ITER under the form of Test Blanket Modules (TBMs) located in equatorial ports of ITER. Four TBS concepts are planned to be tested in ITER, among which two are developed under the responsibility of F4E: WCLL and HCCP, the latter being developed in coordination with ITER KOREA. Each TBS is constituted by several sub-systems among which the tritium related sub-systems (Tritium present as traces (ppm levels) in the TBM process effluents):

- TES, for extraction, recovery, concentration and delivery to TAS of the tritium generated in the breeder material;
- TAS, for tritium accountancy before delivering tritiated streams to the ITER Tritium Plant systems.

All the components of TES and TAS are classified ITER Quality Class 1 and are subject to Pressurized Equipment Directive (PED) and ESPN. Most of the components of TES and TAS are SIC-2 (Safety Important, with respect to the confinement function) but some are SIC-1. They should be designed, fabricated, qualified, inspected and maintained in accordance with the selected codes and standards. For Quality and Safety Class information, please refer to F4E documents QA-115 and QA-113 publicly available at F4E industry portal.

Among other possibilities, the RCC-MRx 2018 could be selected as the applicable design and construction code. The Supplier will possibly be the Regulatory Manufacturer for the PED and ESPN components and/or for the assemblies but a final decision in this regard will be made later.

The main components, common or not to TES and TAS, are:

- Getter Beds, for hydrogen isotopes concentration and extraction;
- Adsorption beds, possibly with zeolites as adsorbent material, for tritiated water extraction
- Q_2O (Q=H,D,T) reducing bed;
- He Circulators;

- Piping and safety isolation valves;
- Ionization Chambers, for on-line dynamic accountancy of tritiated gas;
- Sensors and related control system

The TES & TAS components are made of 316L stainless steel.

b. Tritium Extraction System

The main function of TES is to extract, concentrate and deliver to TAS the tritium generated in the breeder material.
TES operates at low pressure and low temperature, at around 3 barg at room temperature. During regeneration of the getter beds and Q_2O adsorption column, some of the components operate at a maximum temperature of 400 °C.
TES is partly located in Port Cell #16 (11-L1-C16), where it is assembled within the Ancillary Equipment Unit (AEU) Structure, and partly into Tritium Process Room (14-L2-24), where it is assembled within a Glovebox.

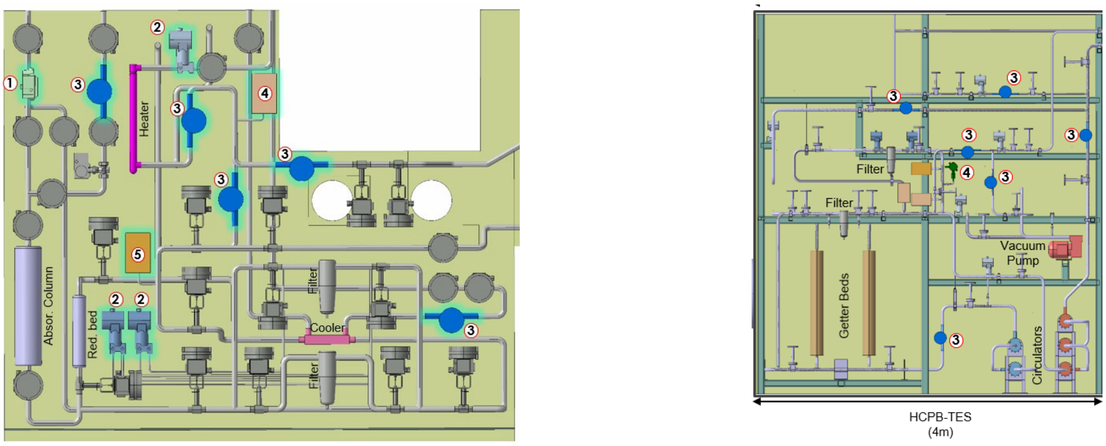

Figure 1 - TES Components (Left: in the AEU; Right: in the Glovebox)

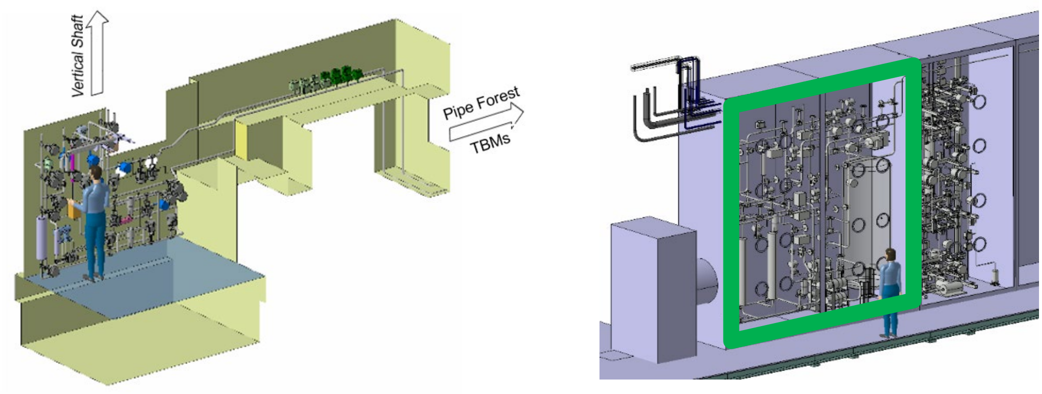

Figure 2 - CAD model for TES (Left: in the AEU; Right: in the Glovebox –see green shape-)

c. Tritium Accountancy System

The main function of the TAS is to provide an accurate tritium accountancy and to route the tritium effluents towards the storage facility.
TAS shall ensure a reliable and safe operation, which consists of a tritium accountancy with very short measurement times, ideally real-time monitoring. As a target, 5% accuracy would allow the comparison between the measurement and the modelling.

TAS performs tritium accountancy on low pressure and low temperature TBS effluents, ranging from 1 to 1.2 barg at room temperature. During regeneration of the Getter Beds, the components operate at a maximum temperature of 400 °C.
TAS is entirely located in the Tritium Process Room (14-L2-24), sharing the glovebox with TES.

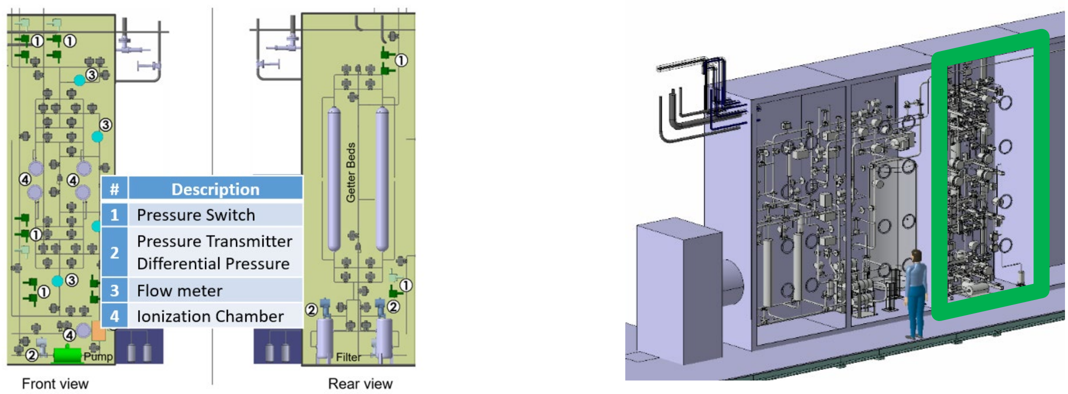

Figure 3 - CAD model for TAS (Left: components; Right: in the Glovebox–see green shape-)

d. Glovebox

The glovebox is located in the room 14-L2-24 (Tritium Process Room - TPR). In these gloveboxes are located part of the equipment of TES, the equipment of TAS and also the Neutron Activation System (NAS). They are part of the Primary Confinement System, used as a Second Barrier around the Primary Confinement First Barrier components, so called the process system.
The selected Codes & Standards are listed below:

- AGS-G006-2017, “Standard of Practice for the Design and Fabrication of Nuclear-Application Gloveboxes (American Glovebox Society).” July 2017
- ISO 10648-1:1997, ISO 10648-2:1997
- ISO 11933-1:1997, ISO 11933-2:1997, ISO 11933-3:1997, ISO 11933-4:1997, ISO 11933-5:1997

The general classifications for the gloveboxes are shown in the below table.

Table 1 - Glovebox Classifications

Component	TAG	Safety Class*	Seismic Class	Quality Class	Tritium Class	Remote Handling	Vacuum Class
Glovebox	GB-0001	SIC-2	SC-1(S)	QC1	TC-1B	Non-RH	No VQC

* During Seismic event SL-2 or Fire, the Gloveboxes do not have to ensure the confinement function.

The detritiation of the glovebox atmosphere is a basic function to be implemented in the the glovebox. For this, the glovebox is connected to the Detritiation System of the Tritium Plant for the

evacuation of the tritium. The glovebox enclosure shall maintain a maximum depression relative to the TPR of 250 Pa. The tentative leak rate is in the order of 0.01% volume/h.
The glovebox atmosphere is an inert dry nitrogen atmosphere at a normal working temperature range between 10 °C and 30 °C. The nitrogen will be supplied by PBS 65 with a purity of 99.99%.

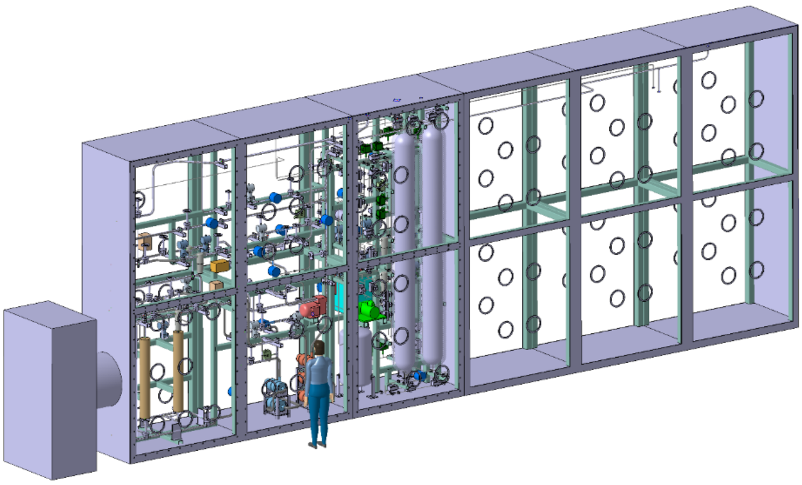

Figure 4 – Glovebox (Left: TES & TAS; Right: Placeholder for NAS)

e. Logistics

Transport of TES and TAS, very likely in a pre-assembled form, from the supplier site to the ITER site will be within the scope of this contract.

The possibility to provide support in the assembly phase inside the ITER facilities will have to be evaluated in the future and clarified in the technical specification of the contract.

3. Scope of the future Call for Tender

The scope of delivery is based on a Preliminary Design approved by IO and provided by F4E to the Supplier. The provisional scope of the contract includes:

- Preparation of the Final Design
- Execution of the Final Design Review (FDR) with the participation of Experts from F4E, ITER Organization and external experts;
- Production of manufacturing drawings and plans;
- Execution of the Manufacturing Readiness Review (MRR) with the participation of Experts from F4E, ITER Organization and external experts;
- Manufacturing and procurement of all components, including sensors and I&C system;
- Factory testing and delivery to ITER Site at Cadarache (F);
- Option: On Site Assistance to IO during Installation and Commissioning.

F4E will provide detailed input to the Supplier, like the system requirements, the load specification, documentation covering different elements of design, engineering analyses including RAMI, developed at a maturity level corresponding to the Preliminary Design.

It is relevant to indicate here that the preparation of the Final Design Review, to be approved by the Nuclear Operator (ITER Organization), will require the finalization of a large documentation package, whose basis is the outcome of the Preliminary Design Phase.

4. Technical and Industrial Capacity

The potential supplier is expected to be experienced in:

- Manufacturing of PED and nuclear components;
- Engineering aspects of processing radioactive fluids;
- Integration engineering;
- Clean environment manufacturing.

5. Risks

The main challenges (high level risks) will be:

- Integration of the AEU equipment due to the limited space available;
- Implementation of the maintainability provision in the design;
- Final design and integration of advanced technologies like Ionisation Chambers, Getter Beds with ZrCo, Mass spectrometer, Gas chromatograph (R&D ongoing with EUROfusion: experimental characterization);
- Definition of the interfaces with IO interfacing systems.

The Supplier must provide information on the parts of the contract which are intended to be subcontracted.

6. Schedule

The main tentative dates and duration of the current planning are indicated below. Due to the current re-baseline, they cannot be accurate:

- F4E plans to launch a Call for Tender in 2025. The contract is foreseen to be signed by in Q2 2026, in connection with the PDR approval.
- The Final Design Review phase is foreseen to last around 1,5 years.
- The procurement and delivery is foreseen to last around 5 years.

7. Market Survey

Please answer to the F4E Market Survey by clicking on this link

LINK TO THE MARKET SURVEY