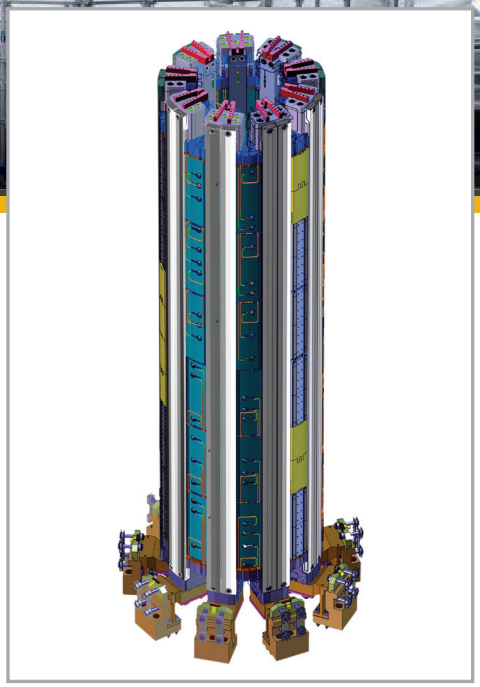
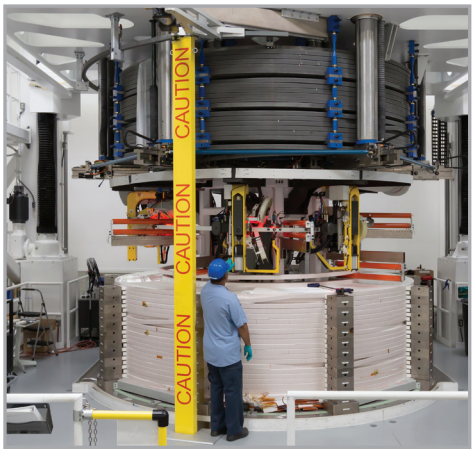
Central Solenoid

The third central solenoid module was positioned on top of the existing two-module stack in April 2024. Photo: ITER Organization



Central solenoid design. Image: US ITER



Turn insulation of a module. Photo: General Atomics

US Contribution

US ITER is responsible for the central solenoid, including the design, research and development, and fabrication of seven modules using supplied conductor (from ITER Japan), 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 coil packs that use a niobium-tin (Nb_3Sn) cable-in-conduit superconducting conductor, held together by a vertical pre-compression structure. The conductor was supplied in unit lengths up to 910 meters.

US ITER is responsible for the six modules of the central solenoid, a spare module, the pre-compression structure that holds them together and links the stack to the rest of the magnet system, and the tooling needed to assemble the central solenoid. US ITER is performing all research and development, engineering, design, procurement, testing, and shipment activities of the components of the central solenoid magnet (the six modules, one spare module, and structure components) and its assembly tooling. 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.

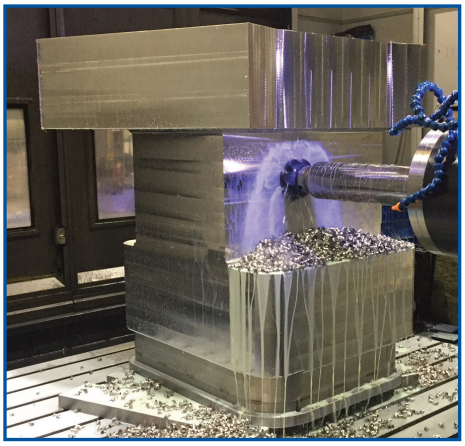
Status

Central solenoid modules, bus bar extensions, and pre-compression structure components are in fabrication with many components already delivered, including the first four modules.

The tooling needed to assemble the central solenoid was manufactured and component deliveries were completed in 2021.

Central Solenoid

A module in the stack and join workstation.
Photo: General Atomics



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

The first central solenoid module arrives at ITER.
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)

Kyle Wooley
US ITER Project Office
Manager, Central Solenoid and
Tokamak Cooling Water System

Oak Ridge National Laboratory
wooleyky@ornl.gov | 865-241-4329