

## **5 Test Blanket Modules (TBM)**

### **5.1 Functions, Basic Configuration and System Boundaries**

Three of the equatorial ports (1, 2 and 18) are dedicated for blanket test modules. The EU and JA ceramic He-cooled modules with horizontal orientation will use the Port 1. The upper part is for the EU, the lower for JA. The RF Li self-cooled and He-cooled modules with vertical orientation will use the Port 2. Port 18 will be used by the EU Pb17Li and JA ceramic water-cooled modules with vertical orientation.

The ports may accommodate modules with the face cross section up to 1310 mm wide x 1760mm high. Cooling equipment for Li, Pb17Li, and the RF He-cooled TBMs will be located in containers in ports or in front of ports. Cooling equipment for water and other He-cooled modules will be located in the TCWS vault.

The tritium measuring equipment for all modules will be located in containers in front of ports. The secondary heat exchanger for the RF-He TBM may be outside of the TCWS vault. The pressure suppression tank for the water-cooled JA TBM may be also outside the TCWS vault. All tritium removal equipment may be installed in Tritium building

### **5.2 General Requirements**

#### **5.2.1 Cooling/ baking requirements.**

The test modules shall be designed to use for heat rejection the pressurized water system of the shielding blanket with the following parameters: nominal pressure of 3.0 MPa at normal operating conditions and inlet temperature 100°C. The water flow and temperature control shall limit the coolant inlet-outlet temperature difference to 50°C for normal loads. The first wall shall be baked as other blanket modules at the maximum temperature of 240C.

#### **5.2.2 Mechanical Requirements**

The Test Blanket modules inside a port must be contained in a “frame”, which provides a standardized interface with the ITER basic structure and provides thermal isolation from the basic machine.

A water cooled shield must be located behind the TBMs and the frame to assure neutron protection for the vacuum vessel and magnets and to reduce the neutron load at the VV boundary to allow hand-on access outside the VV boundary.

The mechanical interface with the ITER machine will be provided by the port closure plate). This plate is supported by the vacuum vessel port extension.

The plumbing which extends through the VV closure plate up to the cryostat boundary, is considered also as a part of the test blanket subsystem (TBS). All the VV plug penetrations must have rigid connection and must not require vacuum-tight flexible connections such as bellows. This arrangement enables the whole TBS (TBMs, frame, shield, VV plug and plumbing) to be a self-contained unit that may be installed and removed as a single piece

without remote handling operations inside the VV port extension. This assembly must be completely assembled and tested prior to installation

The TBM structural connections shall use remote handling compatible connectors, accessible from the back side.

### 5.2.3 Electrical Requirements

The test module shall be electrically connected to the frame with an electrical connector, and through the coolant and purge gas pipes.

### 5.2.4 Remote Handling Requirements

The test blanket module shall be designed for full remote replacement.

The weight of a TBM (without weight of coolant) must be limited to 2 t. Test Blanket Modules will not be repaired but just refurbished or replaced in the hot cell. The hot cell may be used to replace irradiated test modules but it is not designed for post-irradiation studies of the test modules.

The weight of the integrated structure consisting of TBM/Frame/Shield plug to be carried in a transfer cask and installed on the machine must be limited to 40 t.

Welded joints within the plasma chamber and the vacuum vessel extensions shall be done, repaired, and leak tested remotely. Remote coolant draining shall be possible..

Assembly and maintenance tools shall be provided for the structural attachment of the test blanket article:

- a. For welded connections:
  - Wall thickness Up to 7 cm
- b. For pipe welding, cutting, inspection, and leak testing:
  - (i) Cooling pipes
    - Pipe size 5 to 10 cm OD
    - Wall thickness Up to 8 mm
    - Position From inside pipe (inside the VV boundary)
  - (ii) He purge gas lines and instrumentation
    - Be capable of joining, cutting, and leak testing the 0.5 to 2 cm diameter pipes required for the tritium purge gas lines and instrumentaion.

Gripping points must be provided on all replaceable components or assemblies, capable of supporting their full weight over the full range of motion required for installation and removal.

### 5.2.5 Assembly Requirements

To help protect the first wall of the TBM, it can be recessed below the adjacent shielding blanket first wall and, thus, will not have an explicit requirement for alignment to the magnetic surface.

## **2.5.6 Instrumentation & Control Requirements**

The TBS must provide independent instrumentation with data connection through a local controller to the CODAC system. Sensors should monitor the system temperatures, flow rates, pressure, and stresses/deflections to insure that they are within prescribed values. The following minimum parameter set is mandatory.

Instrumentation required for operation:

- a. Inlet and outlet water temperature
- b. Water flow rate
- c. Temperatures inside the test module
- d. Inlet and outlet purge gas pressure and temperature
- e. Inlet and outlet purge gas flow rate and tritium concentration

Additional instrumentation to signal acceptability to operate or to shut down:

- a. Strain gauges
- b. Position detectors
- c. Temperatures at critical points inside the test module
- d. Pressure and moisture sensors in each purge gas line

### **2.5.13 Layout Requirements**

Structural and leak tightness welds shall be removed as far away as possible from high neutron flux locations.

Special attention shall be given to gaps. Radiation streaming shall be minimized by design.