3 Vacuum Vessel

3.1 Function, Basic Configuration and System Boundaries

The Vacuum Vessel (VV) consists of the following sub-components: the main vessel including support fixtures for in-vessel components as well as supporting brackets for VV gravity supports, and port structures including stubs, stub extensions, port extensions, connecting ducts (to the cryostat) and blank closure plates.

The boundaries of the system are as follows:

- pads supported by brackets between the equatorial ports, to be connected with the VV gravity supports by bolts;
- mountings on the internal surface to accommodate blanket module and cooling manifold attachments, and divertor rails;
- flanges at the end portion of the port extensions equipped with the bolts, keys and lip seal joints for connections with "dedicated" port plugs for heating and current drive, diagnostics and test blankets;
- flanges at the end portion of the port extension, to be connected with the RH casks;
- the remaining independent closure plates that are not integrated with the in-port components as port plugs;
- flanges at the end portion of the cryostat connecting ducts, to be connected with the cryostat rubber bellows by bolts;
- pipe stubs for the VV water connections;
- pipe stubs to be connected with the in-vessel drain lines;
- upper port extension feedthroughs for the blanket module piping;
- divertor port extension pipe feedthroughs for the divertor water piping;
- feedthroughs for the in-vessel diagnostics not passing through dedicated port plug closure plates;
- feedthroughs for the service lines of in-port components not passing through dedicated port plug closure plates.

3.2 Requirements

3.2.1 General

(1) The VV shall provide a reliable structural boundary for the lifetime of the reactor as defined by its fluence goals.

(2) The VV shall be segmented to allow a simple assembly.

3.2.2 Vacuum

(1) The VV shall provide a continuous welded wall. Leak detection by in-situ remote leak testing shall be provided (using the torus leak detection system) over the complete internal surface, including field joints.

(2) The vacuum duct size and number shall be compatible with ultra high vacuum requirements.

3.2.3 Mechanical

(1) Drainage of the coolant in each 20-degree sector will be necessary. Drains will be located as near to the bottom of the vessel as practical. In addition, low point drains must be provided from the enclosed volume of the vacuum vessel (or the lower port structures) to enable draining of cleaning fluids or accidental spills.

3.2.4 Thermohydraulic

(1) For decay heat removal, the cooling system shall make use of natural convection.

(2) The heat shall be removed by two independent cooling systems, to minimize the effect of faults. Each 40° sector of the vessel shall be cooled by the two systems in order to limit the maximum possible VV temperature resulting from a coolant leak in one of the VV PHTS loops.

(3) During system shutdowns, vessel temperature must be > 0°C, but < 100 °C.

3.2.5 Electrical

(1) Electroinsulating breaks in the cooling pipes and manifolds of the vacuum vessel shall not be required, but an appropriate arrangement of all pipes and manifolds should be developed to restrict induced currents.

3.2.6 Remote Maintenance

(1) Every intervention to be carried out on the VV requires remote operations (limited hands on accessibility may be possible at the VV port closure plates).

(2) Access to the enclosed volume of the VV shall be possible from the outside without venting the cryostat vacuum.

(3) The design shall allow:
   a. at least two replacement cycles of any 40° vessel sector;
   b. field joints to be capable of being remotely leak tested.

(4) Gripping points must be provided on the components capable of supporting their full weight over the full range of motion required at installation or removal.

(5) The structural supports, coolant lines joints, instrumentation leads and all other interfaces that must be addressed at (dis)assembly must be compatible with the remotely operated tools.

(6) The design must ensure sufficient space for the insertion and removal of the tools.

(7) All liquid and gas pressure joints must be capable of being remotely leak tested to the required level.

3.2.7 Manufacturing Requirements

(1) Each sector of the VV double wall structure must be leak tested before and during assembly.

3.2.8 Assembly Requirements

(1) The number of field joints must be minimised.