Recent Contributions of the ITER Members

More than 80 percent of the cost of ITER is contributed in the form of components manufactured by the partners. Each member has a Domestic Agency to oversee products designed and fabricated by its companies, universities, and laboratories. This list of recent milestones illustrates the value being contributed by each member for the mutual benefit of all.

[Photos and graphics in the links below are available in high resolution on request to ITERCommunication@iter.org.]

Europe

Domestic Agency: Fusion for Energy (F4E) in Barcelona, Spain

On-site construction:

As part of its 45.6 percent contribution to ITER, Europe is constructing all the buildings of the ITER scientific installation. Today, the European Domestic Agency has completed 42 percent of work on site and signed 74 percent of work contracts.

Spectacular work is underway on the concrete-and-steel "bioshield" that will surround the ITER Tokamak. *See more information here and here*.

See the collection of Tokamak Complex construction photos here.
See all ITER construction photos here.

First cryopump:

ITER's six cryopumps will maintain an ultra-high vacuum in the 1,400 cubic meter vacuum vessel where fusion takes place. The cryopumps will trap particles on charcoal-coated panels and extract helium ash from the fusion reaction. Each cryopump will weigh 8 tons and stand 3.4 meters tall.

Two additional cryopumps will maintain a lighter vacuum in the cryostat, the 8,500 cubic meter chamber that will house the entire tokamak.

After 10 years of intensive R&D in Europe involving 15 hi-tech companies (*see more here*)—plus four years of fabrication by Germany's Research Instruments and France's Alsyom (*more on fabrication here*)—the first cryopump was delivered to ITER for testing on 22 August 2017.

After mechanical testing at ITER and cryogenic testing at Germany's Karlsruhe Institute of Technology, fabrication of the additional cryopumps will follow.

See articles on the delivery here and here.
See photos here.

Cryogenic tanks:

The ITER cryoplant will be the largest single-platform cryogenics facility ever built. Nearly 25 tons of liquid helium—at minus 269 °C—will circulate through a five-kilometer network of pipes, pumps and valves to cool the superconducting magnets, thermal shield, vacuum cryopumps and diagnostics.

Europe, India and the ITER Organization are all contributing components. Manufacturers have finalized most of the components of the liquid helium and liquid nitrogen plants and shipped 1,500 tons of material. Installation has started in the cryoplant building on site.

Europe is responsible for the liquid nitrogen plant plus auxiliaries. In October it delivered the last of eleven tanks for helium and nitrogen storage

See more on the ITER cryoplant here, with photos and graphics.
See more on recent tank arrivals here and here, with photos.
Additional photos here.

Negative ion beam source:

Three systems will be used to heat the hydrogen plasma to 150 million °C, the temperature needed for fusion. The "neutral beam" system will provide more than half the heating for the plasma by injecting two high-energy particle beams of 16.5 MW each (33 MW total) into the tokamak vacuum vessel.

The circumference of each particle beam is about 2.5 meters, greatly exceeding the size of previous beams, which had circumference of a dinner plate and a fraction of the power. The size of ITER requires thicker particle beams and faster individual particles in order to penetrate the plasma deeply enough to contribute to its heating.

In addition, new high-energy negative ion source technology must be used, instead of the positive ion source technology used in past machines. Years of research have gone into the optimization of these ion sources (*for more details, see this article*).

Last month, Europe successfully delivered a negative ion source to the SPIDER test bed of the Neutral Beam Test Facility in Padua, Italy. Here the critical components of the system will be tested in advance, before transfer and installation at ITER. Europe, Japan and India are all contributing components.

More on the Neutral Beam Test Facility here.
Photos of the SPIDER negative ion beam source here.

First toroidal field magnet core:

ITER will control the fusion reaction using magnetic confinement. Inside the metal torus or donut-shaped vacuum vessel of the ITER Tokamak will be a second, invisible cage created by magnetic fields. These powerful electromagnets will keep the heated plasma in circulation away from the walls.

Eighteen of these magnets, called toroidal field magnets, will be integrated around the vacuum vessel. These magnets are being manufactured both in Europe and Japan. The first of Europe's toroidal field magnet cores, called a "winding pack" and weighing 110 tons, was completed by the ASG consortium in May 2017 in La Spezia, Italy (*see more about that here*).

The magnet core has now been delivered to Italy's SIMIC, the company that will complete cold tests and insert the magnet core into its final case (*see more about the Japanese-manufactured coil cases here*). The completed magnet will then be delivered to the ITER site.

See more about ITER magnets here.
See pictures of the first European toroidal field winding pack here.

United States

Domestic Agency: U.S. Department of Energy, Oak Ridge National Laboratory in Oak Ridge, Tennessee, USA (US ITER)

Central solenoid:

In Poway, California, General Atomics is creating the ITER central solenoid, a pillar-like magnet standing 18 meters tall, sometimes called "the beating heart of ITER." (*See images from the General Atomics manufacturing line here.*)

The central solenoid is made up of six individual coils, made from approximately 6,000 meters of niobium-tin (Nb3Sn) conductor made in Japan. The central solenoid will be among the most powerful electromagnets ever built, strong enough to lift an aircraft carrier. Its maximum magnetic field will be 13 Tesla, equivalent to 280,000 times the magnetic field of the Earth.

The first central solenoid coil passed its heat treatment tests in May (*see photos*). The six modules of the central solenoid will be assembled at ITER in a vertical support structure. The first parts of the central solenoid assembly platform were delivered in October.

For more on the central solenoid see this article or this webpage.
For a collection of photos, see here.

U.S. completes electrical deliveries:

The U.S. has completed its contribution to ITER's steady state electrical network (SSEN), which will power the pumps and auxiliary loads of the ITER facility. The 35th and final shipment of equipment arrived at the ITER site in October. The global procurement was managed by Princeton Plasma Physics Laboratory; *for more details, see here*.

The U.S. is supplying 75 percent of SSEN components; Europe is supplying 25 percent. *See photo*.

Tokamak cooling water system:

The Tokamak cooling water system will absorb the heat produced by the ITER fusion reaction. More than 36 kilometers of nuclear-grade stainless steel piping for the system is being fabricated in Robinsville and Hernando, Mississippi. *See the story here*.

In October, the final design review was completed for the entire system—which means that more orders for high-tech equipment will soon be placed.

See photos here.

China

Domestic Agency: ITER China Office (ITER China) in Beijing, China

Magnet feeders:

ITER's magnet feeders will relay electrical power, cryogenic fluids and instrumentation cables from outside the machine in to the superconducting magnets, crossing the warm/cold barrier of the machine. These complex systems are equipped with independent cryostats and thermal shields and packed with a large number of advanced technology components such as the high-temperature superconductor current leads, cryogenic valves, superconducting busbars, and high-voltage instrumentation hardware. They will be among the first components installed.

China is supplying all 31 feeders. The first feeder arrived in France in October; *see the story with photos and video here*.

See additional photos here.

Correction coils:

The correction coils are ITER's smallest superconducting magnets. Weighing no more than 4.5 tons each, they are delicate by ITER standards, much thinner and lighter than the massive toroidal field and poloidal field magnets. Yet their role is vital: to fine-tune the magnetic fields to offset any imperfections in the position and geometry of the main magnets.

China is producing these magnets. Eighteen superconducting correction coils will be distributed around the ITER Tokamak at three levels. Qualification activities are completed and production is underway on the first coils and cases. *For details, see here and here*.

See photos here.

Electrical conversion components

In addition to the steady state network that will supply electricity to buildings and auxiliary systems, ITER will operate a pulsed power electrical system (PPEN) to deliver power to the magnet coils and the heating and current drive systems during plasma pulses.

Earlier this year, China delivered the last of the PPEN voltage transformers (*see more here*) for the pulsed power electrical network (PPEN). In October, China delivered four 128-ton converter-transformers for the magnet power conversion system (*see more here*).

See photos here.

Russia

Domestic Agency: Project Center ITER (ITER Russia) in Moscow, Russia

Poloidal field coil #1

Six ring-shaped poloidal field coil magnets will encircle the ITER machine to shape the plasma and contribute to its stability by "pinching" it away from the vacuum vessel walls.

Poloidal field coil #1 (PF1) is being built at the Srednenevsky Shipbuilding Plant in Saint Petersburg, Russia. Specialists from the Efremov Institute and other Russian experts are winding niobium-titanium superconductor material into flat "pancakes." The fifth of eight pancakes that will make up the PF1 magnet is now being wound.

The final PF1 magnet, which will weigh 300 tons, will be shipped to ITER and installed at the top of the machine. *See more details here.*

See photos here.

First completed port stub extension for vacuum vessel

The ITER vacuum vessel, where the fusion reaction occurs, will be encased in a second, much larger vessel, the cryostat. Each of the vacuum vessel's 44 openings will have custom-made "extensions" to create the junction to the cryostat. The upper-level ports are being built in Russia.

While the extension pieces are small in relation to the vacuum vessel, they are still quite sizable. Port stub extension (PSE) #12, for example, weighs more than 17 tons, covers an opening of 4 meters x 2.5 meters, and is 3.4 meters in length. Last month Russia completed PSE #12 and shipped it to Korea, where it will be welded onto its vacuum vessel sector. See more details here.

See photos here.

Power supply and magnet protection system

Russia is responsible for a wide variety of electro-technical components that make up the switching networks, fast discharge units, DC busbars and instrumentation procurement package. Manufacturing is underway now on the busbars and switching network resistors; and the R&D program is concluding for the fast discharge unit components. See more details here.

See photos here.

Korea

Domestic Agency: ITER Korea in Daejeon , Korea

Vacuum vessel fabrication

The ITER vacuum vessel, a donut-shaped stainless steel chamber heavier than the Eiffel Tower and more than 10 times larger than the next largest tokamak, is being built in nine pieces, like sections of an orange. Europe is building five sections, and Korea four.

Korea has completed the first segment of vacuum vessel sector #6 on schedule and is proceding with non-destructive examination. Sector #1 is nearly half complete, and sector #8 is well underway. *For more details on vacuum vessel fabrication, see here.*

For general information on the ITER vacuum vessel see this webpage.
See photos here.

Giant assembly tools to pre-assemble the vacuum vessel

The tools ITER will use to assemble the vacuum vessel sectors are truly colossal: six stories high with “wings” that spread 20 meters. Each tool weighs 800 tons. Each is strong enough to hold a 440-ton vacuum vessel sector and two 310-ton toroidal field magnets in its arms, bringing them together to make a unit.

Two of these “sector sub-assembly tools” (SSATs) will work side-by-side in the 60-meter-high ITER Assembly Hall. They will pre-assemble the nine sectors of the vacuum vessel with other components before their transfer to the Tokamak Pit, where they will be welded together to form the ITER vacuum chamber.

Korea delivered the first SSAT to ITER in batches over the summer. It is currently being erected in the Assembly Hall. A second, identical, tool is under fabrication in Korea. For more details, see here, here and here.

See photos here.

Thermal shield

Since ITER's superconducting magnets must be cooled to minus 269°C, they must be heavily protected from any heat source. The toroidal field magnets, which surround the vacuum chamber, require a special high-tech thermal shield: stainless steel electroplated in silver.

At SFA Engineering Corporation in Changwon, Korea, the fabrication of the ITER thermal shield is now underway. *See more details here.*

See photos here.

India

Domestic Agency: ITER India in Gandhinagar, India

Cryostat assembly underway

The 3,800-ton ITER cryostat will be the largest stainless steel vacuum chamber in the world. It will encase the entire vacuum vessel and all the superconducting magnets, ensuring an ultra-cool, protective environment.

India is manufacturing the cryostat, but it is far too massive to be shipped as a whole. Steel segments have been precision-fabricated by Larsen & Toubro in India and transported by sea to Marseille. About half the cryostat has been shipped so far. At the ITER worksite, the Indian Domestic Agency is supervising a team of German welders in the final fabrication of the first two sections—the base and lower cylinder.

The cryostat base, at 1,250 tons, will be among the heaviest single loads of machine assembly. It will also be the first major component installed. *For more details on the fabrication, see here. For recent progress, see here.*

See photos here.

Cryolines

More than five kilometers of "cryoline" piping will be used to deliver cryogenic cooling fluids—liquid helium and liquid nitrogen—to ITER components. These cryolines will travel along an elevated bridge from the cryoplant to the Tokamak Building. From there, the distributed cryoline network will cool the ITER magnets, thermal shield, and cryopumps.

The first batch of cryolines was shipped to ITER in June. *For more details, see here.*

See photos here.

Japan

Domestic Agency: ITER Japan in Naka, Japan

Toroidal field coil magnets and cases

Japan has the responsibility for making 9 of ITER's 19 toroidal field coil magnets, as well as all of the cases for these magnets. Japan's first toroidal field winding pack was realized in 2017 by Mitsubishi Heavy Industries Ltd/Mitsubishi Electric Co; a second is underway at Keihin Product Operations/Toshiba Corp.

The steel cases are being made in segments at Mitsubishi Heavy Industries in Futumi, Japan. They constitute the main structural element of the magnet system—not only encasing the winding packs that make up the core of the toroidal field magnets, but also anchoring the poloidal field coils, central solenoid and correction coils.

In September Japan shipped the first segment of the first case. *See more details here. For more about the function of the cases, see here. For more about the completion of Japan's first toroidal field magnet core earlier this year, see here.*

See photos here.

Superconductor for the central solenoid

The central solenoid, the gigantic pillar at the core of the ITER Tokamak, is being built in southern California. But the production of 43 kilometers (745 tons) of special niobium-tin (Nb_3Sn) superconductor that will make up this magnet is the responsibility of Japan.

Japan recently completed a major milestone, shipping the last of this material to the U.S., where it will be wound into the modular coils that make up the central solenoid magnet. *For more on the fabrication of the central solenoid, see here. For more on Japanese production, see here.*

See photos here.

Deliveries to the Neutral Beam Test Facility

The "neutral beam" system will provide more than half the heating for the ITER plasma. Given the groundbreaking nature of this system, a full-scale Neutral Beam Test Facility has been constructed in Padua, Italy, with significant contributions from Japan.

In November, Japan completed its deliveries of power supply components. *More information [here](#).*

See photos [here](#).

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