MECHANICAL INSTRUMENTATION OF THE WENDELSTEIN W7-X

CRYOGENIC STRUCTURE

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Wendelstein 7-X (W7-X) is the world's largest stellarator fusion experiment which is currently being assembled in Greifswald, Germany. 70 superconducting coils provide the complex magnetic field required for steady-state plasma experiments. The coils are mechanically supported by a central support ring and inter-coil structure elements which are highly loaded by electromagnetic forces during operation.

Instrumentation to monitor mechanical strains and displacements has been developed. It is based on strain gauges with low temperature and magnetic field dependences over the operating ranges from 300 K to 4 K and up to 6 T, respectively. Special electronics for the approximately 700 strain and displacement sensor assemblies compensate for thermo-electric effects arising from the temperature differences within the measurement chain.

The strain gauges are standard low-temperature rosettes in half-bridge configuration. Highly efficient compensation techniques were verified by tests spanning the complete operational temperature and field ranges. The results confirmed the effective reduction of the temperature curve run in the operating range, and this remaining dependence can now be easily corrected during data processing. Magnetic field sensitivities were found to be below the measurement resolution.

During high field operation the coils deform, and some bolted flanges are designed to open which is made possible by elastic deformation of long Inconel bolts. In order to measure these mechanical displacements, devices based on commercially available beams (cantilevers) were developed. These cantilevers are instrumented with strain gauges in full-bridge configuration. Each beam is assembled onto a frame and is pre-loaded by a pull-spring in opposite direction to the main operational movement. This way the measurement range can be increased by preserving good linearity at ambient and cryogenic conditions.

The paper describes the development and application of the instrumentation, cabling and electronics for correct measurements in a hostile physical and electrical environment.