



INSTRUMENTATION & CONTROLS

U.S. scope for instrumentation and controls spans seven different hardware systems. Photo: iStock

U.S. CONTRIBUTION

US ITER is providing instrumentation and controls for six systems of the international ITER fusion project: electron cyclotron heating transmission lines, ion cyclotron heating transmission lines, diagnostics, pellet injection, roughing pump systems, and vacuum auxiliary systems.

OVERVIEW

The work scope for instrumentation and controls includes conceptual, preliminary, and final design; software design; hardware and software procurement; equipment fabrication; software code development; and qualification and testing.

The instrumentation and controls for non-safety ITER systems conform to the distributed real-time control of ITER plant systems based on EPICS (Experimental Physics and Industrial Control System).

For four of the ITER systems – electron cyclotron heating transmission lines, ion cyclotron heating transmission lines, pellet injection, and disruption mitigation systems – instrumentation and controls must provide hierarchical control and exception handling to the ITER Plasma Control System for control of plasma shape and kinetic parameters. For ITER systems involving nuclear safety, functions of instrumentation and controls are qualified based on International Electrotechnical Commission (IEC) safety lifecycle standards for nuclear power plants. All instrumentation and controls also are designed in compliance with the French Nuclear Safety Authority (ASN), including IEC and Institute of Electrical and Electronics Engineers requirements related to nuclear power plants as a nuclear licensed fusion reactor.

STATUS

For instrumentation and controls, several systems are in fabrication stage with deliveries ongoing: the non-tritiated service vacuum pumps, cryostat roughing and regeneration pumps, the cryo-guard vacuum system, and the service vacuum system. Final design is complete for instrumentation and controls of the vacuum auxiliary system, service vacuum system, and electron cyclotron heating transmission lines. The roughing pump tritiated system, vacuum auxiliary system tokamak and diagnostics residual gas analyzer I&C systems are in the final design phase. Preliminary design is ongoing for the pellet injection system and ion cyclotron heating transmission lines.



Static magnetic field testing of variable power supply. Photo: US ITER



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National Laboratory





Neutron testing of operational amplifiers and level translators at Ohio State University Research Reactor. Photo: US ITER/ OSURR



Gamma testing of piezo-resistive pressure transducers at Sandia National Laboratory Gamma Irradiation Facility. Photo: US ITER/SNL



Testing of I&C components at the Ohio State University Research Reactor. Photo: US ITER/ OSURR

TECHNICAL DESCRIPTION

Vacuum I&C: Includes the vacuum system (VICS) and development of custom radiation-hardened electronics, as well as VICS-supervised I&C systems for the cryo-guard vacuum system, service vacuum system, electron cyclotron heating, ion cyclotron heating, and Type 2 diagnostics. These I&C systems span from conventional programmable logic controllers to custom electronics for high-radiation/high-magnetic field areas. The I&C systems monitor process conditions with vacuum gauges and other instruments and actuate vacuum and gas supply valves. For the roughing pump system, 44 pumps of three different pumping technologies and four condensable vapor devices will be monitored and controlled. Additionally, the controls of the cooling water system for the pumps and for the positive pressure gas and venting systems are provided.

Ion cyclotron heating I&C: Scope includes an interface to fast arc detection, real-time processing of a multi-variable state-space impedance control system to enable maximum radio frequency power transmission to the plasma, calorimetric measurements and control of water cooling loops and gas cooling loops.

Electron cyclotron heating I&C: Scope includes fast arc detection, calorimetric power measurements, polarization control, data acquisition, and monitoring and control of cooling loops for the transmission lines.

Pellet injection I&C: Scope includes control of valve actuators and monitoring of gas and pressure under real-time interaction with ITER plasma control.

Diagnostics I&C: Scope includes development of diagnostic residual gas analyzer readout system, development of custom impedance matching of quadrupole mass spectrometer radio-frequency controller to enable operation in high radiation environment, plus coordination of U.S. diagnostic infrastructure system architecture, common I&C solutions, and expert guidance on ITER standards and procedures.

CONTRIBUTORS INCLUDE

Cosylab USA, Inc. (Palo Alto, CA): I&C software design and development

Ellitek, Inc. (Knoxville, TN): Fabrication of wall-mounted cubicles for the service vacuum system and cryo-guard vacuum system maintenance and commissioning control system carts

Hidden Analytical (Warrington, United Kingdom): Radiation hardened quadrupole mass spectrometer prototype development

O'Brien/Ametek (St. Louis, MO): Fabrication of pneumatic tubing bundles

Ohio State University (Columbus, OH): Neutron radiation test user facility used for neutron testing of I&C components

PMC-STS (Danbury, CT): Radiation hardened piezo-resistive pressure transducer prototypes

Sandia National Laboratory (Albuquerque, NM): Gamma Irradiation Facility used for gamma testing of I&C components

VTI, Inc. (Oak Ridge, TN): Fabrication and I&C procurement of the cryo-guard vacuum system cubicles

CONTACT

Team Manager:

Claudell Harvey
harveycm@ornl.gov

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US ITER is managed by Oak Ridge National Laboratory in Tennessee, with partner labs Princeton Plasma Physics Laboratory in New Jersey and Savannah River National Laboratory in South Carolina.