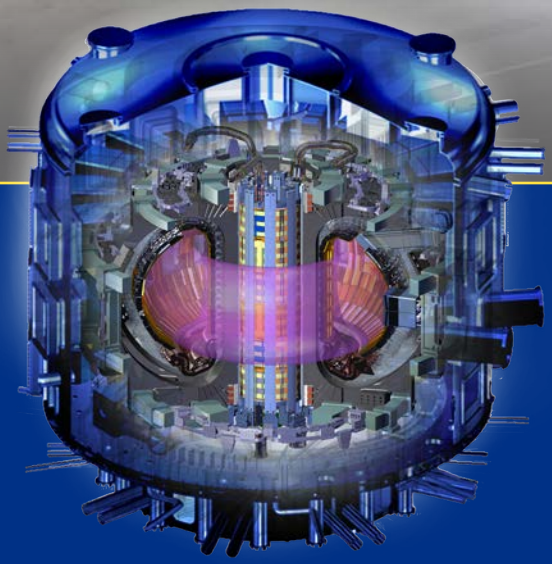


ITER Central Solenoid

Building the World's Largest Pulsed Superconducting Magnet

GENERAL ATOMICS

What is ITER?

ITER is being built in southern France

- World's largest scientific experiment being built by a partnership of 35 nations
- Plasma physics experiment to demonstrate the technological and scientific feasibility of magnetic fusion

What Will ITER Do?

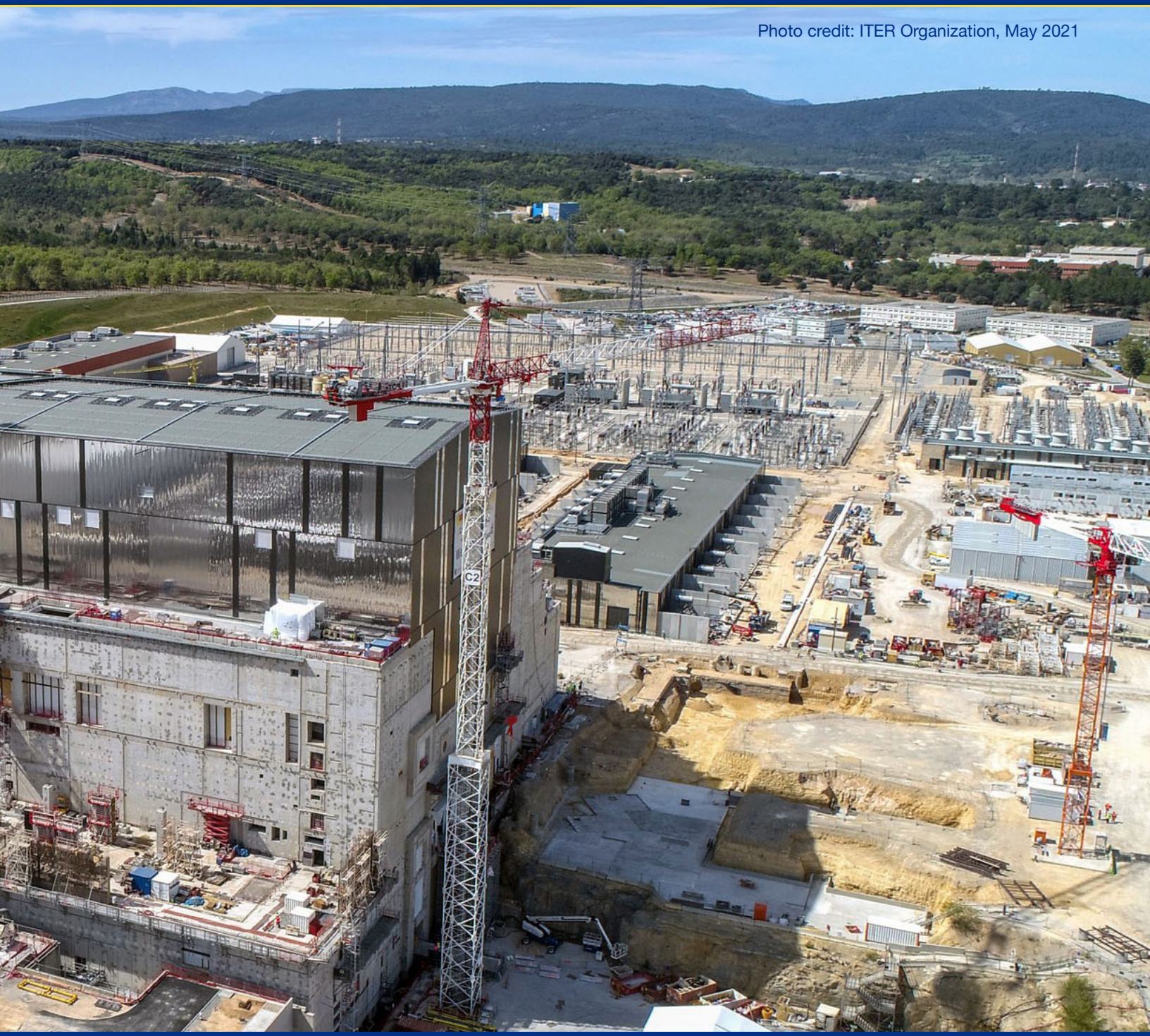


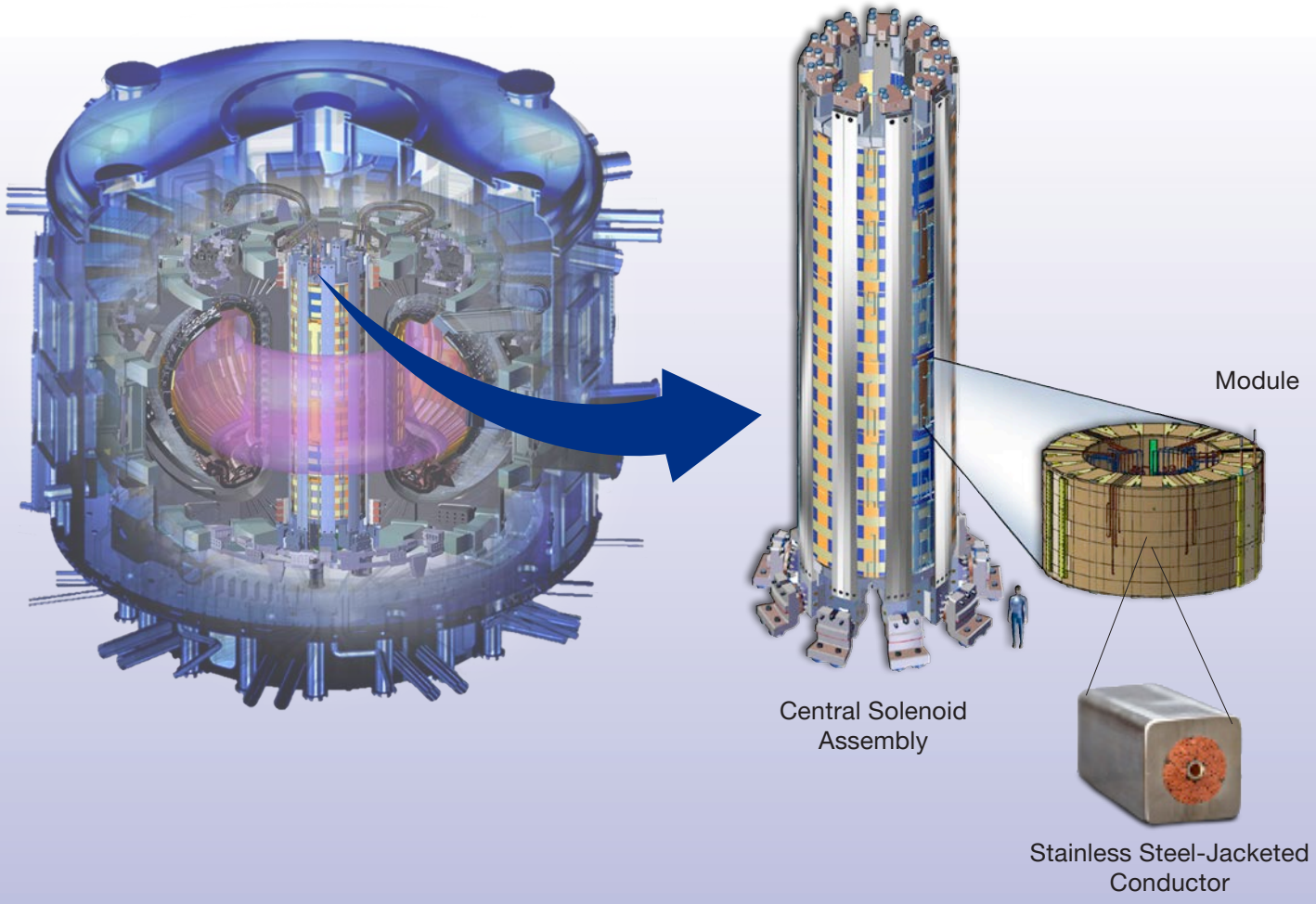
Photo credit: ITER Organization, May 2021

- Produce 500 MW of power, which is 10 times the input heating power
- Demonstrate the integrated operation of technologies for a fusion power plant
- Achieve a deuterium-tritium plasma in which the reaction is sustained through internal heating
- Test tritium breeding

ITER Central Solenoid

The heart of the international fusion energy device

The Central Solenoid is the heart of ITER. The 5-story, 1,000-ton magnet will drive 15 million amperes of electrical current in ITER's fusion plasma for stabilization. General Atomics (GA) is fabricating the modules in a dedicated facility in San Diego, CA.



CENTRAL SOLENOID ASSEMBLY

- 6 modules
- Height: 59 feet (17.7 meters)
- Diameter: 14.1 feet (4.3 meters)
- Weight: 1,000 tons (900 tonnes)
- Peak field strength: 13.1 Tesla
- Stored energy capacity: 5.5 gigajoules

EACH MODULE

- 250,000 lb. (110-tonne)
- Height: 7 feet (2.1 meters)
- Diameter 13.6 feet (4.1 meters)
- 3.6 miles (5.8 kilometers) of steel-jacketed conductor
- Conductor wound into 40 layers

Central Solenoid Module Fabrication

Flows through 10 custom-built process stations

It takes 22-24 months to manufacture each coil and prepare it for full current testing at 4.7 K

Conductor Receiving Inspection

Winding

Joint & Terminal Preparation

Stack & Join/Helium Penetrations

Reaction Heat Treatment

Turn Insulation

Ground Insulation

Vacuum Pressure Impregnation

Turn Over Tool

Helium Piping

Final Test

Central Solenoid Fabrication Facility

- 6,000 sq. meters of temperature-controlled production space
- 0.6 meters thick concrete floors
- 1MW diesel generator
- 1MW cooling tower
- Liquid argon, liquid nitrogen, & liquid helium systems
- Gantry & bridge cranes
- Two 100+ horsepower air compressors

Production Facility
Under Construction

Completed High Bay

Final Test Facility

Station 1

Receiving the Conductor

One of 54 spools of conductor received at the Central Solenoid production facility

Unloading a conductor spool from the delivery

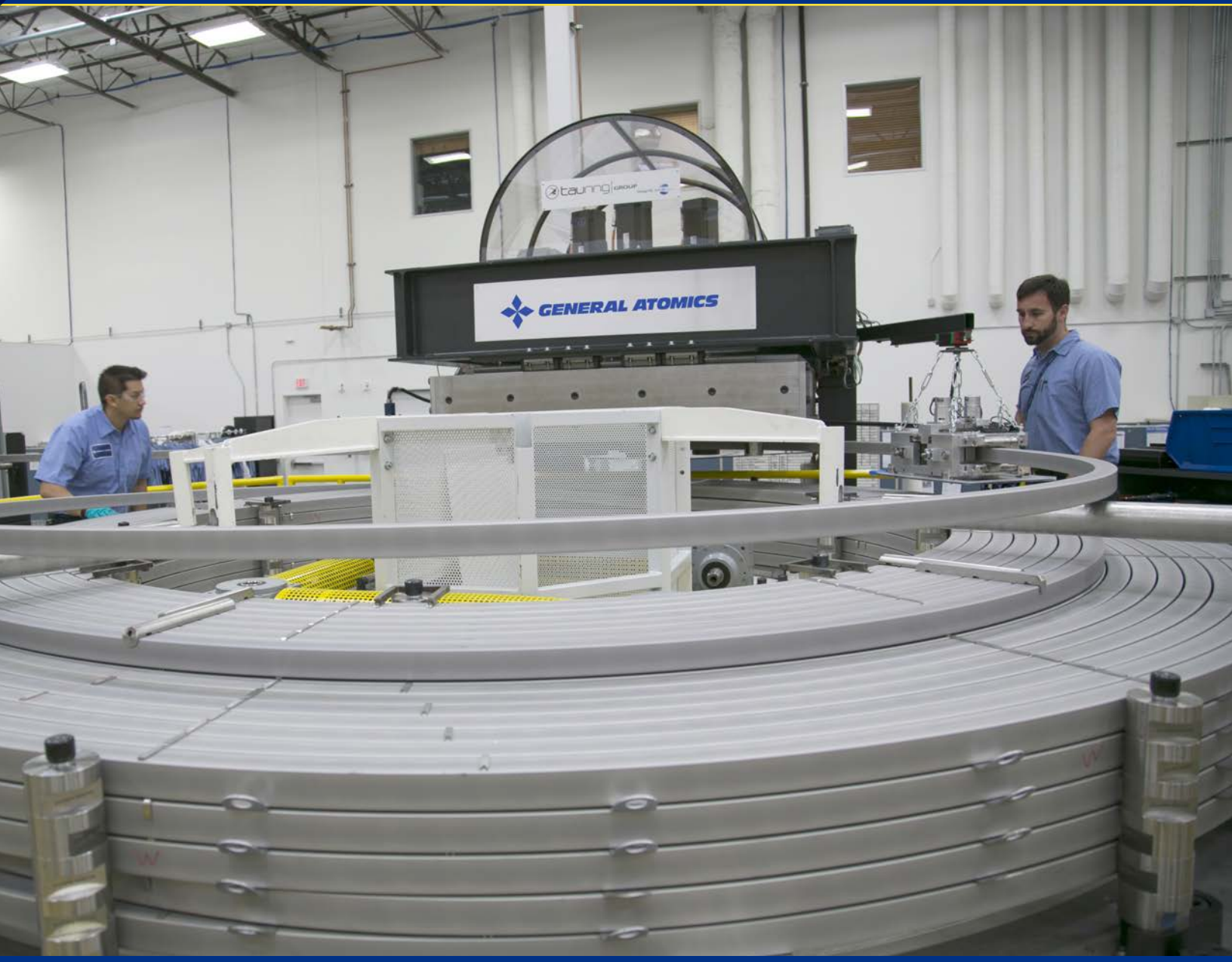
Conductor spools stored prior to winding

Moving Module Between Stations

Moving 250,000 lb. (110-tonne) module in facility requires air transporter

Station 2

Winding the Module



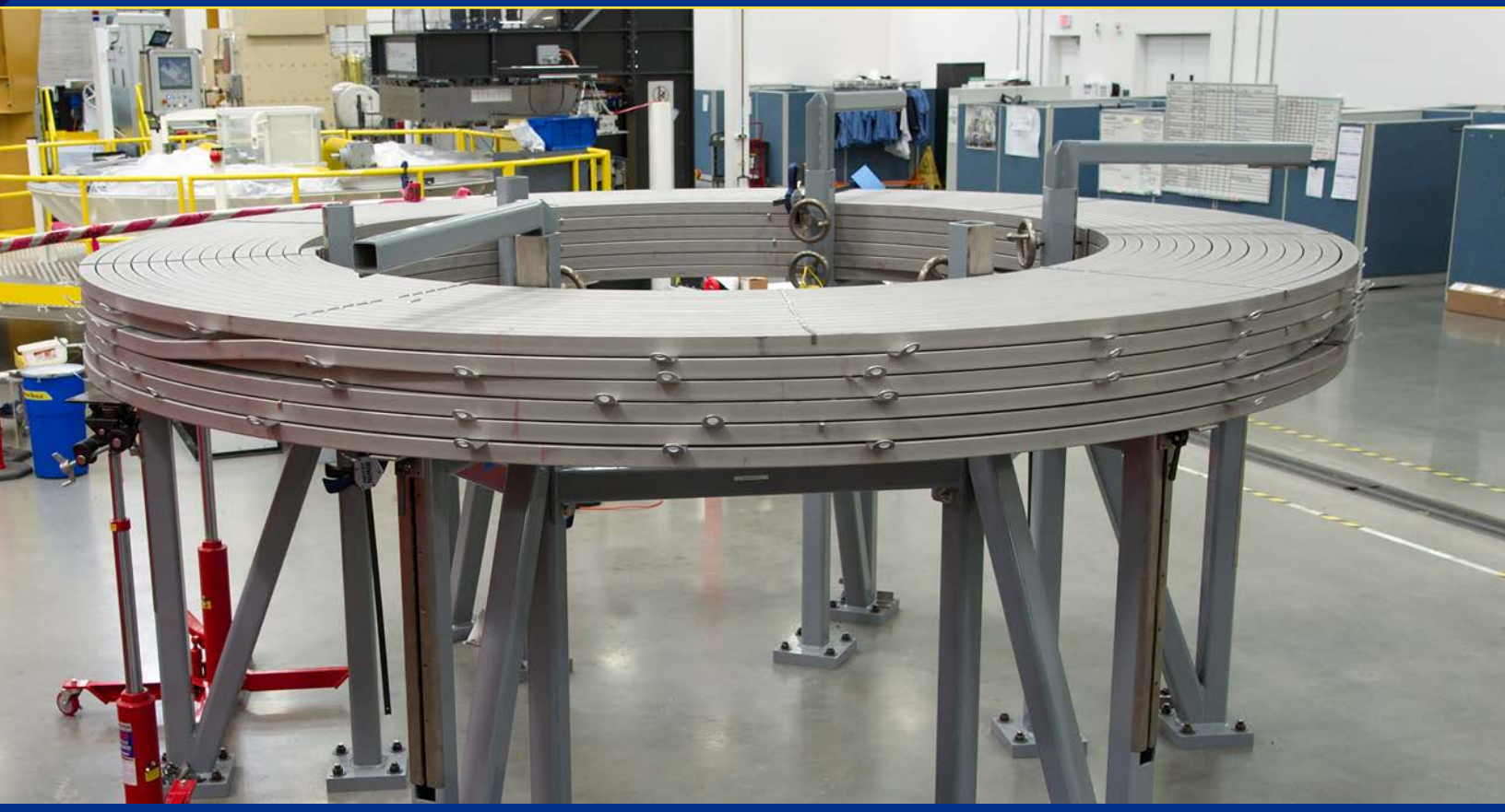
Each Central Solenoid module is fabricated from approximately 6,000 meters of niobium-tin (Nb_3Sn) conductor. The production module segment here is wound from 900 meters of conductor into 14-turn pancakes with six layers.

Bending to the required shape

Two spools loaded for winding

Station 3

Joint and Terminal Preparation



Wound six-layer submodules ready for terminal preparation

Terminal lead nearing completion

Conductor strands prior to chrome stripping

Conductor strands after chrome stripping

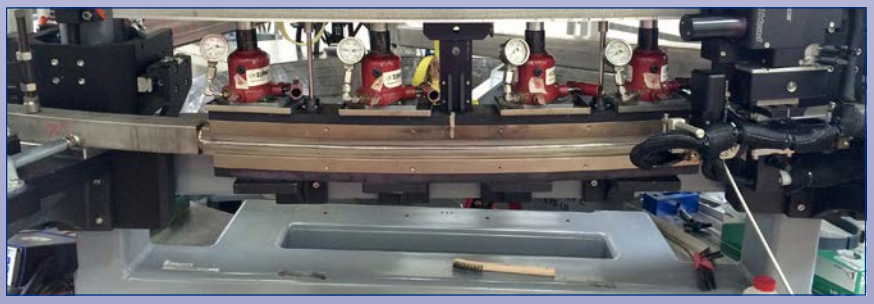
Station 4

Joining Coil Segments Together

Two hex submodules prepared prior to joining

Module with six completed splice joints

Splicing the conductor cable together similar to splicing a rope



Welding stainless steel cover over the splice joint

Six ITER CS modules in different fabrication stages:

1. Post resin injection on VPI station
2. Piping complete and ready for final test
3. Ground insulation
4. Post heat treatment
5. Stack and Join
6. After thermal cycle and power testing

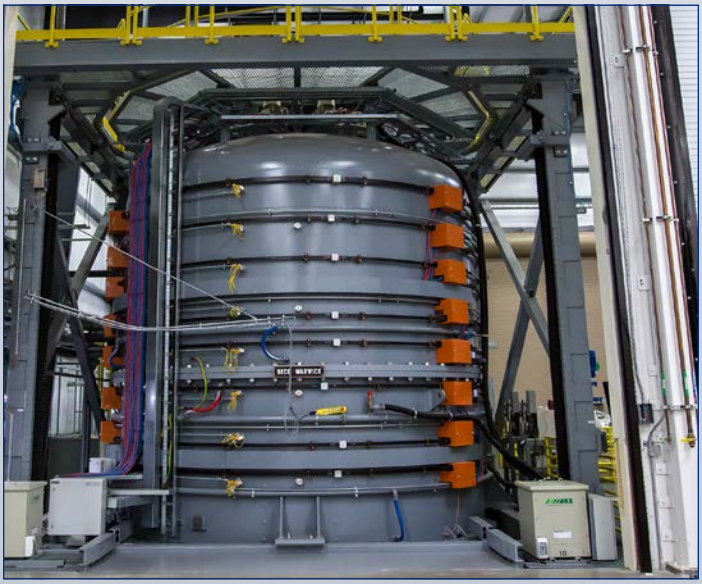

KONECRANES
25 TON
15 TON
22 TON
4
5
6

Station 5

Reaction Heat Treatment

Placing module in furnace for heat treatment at 650°C (1200°F)

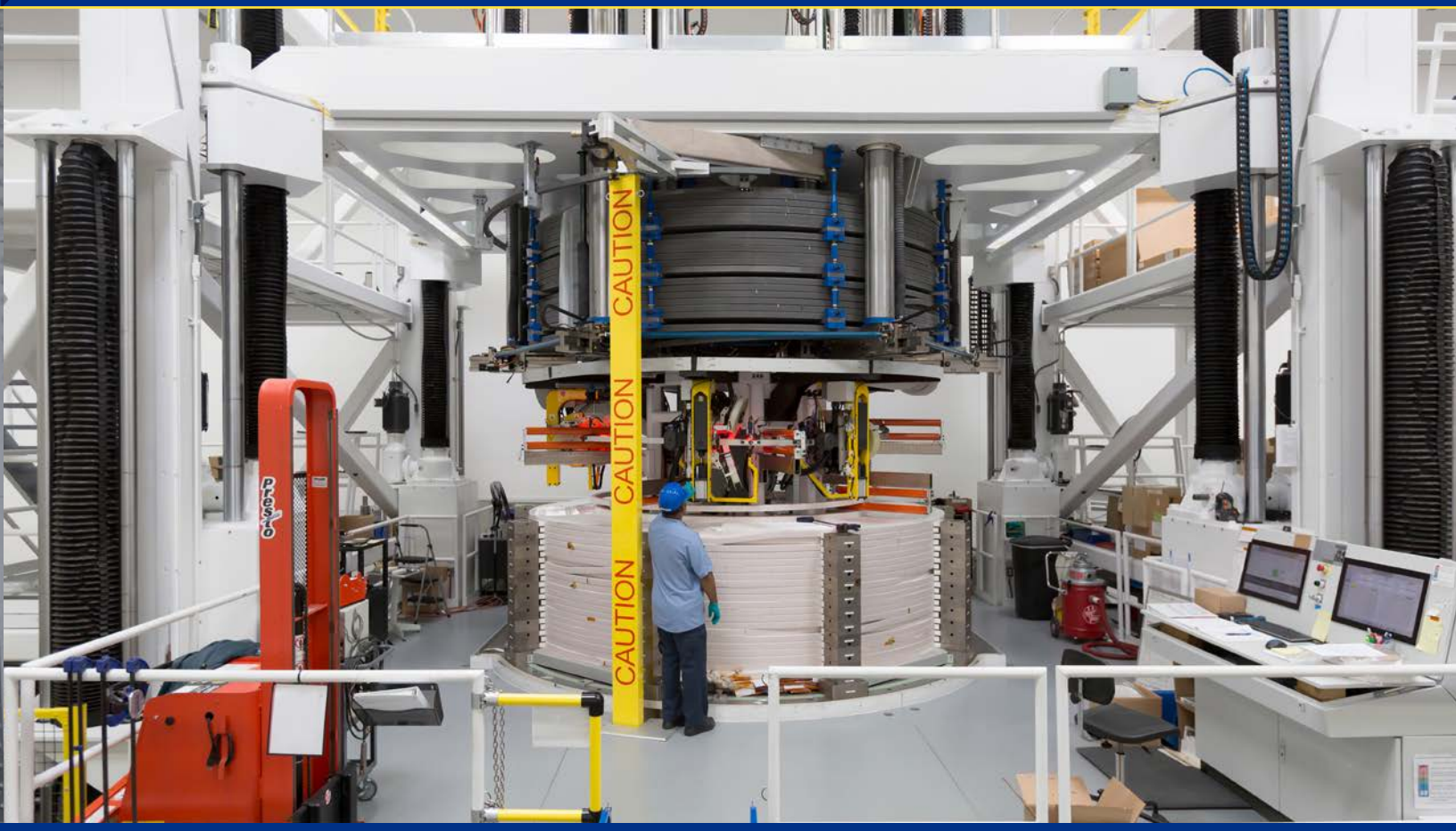
Technician inspecting module after heat treatment



Furnace closed for module heat treatment

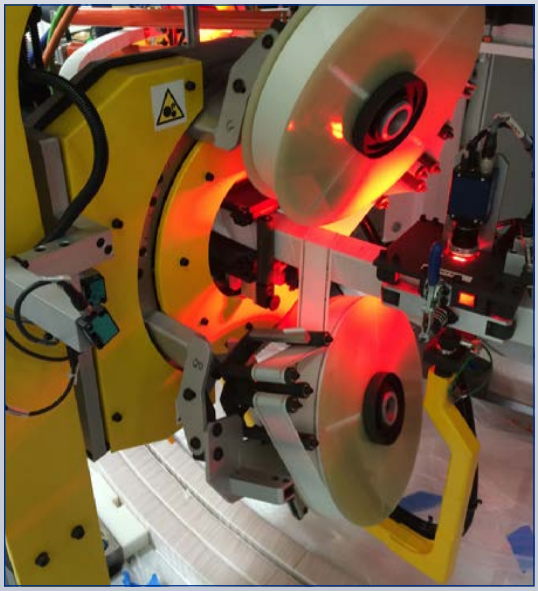
Station 6

Turn Insulation Station



Turn insulation station structure lifts and raises 110-tonne module and releases individual turns for insulation wrapping

Turn insulation of module nearing completion



Automated heads wrapping fiberglass tape around the conductor

Station 7

Ground Insulation Station

Helium inlet pipe with ground insulation

Module during ground insulation application

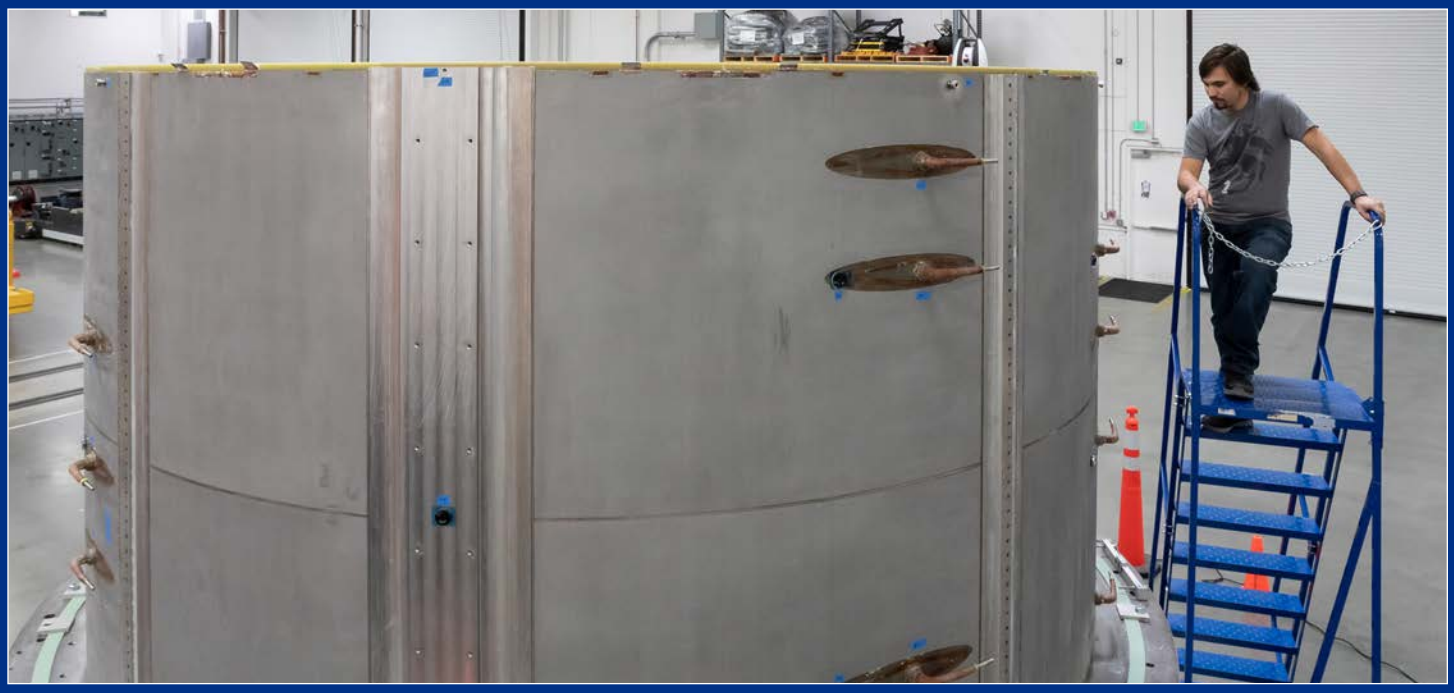
Technician inspects helium outlet pipe insulation on a completely insulated module

Station 8

Vacuum Pressure Impregnation

VPI mold being placed over the module in preparation for resin injection

Module mold alongside resin tanks and mixing pump system for injecting 3,500 liters of resin to encapsulate the module



Completed module after resin injection

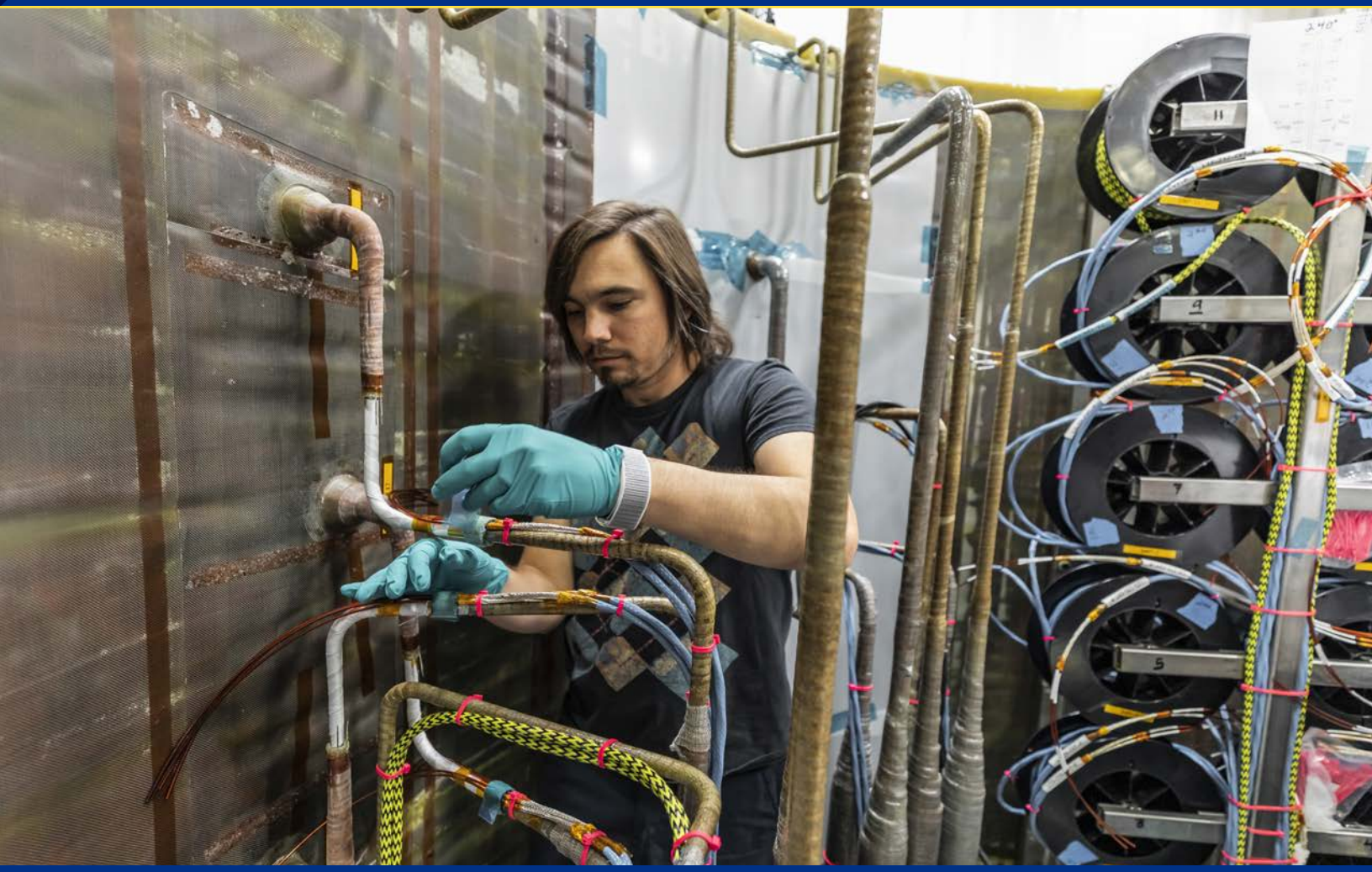
Turnover Tool

Modules require rotation to exchange bases under coil and allow access for piping installation

Turnover of module in process

Station 9

Helium Piping



Technician applying insulation to piping on inner bore

Thirty-nine helium pipes welded and insulated to provide the supply and return for supercritical helium at 4.7 K

Module after piping installed

Station 10

Final Testing

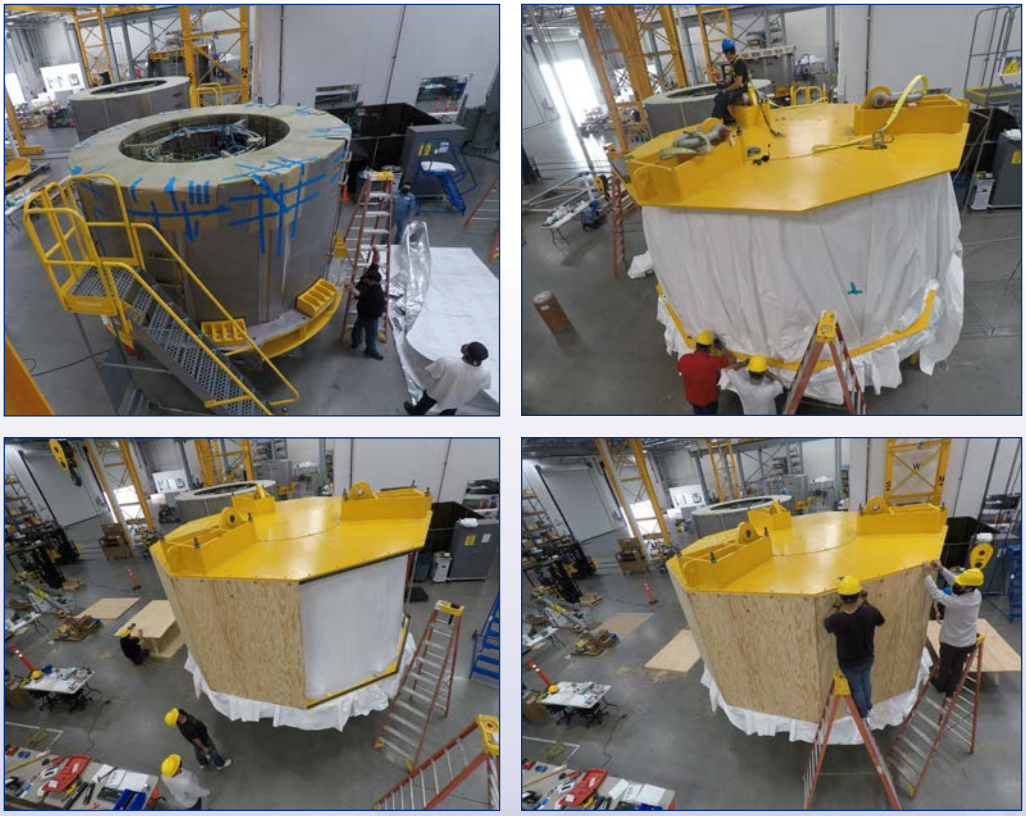
Module in final test chamber with camera system installed ready to begin high voltage testing

1 kW supercritical helium supply system used for cooling the CS modules to 4.7 K

Module in final test chamber

50kA magnet charging power supply with 1GJ fast discharge system including 7kV DC switch and dump resistor for full-current testing of CS modules

Preparing module for shipment



Preparation for Shipment

Moving the packaged module out to the loading dock

Loading module for transport

Lowering module into the 24-axle super-heavy trailer

Setting the module inside the cradle

Locked down and ready to go

Transporting module to port in Houston, TX


OVERSIZE LO

If you have unique, precise superconducting magnet fabrication needs, contact us:

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