Fabrication, Tests and Assembly of the Wendelstein 7-X Magnets and Perspectives for the Technological Development of Fusion

C. Sborchia

Max-Planck-Institut für Plasmaphysik, EURATOM Association,
Wendelsteinstrasse 1, D-17491 Greifswald, Germany

The W7-X machine is a low-shear stellarator of the Wendelstein line being assembled in Greifswald, Germany. The magnet system of W7-X consists of 70 superconducting coils integrated with a central support structure and intercoil elements, busbars, current leads and power supplies. The magnets are sub-divided into 50 non-planar coils, which establish the basic magnetic confinement configuration, and 20 planar coils. They are manufactured with a superconducting NbTi cable co-extruded in an Aluminium jacket. After insulation and vacuum pressure impregnation, the windings are embedded in cast stainless steel casings, which are then finish-machined and equipped with cooling systems. All coils are tested in cryogenic conditions in a dedicated facility at CEA Saclay.

The construction and testing of the magnets and structures is in a well advanced stage. The superconductor production is complete, 47 winding packages for the non-planar coils and the 20 winding packs for the planar coils have been manufactured. About 35 out of 70 coils are at various stages of completion. 12 coils have passed the cold tests at Saclay and 6 of them are being prepared for assembly on-site of the first two half-modules of the machine.

Several design changes in the structural elements had to be implemented in the course of fabrication and a series of manufacturing problems were encountered and had to be corrected. This has required further qualification programmes and the introduction of additional work acceptance tests, in particular high voltage tests in reduced pressure (Paschen-minimum) conditions for the coils, quench detection cables and other components. Cold testing of the coils has proven to be a powerful tool to validate the design and quality of the manufacture.

The W7-X magnets are part of the largest superconducting fusion device being constructed at present. They represent a technical challenge at industrial level due to the design complications and the need for proven techniques and manufacturing processes in accordance to the highest quality standards. The production of these components has required the management of large contracts with a series of sub-suppliers and the collaboration from other research institutes and laboratories for qualification and full-scale tests.

This presentation will give an overview of the manufacture, testing and assembly of the W7-X magnets and highlight the main technical and project management challenges. The main lessons learned in the large scale production of superconducting cables, windings and structures will be presented. The critical items to be considered in the design, manufacture and testing of similar systems for future large fusion devices, such as ITER, will be highlighted.

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