Blanket Module Project (L-4)

**Objective**
- Develop and fabricate prototype components for the shielding blanket, in order to assess their manufacturing feasibility.
- Assemble them together and develop bolting, welding and cutting tools for the remote removal of the components.
- Obtain confirmation of the design choices by results from accompanying R&D on materials, joining techniques and neutronics using a fast neutron source.

Full-scale prototypes include multi-layered first walls made of stainless steel as structural material with copper alloy as heat sink and Be or C as protection material, massive stainless steel shields, and flexible supports.

The feasibility of installation and removal of a blanket module with mechanical attachments has been demonstrated and tested in a prototype assembly. A hydraulic, remotely driven bolting tool has been developed, which achieves high pre-loading using heating rods. High quality remoted hydraulic laser-welded connections have also been made through a 30 mm penetration hole in the front of the module.

**Joining Techniques**
- Be/Cu joints of high heat flux components (e.g., limiter): fast amorphously CuInSiNi-brazed small tiles on curved Cu surface (RF), withstood 4500 cycles at 12 MW/m².
- Be/Cu joints of lower heat flux components (e.g., first wall): hot isostatic pressing (HIP) of Be tiles with Ti interlayer (EU), withstood 13000 cycles at 0.7 MW/m².
- Joining of Cu/SS parts with high precision: solid-solid HIP of the first wall withstood (e.g., JA) 2500 cycles at up to 7 MW/m².

Full-scale prototype manufacture (JA). Module cut for inspection.

In the frame of this R&D, innovative technologies have been developed and existing technologies have been improved, giving confidence in the feasibility and robustness of the chosen blanket design.

Divertor Cassette Project (L-5)

**Objective**
To develop the technology needed to construct full-scale armoured components capable of providing adequate armour, armour-heat sink joint (CfC-Cu & W-Cu), and baseplate lifetime, and sustaining thermo-hydraulic and electro-mechanical loads, while utilizing the most cost-effective and reliable manufacturing processes.

**Major issues include**
- the bonding of different plasma facing materials on the same component,
- the selection of the heat sink material (CuCrZr now preferred), and the demonstration that it maintains its properties after manufacturing.

The graph of component test results shows that various tile geometries can meet the ITER requirements. However, the monoblock has proved to be the most reliable with no complete detachment of tiles. Tungsten brush type armour proved to be a solution to having a Cu-W joint able to withstand the large difference in thermal expansion of the two materials under the high heat flux loads.

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**Results of CfC/Cu high heat flux component testing.**

An additional aim of the project was to integrate key plasma facing components together into a realistic prototype of the cassette body. Following the decision of the US to pull out of ITER, the EU has constructed an integration prototype. It is not essential to use all the real materials for these prototypes, and dummy components have been made - thermohydraulic equivalents of the real components.

Several middle and large scale CfC and W-armoured divertor prototypes have been successfully tested at heat fluxes ~ 20 MW/m² x 1000 cycles, which is consistent with ITER operational needs.