ELECTRON CYCLOTRON TRANSMISSION LINES

A prototype transmission line assembly. Photo: US ITER

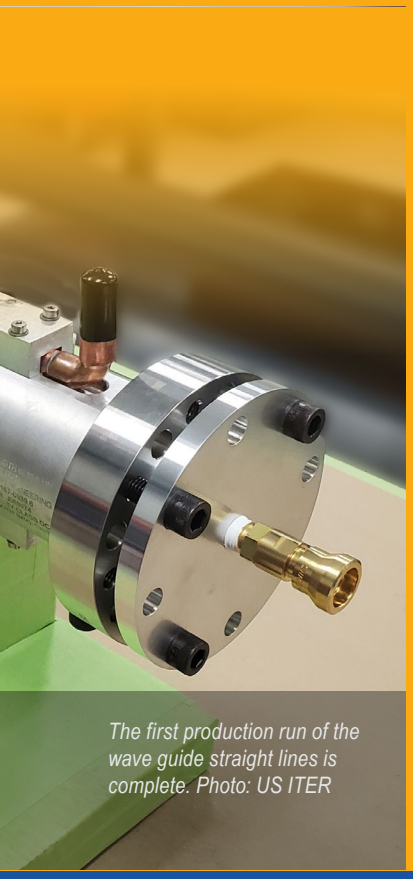
U.S. CONTRIBUTION

US ITER is responsible for research and development, design, and fabrication of the electron cyclotron heating transmission lines for the international ITER fusion project.

OVERVIEW

The electron cyclotron heating transmission lines enable a mission-critical plasma in ITER by supporting the delivery of microwave energy with a unique range of power, pulse length, and frequency.

The system heats the electrons in the plasma, using a high-intensity beam of microwave radiation to heat very specific locations in order to generate, guide, and control the plasma. Power is provided by high frequency gyrotrons with efficient power transfer from the gyrotron sources to launchers in the tokamak port plugs. The transmission lines feature multiple lines of evacuated aluminum waveguides with internal corrugations that minimize power transfer losses to 10% or less. Approximately 2.5 miles (4 kilometers) of transmission line will be provided, connecting 24 sources to 56 feeds.



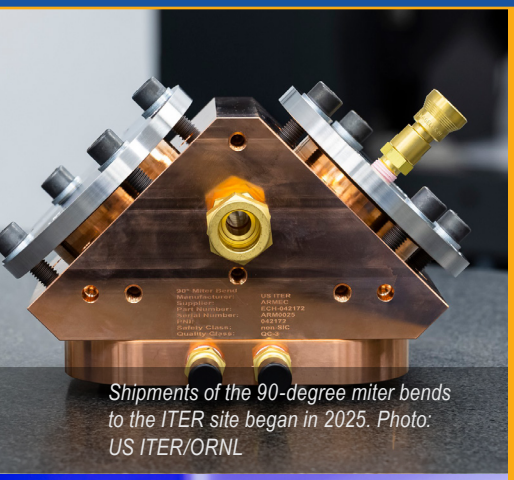
The first production run of the wave guide straight lines is complete. Photo: US ITER

STATUS

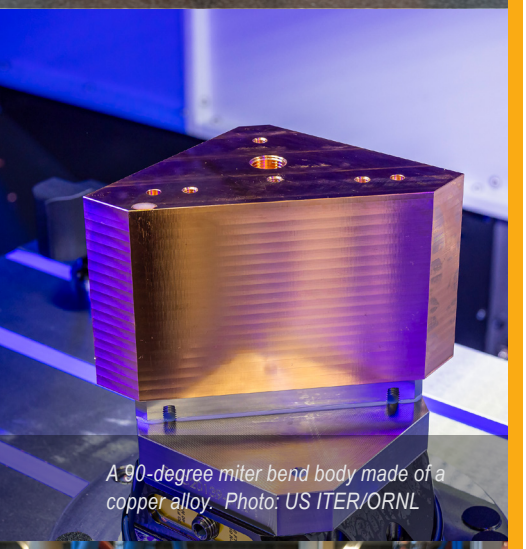
In early 2026, the team received full approval on final design for the first 24 transmission lines, including all microwave components and structural supports.

Fabrication and high-power microwave testing have been completed on 9 of 10 prototype components, with testing of the final prototype scheduled later this year. Contracts have been awarded to industry for the transmission line waveguide, switches, miter bends, expansion units, the direct-current (DC) breaks, pump outs, and radio-frequency load components.

In late 2025, the international project approved a major upgrade of the electron cyclotron heating transmission line system after deciding to use tungsten for the tokamak's first wall. The resulting revisions to the first 24 transmission lines will be finalized later this year. Due to confidence in US ITER's design capability and supply chain execution for electron cyclotron components, the international project approved a task agreement for US ITER to provide an additional 48 transmission lines. The next round of final design reviews for specific components are scheduled for 2026 and 2027.



Shipments of the 90-degree miter bends to the ITER site began in 2025. Photo: US ITER/ORNL



A 90-degree miter bend body made of a copper alloy. Photo: US ITER/ORNL

A direct-current (DC) break for electron cyclotron transmission lines.Photo: US ITER

CONTACT

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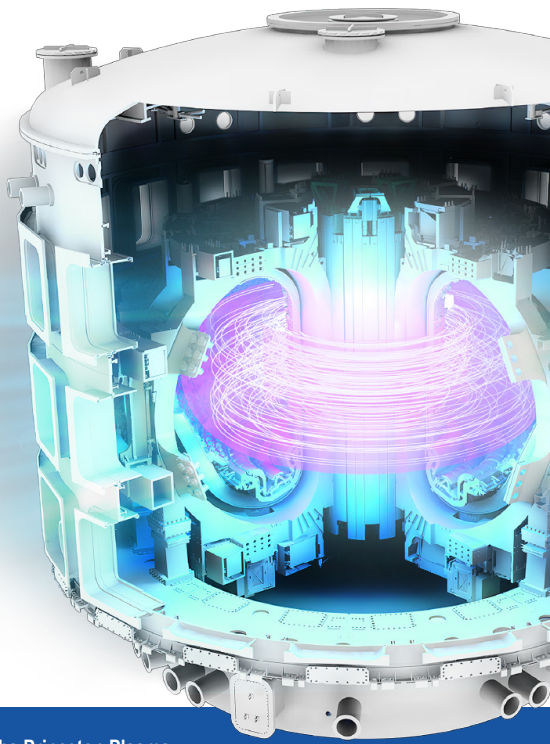
TECHNICAL DESCRIPTION

Power transfer from 170 GHz gyrotron sources to launchers
Provide efficient power transfer from 72 170-GHz gyrotron sources to five separate launchers
Transmit up to 1.2 MW per line for up to 1 hour
On average, power loss < 10%
On average, HE11 mode content > 93%

CONTRIBUTORS INCLUDE

ARMEC Corporation (Knoxville, TN)
Curti Costruzione Meccaniche S.p.A (Castel Bolognese, Italy)
Dymenso LLC (San Francisco, CA)
EPFL Swiss Plasma Center (Lausanne, Switzerland)
General Atomics (San Diego, CA)
Keller Technology Corporation (Tonawanda, NY)
Lisega, Inc. (Kodak, TN)
Precision Fabricating & Cleaning, Inc. (Cocoa, FL)
Rhinestahl AMG (Mason, OH)
Technetics Group (Columbia, SC)
Teledyne Brown Engineering Inc. (Huntsville, AL)
Vacuum Technology, Inc. (Oak Ridge, TN)



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