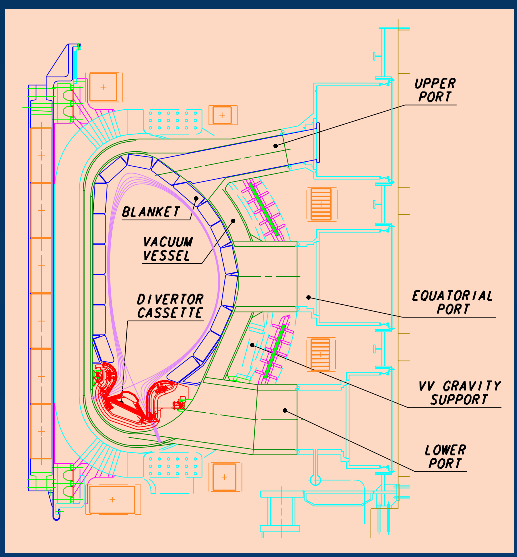
ITER Engineering Design Activities - R & D

Vessel, Blanket & Divertor (I)



The double-walled vacuum vessel is lined by modular removable components, including blanket modules composed of a separate first wall mounted on a shield block, divertor cassettes, and diagnostics sensors, as well as port plugs such as the limiter, heating antennae, and test blanket modules. All these removable components are mechanically attached to the VV.

These vessel and internal components absorb most of the radiated heat from the plasma and protect the magnet coils from excessive nuclear radiation. This shielding is accomplished by a combination of steel and water, the latter providing the necessary removal of heat from absorbed neutrons. A tight fitting configuration of the VV to the plasma aids the passive plasma vertical stability, and ferromagnetic material in the VV located under the TF coils reduces the TF ripple and its associated particle losses.

The initial blanket acts solely as a neutron shield, and tritium breeding experiments are confined to the test blanket modules which can be inserted and withdrawn at radial equatorial ports. The blanket module design consists of a separate faceted first wall (FW) built with a Be armour and a water cooled copper heat sink attached to a SS shielding block. This minimizes radioactive waste and simplifies manufacture. The blanket is cooled by channels mounted on the vessel.

The divertor is made up of 54 cassettes. The target and divertor floor form a V-shape and the large opening between the inner and outer divertor legs to allow an efficient exchange of neutral particles. These choices provide a large reduction in the target peak heat load, without adversely affecting helium removal.

The current design uses carbon at the vertical target strike points. Tungsten is being considered as a backup, and both materials have their advantages and disadvantages. The best judgement of the relative merits can be made by the time of procurement. Carbon has the best behaviour to withstand large power density pulses (ELMs, disruptions), but gives rise to tritiated dust. Procedures for the removal of tritium codeposited with carbon by a number of schemes are under consideration and need further development.

Vacuum Vessel Sector Project (L-3)

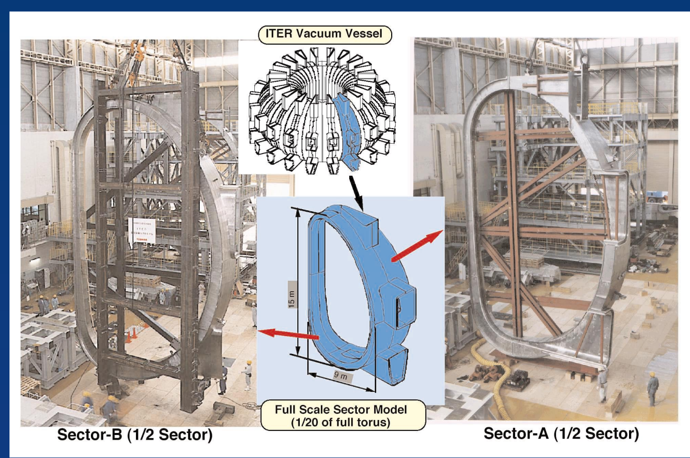
Objective
To provide input required to complete the design, especially regarding critical issues of fabrication technology: dimensional accuracy, welding distortions and achievable tolerances.

The ITER vessel will be more than twice the linear dimensions and over 16 times the mass of the largest existing tokamak vessel. The key issues can only be properly resolved by building a model at full scale.

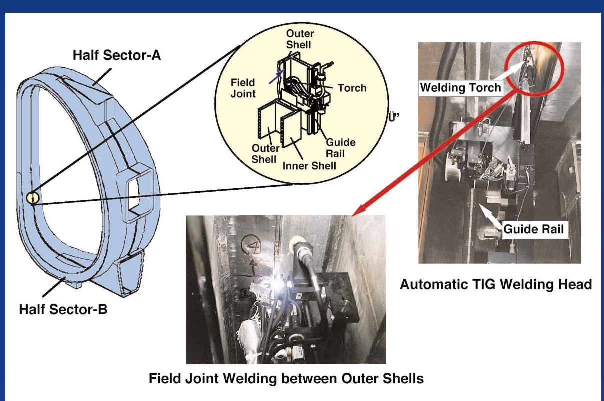
The dominant feature of the project is a full-scale sector model (sized for the larger 1998 ITER design), manufactured by the Japanese Home Team. Hitachi and Toshiba each built half sectors. The distributed manufacturing offered opportunities to test and compare different candidate weld schemes.

After the half sectors were fabricated, they were leak, pressure and mechanically tested to determine their structural characteristics. The welding together of the two half sectors demonstrated the automatic welding techniques and verified the ability to undertake joint inspection by ultrasonic testing.

In parallel, the Russian Federation Home Team manufactured a full-scale model equatorial port extension, developing and demonstrating fabrication technologies to the required specifications and tolerances and related inspection techniques and procedures. The US Home Team developed a fully remotized welding/cutting system. This technology has now been transferred to the Japanese Home Team and has been used to join the port extension to the sector model.

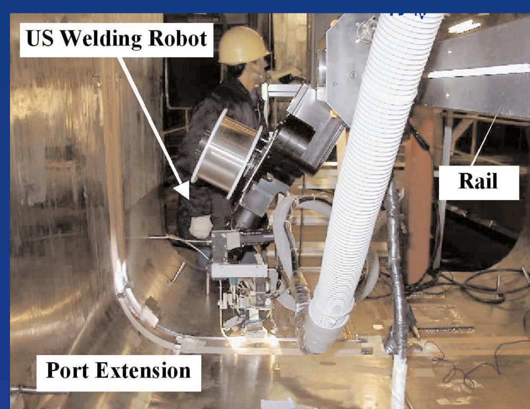


View of full-scale sector model of ITER vacuum vessel completed in September 1997 with dimensional accuracy of ± 3 mm.



Field joint welding test of VV sector.

Equatorial port extension shipped from the RF to the test site at JAERI Naka for integration testing.



Inner shell welding demonstration using full scale sector and port extension.

The manufacture of the full-scale sector of the 1998 ITER design gives a sound basis for the present design. To reduce the vessel fabrication cost, forging, powder HIPing and/or casting are being investigated particularly for the blanket module support housings.