

MANUFACTURING AND ASSEMBLY OF THE PLASMA- AND OUTER VESSEL OF THE CRYOSTAT FOR WENDELSTEIN 7-X

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WENDELSTEIN 7-X is a helical advanced stellarator which is presently under construction at the Greifswald branch of IPP. A set of 70 superconducting coils arranged in five modules provide a twisted shaped magnetic cage for the plasma and allow for steady state operation. Operation of the magnet system at cryogenic temperatures requires a cryostat which provides the thermal protection and gives access to the plasma. The main components of the cryostat are the plasma vessel, the outer vessel, the ports, and the thermal isolation.

The German company, MAN Turbo AG Deggendorf (former MAN DWE GmbH Deggendorf), is responsible for manufacture and assembly of the plasma vessel and the outer vessel.

The shape of the plasma vessel has to closely follow the twisted shape of the plasma and has a cross section which continuously varies between triangular and bean shaped. Following the symmetry of the plasma the plasma vessel is composed of 10 half-modules. Each half-module is again divided into two sectors to allow stringing of the coils during assembly.

The main body of the outer vessel is formed by a toroidal shell with a minor diameter of 4.4 m and a major diameter of 11 m. The manufactured wall thickness is 25 mm. The outer vessel is toroidally divided into 5 modules. A module is composed of five faceted toroidal sectors. In order to allow an effective assembly the plasma vessel, the magnet system with the ports and support structure, each module of the outer vessel is made and delivered in separate lower and upper semi-shells. The outer vessel has 524 domes, some of them are multiple for a total of 549.

Extensive finite element analyses have been performed to define the wall thickness of the domes and the welding seams between the main body and the domes.

The sectors of a module were formed by rolling. Five sectors were welded together to form a module shell. Vacuum tightness of the welds was checked by a helium leak test. Precise cutting of the holes for the ports was performed by plasma cutting and following milling. The welding of the domes was performed under control of a laser positioning system. Finally a pre-assembly was performed. The contours of the semi-shells and the positions of the domes were measured by laser tracking system and were well within the given narrow tolerances. The manufacturing and delivery of the semi-shells of the outer vessel was finished end of 2009.

In 2009 the semi-shells of the first module were installed with the thermal isolation. The assembly of first semi-shells to a module of the outer vessel was finished on site at the end of 2009.

This paper describes the manufacturing and assembly technology of the plasma and outer vessel of the cryostat for WENDELSTEIN 7-X.