

## 4 Blanket

### 4.1 Functions, Basic Configuration and System Boundaries

The blanket system is composed of the following elements and their components.

#### Primary Modules, NB Port Modules and Limiters

The structure facing the plasma is subdivided into a primary wall and shield, providing the first generic protection to the components located behind it, and limiters for specific protection at distributed locations around the torus. Neutral Beam (NB) port modules are specially tailored primary modules to fit round the NB port. The option of replacing part of the shielding blanket during the last 10 years of ITER operation with a breeding blanket is not precluded.

#### Cooling Manifold and Filler Shield

The cooling manifold mounted inside the vacuum vessel provides the coolant water to the blanket modules. Where required, static shielding elements with no first wall are located between the modules and incorporated into the manifold.

#### Common Features

All modules include their attachment to the underlying structure as well as coolant connections and manifolds out to the port flange. The blanket system also includes integral instrumentation and controls required for operation, and special assembly and maintenance tools and end-effectors.

The system has the boundaries are the following.

#### (1) Boundary to the vacuum vessel

- The blanket modules are supported by the vacuum vessel structure through module attachments. These are bolted to the vacuum vessel blanket support recesses.
- The cooling manifolds and filler shields are mounted on the vacuum vessel plasma-side surface. The connection to the vacuum vessel is made by bolts and welds. The cooling manifolds require upper port feedthroughs.
- Helium purge gas lines for the breeding blanket modules are also mounted on the vacuum vessel plasma-side surface. The gas lines are bolted or welded to the vacuum vessel and require upper port feedthroughs.
- The port limiters are installed in the equatorial ports, and supported by bolts and keys provided as part of the vacuum vessel at the end portion of the port extensions. The port plug is equipped with bolts, keys and lip seal joints to interface to the vessel flange.

#### (2) Boundary to the primary heat transfer system (PHTS)

- The blanket module cooling interface to the primary first wall/blanket PHTS is outside the primary vacuum penetration at the upper port pipe chimney.
- The port limiter cooling interface to the divertor/limiter PHTS is at a pipe stub outside the bioshield at the equatorial level.

#### (3) Boundary to the remote handling equipment

- The blanket system provides gripping points and joints prepared for welding on the modules for the remote handling end-effectors.

(4) Boundary to the diagnostics

- The rear surface of inboard blanket modules is grooved to provide cut-outs for the diagnostic cables. On the outboard side, diagnostics and their cabling are integrated in the coolant manifolds. The diagnostics requires recesses at specified inboard modules to provide polarimeter retroreflectors.

(5) Boundary to the fueling

- The blanket system makes way for the pellet flight tube in the inboard region.

## **4.2 Design Requirements**

### **4.2.1 General**

The limiter shall withstand at least 3000 cycles (with a goal of 10000) at nominal parameters, including plasma disruptions (except VDE-type heat loads, not expected for limiter). The design lifetime of the PFCs shall be suitable in terms of both erosion life and component fatigue lifetime due to thermal and mechanical load combinations.

### **4.2.2 Vacuum**

The design, construction and outgassing rate of the blanket system shall be consistent with providing a high quality vacuum. Capability shall be provided within the blanket system design to facilitate the in-situ leak testing of the blanket system.

### **4.2.3 Mechanical**

- (1) The routing of the coolant supply lines should accommodate relative movements between the blanket and VV during thermal transients without the use of bellows.
- (2) It is preferable to avoid water-containing welds in high fluence and/or stress regions, such as near the first wall, to avoid stress corrosion cracking.
- (3) Drainage and drying of the water from the shield and FW shall be possible.
- (4) The modules will be sized according to the limits placed by electromagnetic loads, the need to maintain a sufficiently low toroidal resistance, and weight limits imposed by remote handling.
- (5) Materials shall be used with well-characterized mechanical and structural properties for their respective service conditions (temperature, stress, nuclear, etc.) in order to obtain a high degree of confidence in their performance.
- (6) The segmentation scheme used to determine the number and positioning of modules shall strive to minimize the number of different modules.
- (7) Special attention shall be given to gaps between modules, divertor area and ports. Radiation streaming shall be minimized by design.

- (8) The design should minimize gaps between modules, and between modules and filler shields, with a goal of 20 mm.

#### **4.2.4 Thermohydraulic**

- (1) The selected heat transfer fluid for both normal operation and baking is water.
- (2) Bulk boiling is not allowed during normal operation or baking. Local boiling should be avoided where practical.

#### **4.2.5 Electrical**

- (1) The blanket system shall be electrically connected to the vacuum vessel only through electrical straps and the coolant and purge gas pipes. The blanket structural supports shall contain an electrical break.

#### **4.2.6 Remote Handling**

- (1) The shielding may be designed as RH Class 3. However if it is structurally integral with a portion of the FW, its RH Class will be that of the attached FW.
- (2) The blanket modules must be capable of remote insertion/removal through the vacuum vessel equatorial ports by use of in-vessel remote handling equipment.
- (3) All in-vessel cooling water and purge gas connections shall be sealed by welds. The connections required for FW and module maintenance shall be remotely welded, drained and dried, cut, repaired, and leak tested from inside the pipes.
- (4) The design should allow, wherever possible in a reasonable time, in-situ repair, minimizing the size and weight of the component to be replaced.
- (5) At prescribed intervals and after a significant off-normal event, it shall be possible to conduct all specified pre-operational tests
- (6) 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.
- (7) All interfaces necessary for (dis)assembly must be compatible with the capability of the remotely operated tools.
- (8) Sufficient space for the insertion and removal of tools must be assured.
- (9) All liquid and gas pressure bearing joints must be capable of being leak tested remotely.
- (10) Mechanical guides should be provided to aid the transporter for final positioning and alignment and to protect adjacent components from damage due to collisions.

#### **4.2.7 Manufacturing**

- (1) Manufacturing tolerances shall be consistent with achieving overall installation tolerances, taking into account inaccuracies resulting from installation and tolerances of mating components. Tolerances of limiter plasma facing wall contours are especially critical.
- (2) The blanket system shall be fabricated as a set of modular components and sub-assemblies capable of being assembled by a contractor at the construction site. The blanket system shall be assembled using a plan that is compatible with the project's general assembly plan. The assembly plan will be developed considering facility restrictions on size and handled weight.

#### **4.2.8 Assembly**

- (1) The primary modules and limiter alignments are defined in DRG1. Special conditions shall apply to modules next to the ports depending on the system in the port.
- (2) All assembly techniques must be compatible with maintaining the vacuum requirements on the system. Handling, cleaning, limits on the use of potential contaminants, etc. must be in compliance with the VDH.
- (3) Breeding blanket installation is to be capable of being carried out remotely without rehearsal on the machine.
- (4) If used, bolts should be secured (lock welding).

#### **4.2.9 Testing**

- (1) The blanket system must pass both a hot and a cold leak test with helium gas at 1.15x design pressure after completion of its assembly within the vacuum vessel and prior to start of operation.
- (2) The system must be pressure tested with water at 1.25 x design pressure after welding of the complete circuit inside the vacuum vessel to demonstrate its ability to withstand the design pressure.
- (3) Each flow circuit must be flow tested to demonstrate the required flow rate at the design pressure differential after welding of the complete cooling circuit.