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Wendelstein 7-X News, April 2011

Current leads enter serial production

Wendelstein 7-X (W7-X) will use superconducting modular coils to generate the confining field. This will enable a discharge length of 30 min.

Connecting the superconducting coils to their power supplies represents a considerable technical effort. The current leads provide the electrical connection, as well as a transition from cryogenic temperature to room temperature. In operation, the W7-X coils will have to conduct 18,200 A at –269°C. In the case of a sudden shutdown, the components have to cope with voltages of several thousand volts; they have been tested up to 13,000 volts.

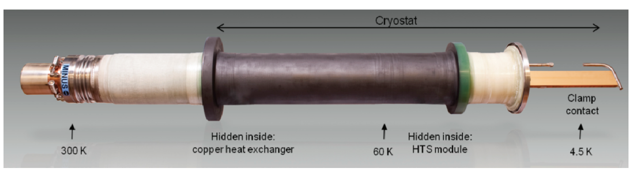

Fig. 1. W7-X current lead prototype developed at KIT and IPP. During operation, the left side is at room temperature, while the right side is connected to the superconducting coils. The heat exchanger is based on a development from CERN. Photo: KIT.

Staff at Karlsruhe Institute of Technology (KIT), in collaboration with the Swiss CRPP Institute, have been able to meet these extremely difficult specifications. In 2003 they produced a demonstration current lead for ITER. Figure 1 shows a photograph of a prototype current lead, based on the ITER design but developed specifically for W7-X, that passed all tests at the end of last year. The core is a high-temperature-superconductor (HTS)—a material that becomes superconducting at comparatively "high" temperatures around –163°C. However, due to the high currents and magnetic fields in W7-X it will be kept below –213°C. The advantage of using ceramic HTS is to provide a junction that combines practically zero electrical resistance with good heat insulation.

As strange as it sounds, the cooling of the HTS module uses the heat conduction in the materials. The "cold" side is connected to components that are cooled to –269°C by liquid helium. The "warmer" side is kept at –223°C by helium gas fed into a heat exchanger. The external connection can be kept at room temperature during operation.

One special feature of the newly developed current leads is that they allow the cold end of the connection to be at the top. In contrast to all previously constructed current leads, in Wendelstein 7-X the current enters the machine from below. This increases the effect of convection, which transports heat upwards and could compromise the function of the heat exchanger. The design has been modified to suppress convection, and the recently completed tests showed that the new W7-X design can be implemented successfully.

A total of 14 serially produced current leads will be manufactured and tested at KIT by the end of 2012. The first serially produced pair successfully passed the acceptance test in late April 2011. Assembly of the current leads in W7-X is planned by IPP as a cooperation with Oak Ridge National Laboratory (see Fig. 2). Assembly is facilitated by the short distance from the coils to the heavy-duty power supplies, which are located in the basement below W7-X.

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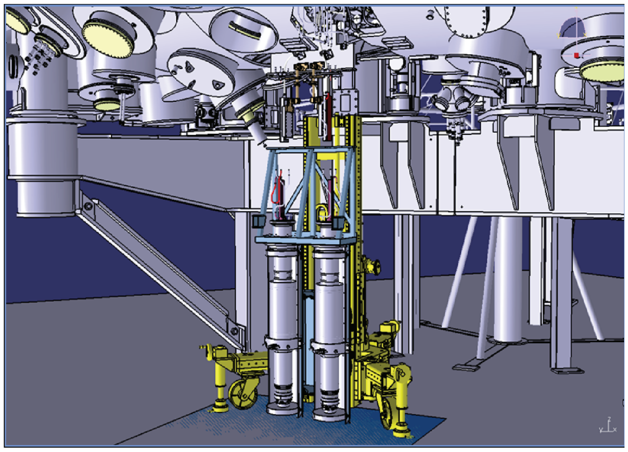

Fig. 2. CAD diagram of the assembly procedure for the current leads. The assembly ramp, marked in yellow, guides the current leads into the W7-X cryostat from below.

The results of the tests for the prototype current leads developed at KIT are so impressive that current leads using the same design are planned for other fusion experiments. Starting in 2013 these current leads will be built into the superconducting tokamak JT-60SA, a joint project between the EU and Japan.

Wendelstein 7-X status

For the most part, the assembly of W7-X is progressing on schedule. Four of five modules are now in their final position on the machine foundation. One of the biggest remaining tasks is mounting the 254 ports. The challenge here is to keep the deviations from the intended placement within the allowed limits. This requires somewhat more effort than originally assumed; however, the use of time buffers means that deadlines remain unaffected. An overall view of the W7-X torus hall is shown in Fig. 3.

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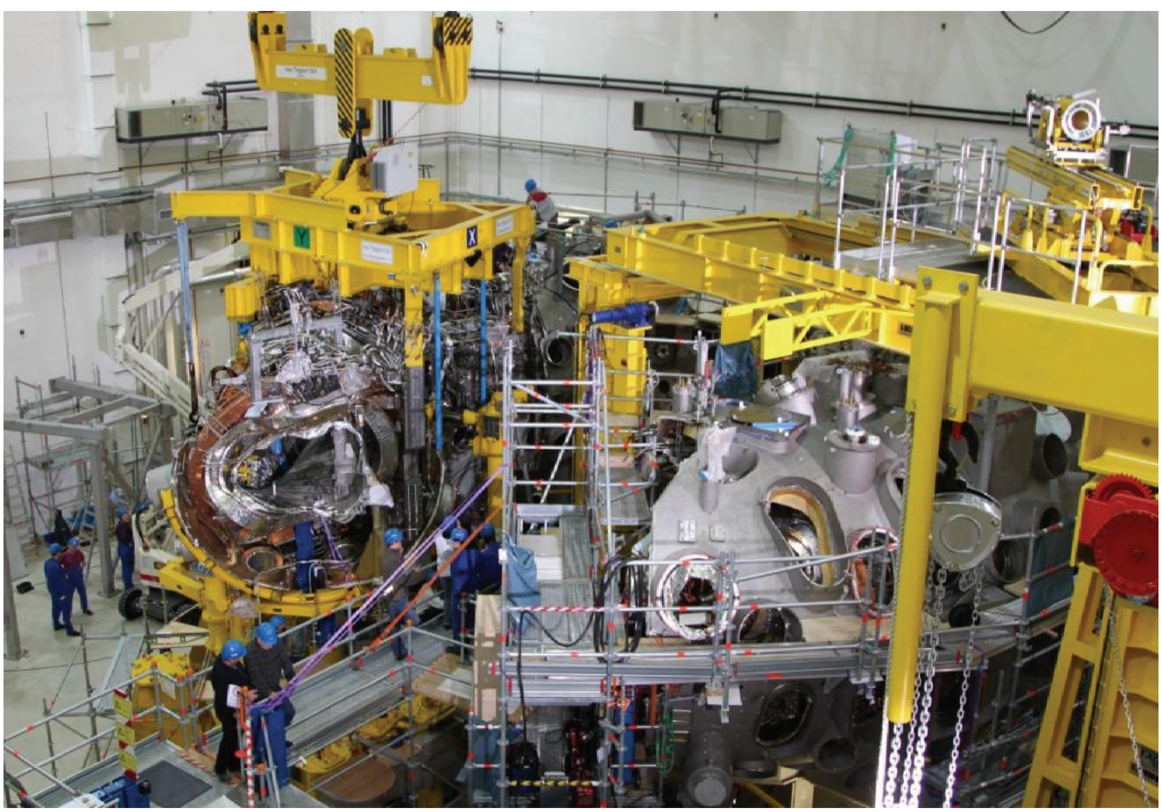

Photo:Tino Schultz

Fig. 3. The W7-X torus hall, with 4 modules in their final position on the machine foundation.