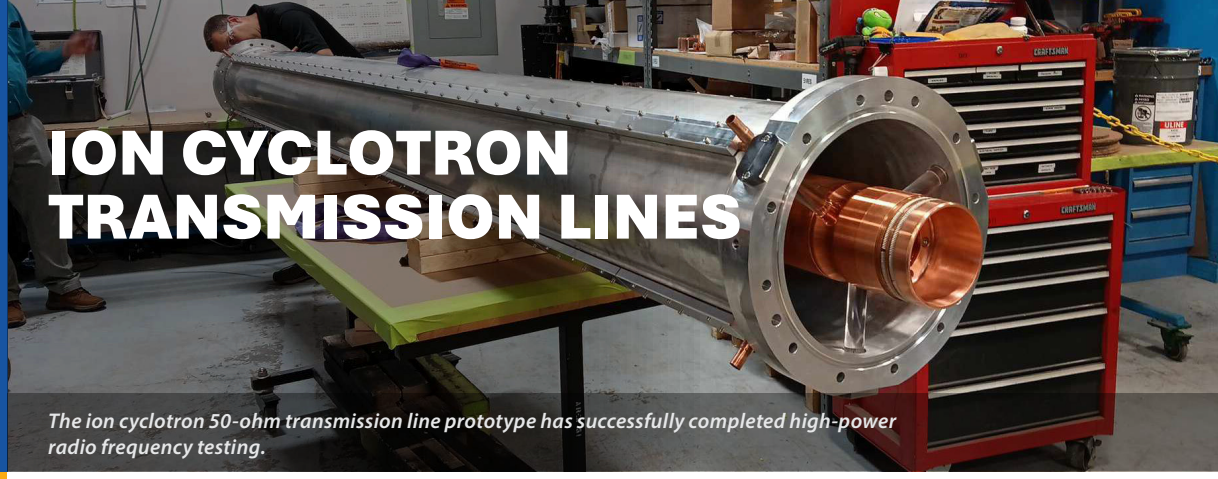
ION CYCLOTRON TRANSMISSION LINES



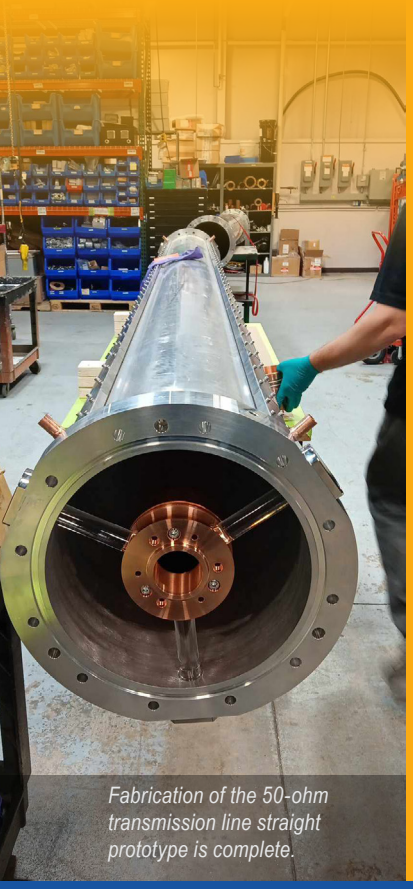
The ion cyclotron 50-ohm transmission line prototype has successfully completed high-power radio frequency testing.

U.S. CONTRIBUTION

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

OVERVIEW

The ion cyclotron heating transmission lines enable a mission-critical burning plasma in ITER by supporting the delivery of high-power radio frequency heating. The ion cyclotron heating and current drive system heats the ions and electrons in the plasma with a high-intensity beam of electromagnetic fields. Generators produce high-power radio frequency waves that are carried along multiple transmission lines to antennas in the vacuum vessel, which then launch the heating fields into the plasma. The ion cyclotron transmission lines will provide efficient power transfer from between the radio frequency sources and the plasma heating antennas.
The system includes coaxial transmission lines and a matching/tuning system to minimize power transfer losses. The pressurized lines can transmit up to 6 MW per line. In total, approximately a mile (1.5 kilometers) of line will connect 8 sources to 16 antenna feeds.



Fabrication of the 50-ohm transmission line straight prototype is complete.

STATUS

Major layout changes were introduced to the ion cyclotron transmission line system in late 2025 as a result of the international project's decision to implement a tungsten first wall. The team has nearly completed preliminary design of the transmission lines system. Of 16 prototypes planned, industry partners have fabricated four: a transmission line straight, a gas barrier, a 90-degree elbow, and an assembly bellows. Testing at Oak Ridge National Laboratory is scheduled to begin this year. Multiple design-build prototype contracts with industry are planned as part of preparation for manufacturing.

U.S. DEPARTMENT of ENERGY
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The resonant ring line at ORNL. Photo: US ITER

A 50-Ohm transmission line straight component. Photo: US ITER/ORNL

A blower component for the high-powered resonant test line at ORNL. Photo: US ITER/ORNL

TECHNICAL DESCRIPTION

Transmission line operational frequency range: 40-55 MHz

Transmission line connects 4 RF sources to 8 antenna feeds

1 km combined length, 30 cm diameter transmission lines through three buildings

Power coupled to plasma per antenna: 10 MW (future upgrade, 20 MW)

Maximum pulse length: 3,600 s, 25% duty cycle (1 hour on, 3 hours off)

Provide fast arc detection, real-time processing of a multivariable state-space impedance control system to enable maximum radio frequency power transmission to the plasma

CONTRIBUTORS INCLUDE

Cincinnati Fan (Mason, OH)

Comet (San Jose, CA)

Dielectric Communications (Raymond, ME)

Microwave Techniques, LLC (Gorham, ME)

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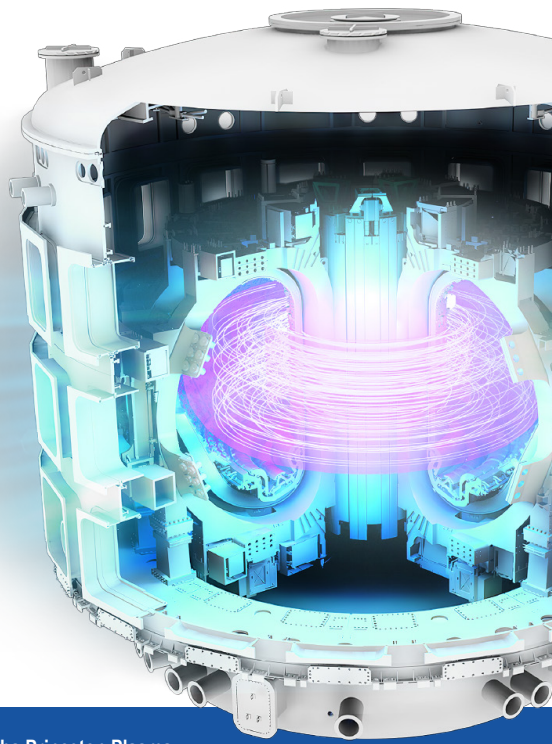
Vacuum Technology, Inc. (Oak Ridge, TN)



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