Wendelstein 7-X

NEWSLETTER

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Current Leads enter Serial Production

Wendelstein 7-X will be taking advantage of its stellarator design, and using specially formed coils to achieve steady state plasma confinement. To make the most of this advantage, the magnetic field must be generated by superconducting coils. Electric current flows with almost no losses in superconducting materials, at temperatures close to absolute zero. In standard materials, the required currents would produce too much heat. This limits the duration of the plasma discharge due to overheating or requires intensive cooling. The energy for cooling would even exceed the energy produced in a fusion power plant.

A considerable technical effort is how to connect the superconducting coils to their power supplies. The connection requires special components known as “current leads”. These leads provide the electrical connection, as well as a transition from cryogenic to room temperatures. In operation, the Wendelstein 7-X coils will have to conduct 18,200 amperes at -269°C. In the case of a sudden shut down, the components have to cope with high voltages of several thousand volts; they have been tested up to 13,000 volts.

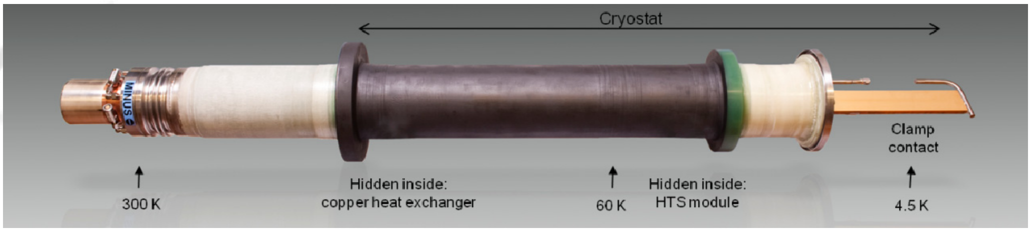

photo: KIT

Figure 1: Photograph of the 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.

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 this 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 Wendelstein 7-X it will be kept below -213°C. The advantage of using HTS is to provide a junction which 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 which 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 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.

14 serially produced current leads will be manufactured and tested at KIT by end of 2012. The first serially produced pair will undergo the acceptance test in April 2011.

Assembly of the current leads in W7-X is planned by IPP as a co-operation with Oakridge National Laboratory (see Figure 2). The assembly is helped by to the short distance from the coils to the heavy duty power supplies, in the basement below W7-X.

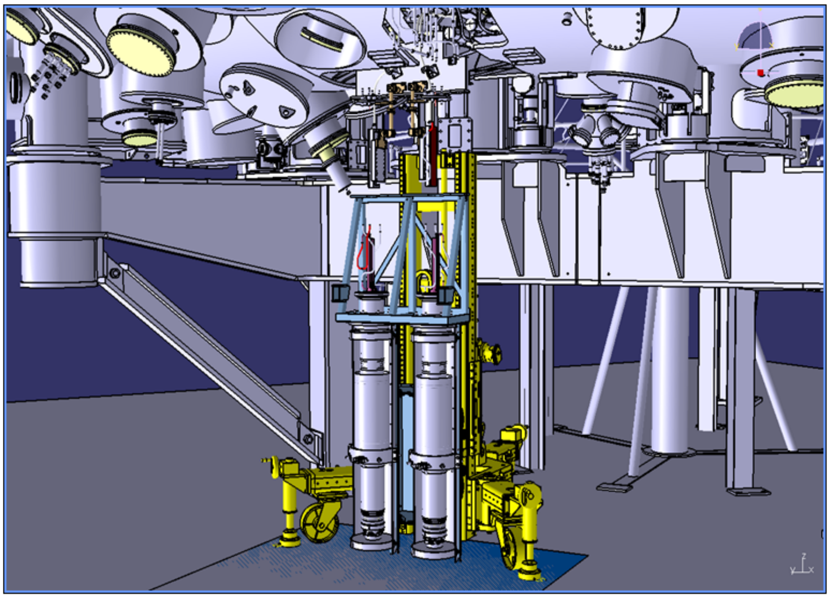

Figure 2: CAD diagram of the assembly procedure for the current leads. The assembly ramp, marked in yellow, guides the current leads into the W7-X cryostat from below.

The results of the tests for the prototype current leads developed in 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: All in all, the assembly of W7-X is progressing on schedule. 4 of 5 modules are now in their final position on the machine foundation. One of the biggest remaining tasks is mounting 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.

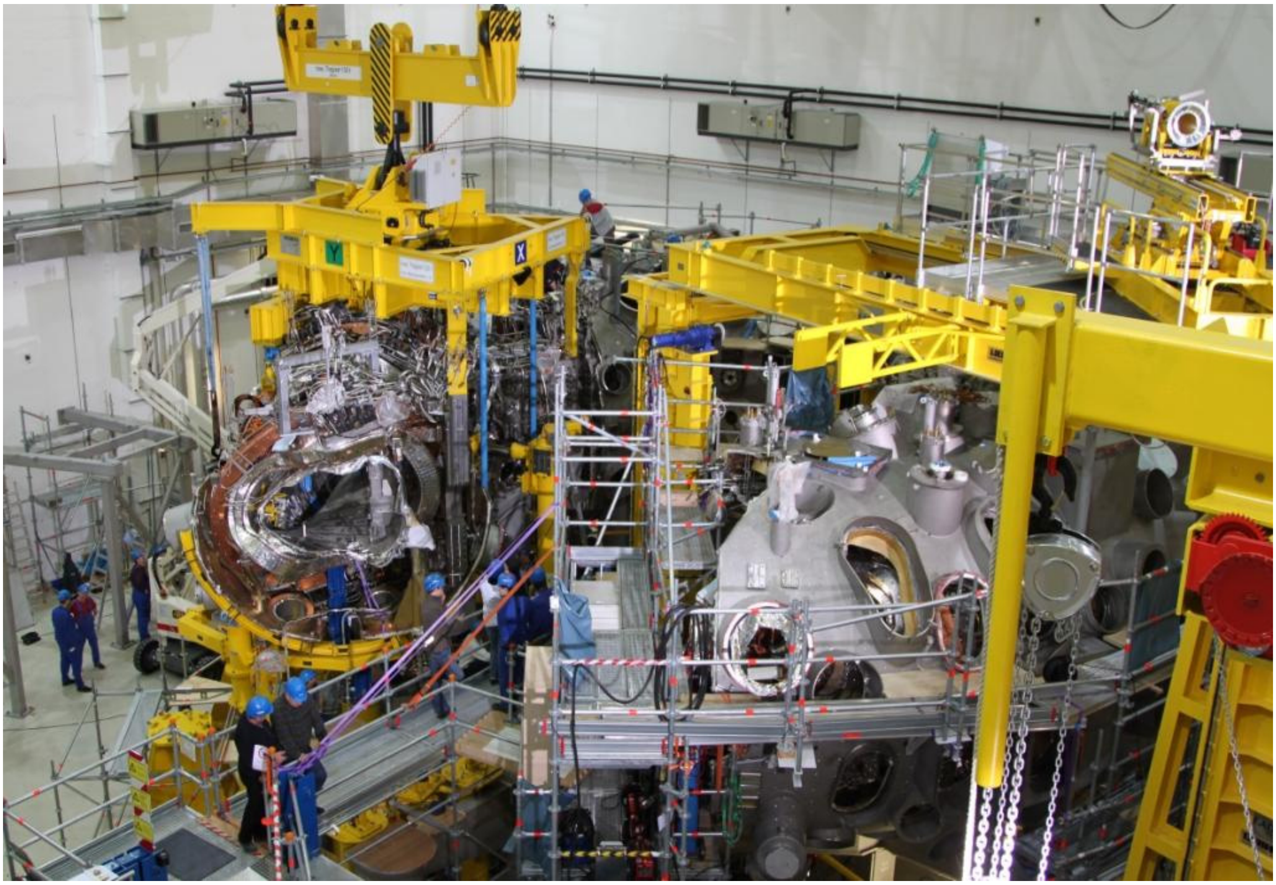

photo: Tino Schulz

Figure 3: A peek inside the W7-X torus hall, with 4 modules in their final position on the machine foundation.

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