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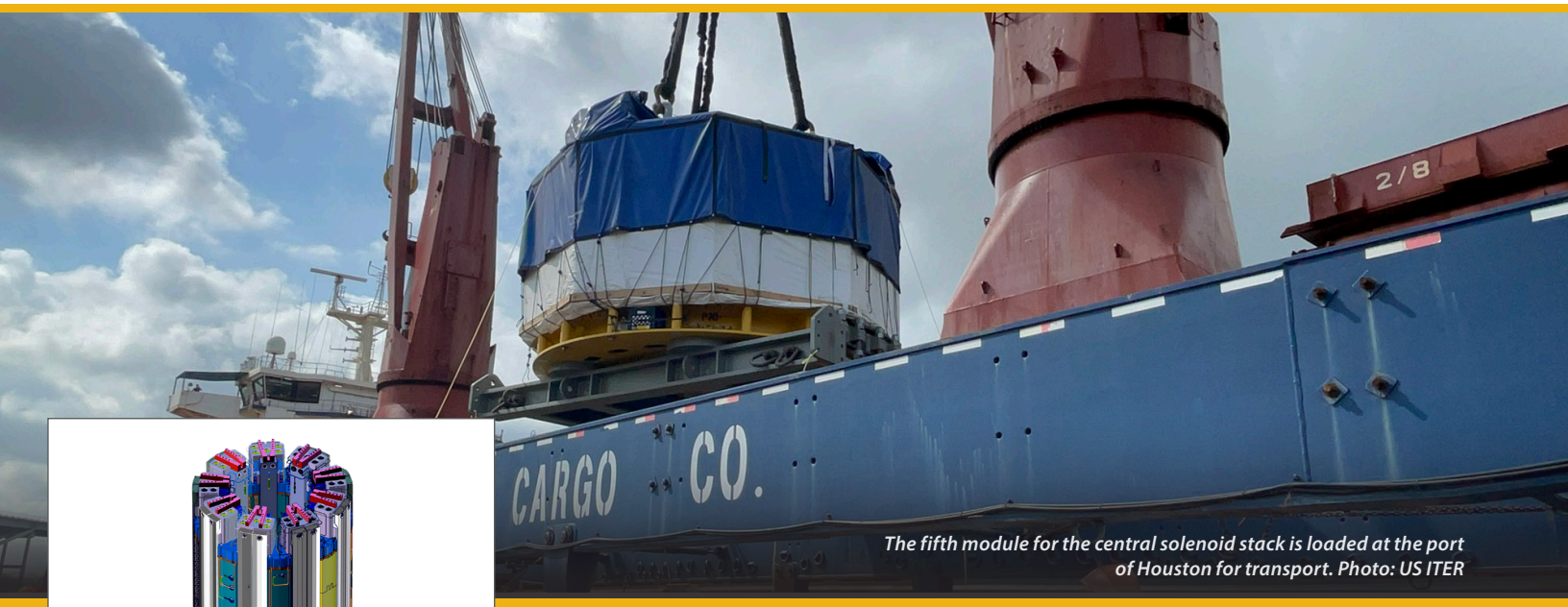
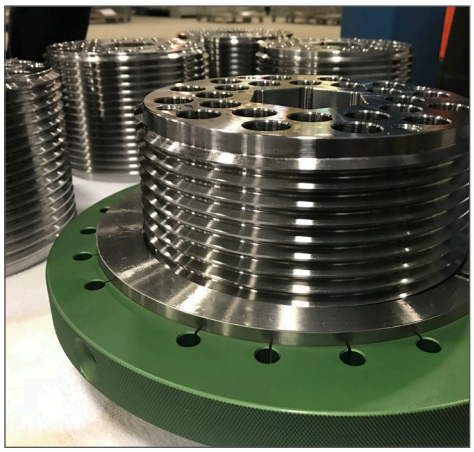
Central Solenoid



The fifth module for the central solenoid stack is loaded at the port of Houston for transport. Photo: US ITER

Central solenoid design. Image: US ITER



Bolts for the central solenoid support structure. Photo: Superbolt/US ITER.

U.S. Contribution

US ITER is responsible for the central solenoid, including the design, research and development, and fabrication of seven modules using supplied conductor, plus the associated structure, assembly tooling, bus extensions, and cooling connections.

Overview

The central solenoid is the heart of the ITER tokamak and serves as a critical element in the ITER magnet system. The central solenoid induces the majority of the magnetic flux change needed to initiate the plasma, generate the plasma current, and maintain this current during the burn time. It is made of six independent modules, each wound from approximately 3.5 miles of niobium-tin (Nb_3Sn) superconducting cable that was supplied by ITER Japan. The stacked modules are held together by a vertical 60-foot-tall pre-compression support structure comprised of more than 9,000 parts.

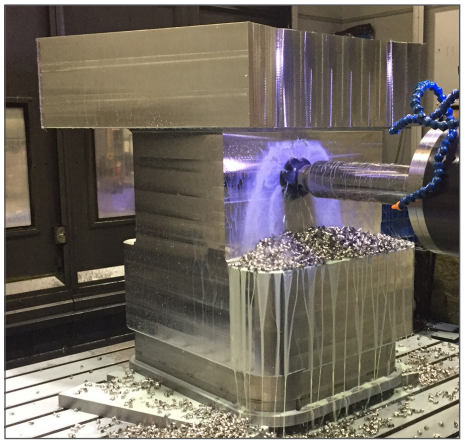
US ITER is responsible for the six modules of the central solenoid, a spare module, the pre-compression support structure, and the tooling needed to assemble the central solenoid. US ITER's scope includes performing all research and development, engineering, design, procurement, testing, and shipment activities of these components. In addition, the design, fabrication, and testing of an insert coil was used to validate the manufacturing processes prior to starting production on the central solenoid modules. This effort was completed in 2015 and cleared the way to begin fabrication of the central solenoid modules.

Status

Four central solenoid modules have been delivered by US ITER and stacked on a dedicated assembly platform. The fifth and sixth modules have completed testing, with the fifth delivered to the ITER site and the sixth being shipped in 2025. The seventh module, a spare, is being finalized. The tooling needed to assemble the central solenoid was delivered in 2021, and delivery of the components of the support structure was completed in 2025.

Central Solenoid

The fourth module installed on the central solenoid stack. Photo: ITER Organization



Machining of a lower key block. Photo: Petersen, Inc.

Five modules have been delivered to the ITER site. Photo: ITER Organization

Technical Description

Height: 18 m
Diameter: 4.13 m
Total weight: 1,000 t
Number of coil packs (modules): 6 plus 1 spare
Individual module weight: 110 t
Peak field strength: 13.1 T
Test Voltage: 30 kV
Operating voltage: 14 k V
Test current: 40 kA (@ 4 K)
Operating current: 45 kA
Stored energy capacity: 5.5 GJ

Central Solenoid Superconducting Cable

Provided by ITER Japan (Japan Domestic Agency)
Strand material: Niobium-tin (Nb_3Sn)
Strand diameter: 0.83 mm (unreacted, after coating)
Non-copper critical current density: >1,000 A/mm^2 (@ 12 T)
Copper to non-copper ratio: 1:1
Cable design: CICC (cable-in-conduit-conductor)

Contributors include

General Atomics (San Diego, CA)
ARMEC Corp (Knoxville, TN)
Climax (Newberg, Oregon)
Cryomagnetics (Oak Ridge, TN)
Hamill Manufacturing Co. (Trafford, PA)
Kamatics Corporation (Bloomfield, CT)
Keller Technology Corporation (Buffalo, NY)
Major Tool and Machine (Indianapolis, IN)
National High Magnetic Field Laboratory, Florida State University (Tallahassee, FL)
Petersen, Inc. (Ogden, UT)
Precision Custom Components (York, PA)
Rhinestahl (Cincinnati, OH)
Robatel Technologies (Roanoke, VA)
Superbolt, Inc. (Carnegie, PA)

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