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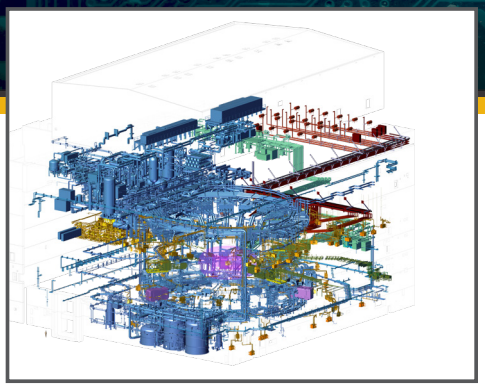
Instrumentation & Controls

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



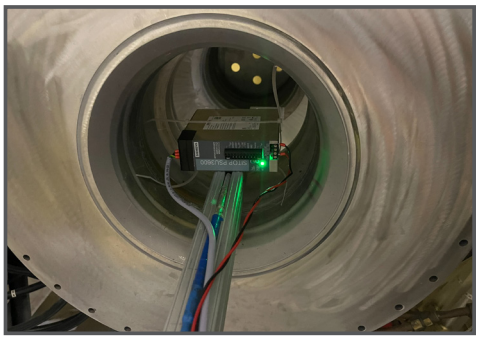
US ITER is responsible for providing instrumentation and controls for seven U.S. systems. Image: US ITER

U.S. Contribution

US ITER is providing instrumentation and controls (I&C) for six systems: the electron cyclotron transmission lines, ion cyclotron 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; and qualification and testing. Distributed real-time control of ITER plant systems is based on EPICS (Experimental Physics and Industrial Control System) for non-safety systems. Hierarchical control and exception handling is provided to the ITER Plasma Control System for control of plasma shape and kinetic parameters for electron cyclotron and ion cyclotron plasma heating systems, pellet injection, and disruption mitigation systems. Nuclear safety functions are based on the HIMA Planar4 logic solver contained within a cubicle assembly and qualified based on International Electrotechnical Commission (IEC) 61513 I&C safety lifecycle for nuclear power plants. All I&C equipment must be 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.



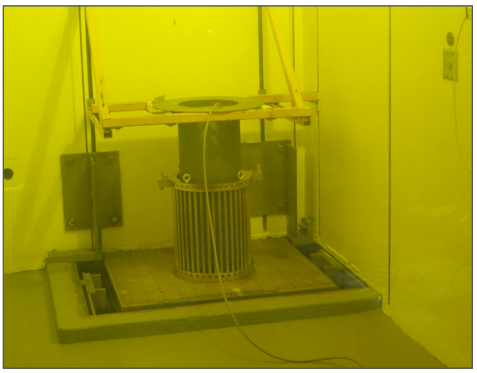
Static magnetic field testing of variable power supply. Photo: US ITER

Status

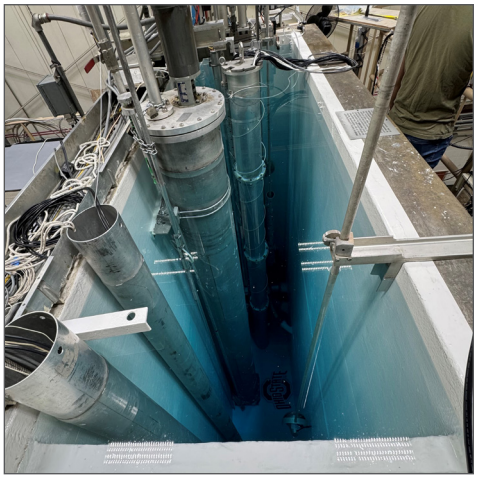
For instrumentation and controls (I&C), final designs have been completed for the cryo-guard vacuum system and the service vacuum system, and these systems are in the fabrication phase with deliveries ongoing. Final design is also complete for the non-tritiated service vacuum system pumps and cryostat roughing and regeneration pumps. I&C teams are in preliminary design phase for the roughing pump tritiated systems and the vacuum auxiliary system supervisory control. The ion cyclotron heating transmission lines team has completed a final I&C design review for the radio frequency (RF) building, and the electron cyclotron heating transmission lines team also has completed a final I&C design review.

Instrumentation & Controls

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 I&C 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 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 condensating vapor devices will be controlled and monitored. Additionally, the piping and 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 124 water cooling loops and 14 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 584 cooling loops for the 24 transmission lines.

Pellet injection I&C: Scope includes control of actuators and monitoring of gas and pressure sensors 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 quadrapole 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

Dynamic Structural & Materials (Franklin, TN): Design and fabrication of prototype custom radiation hardened piezo pilot valves

Ellitek, Inc. (Knoxville, TN): Fabrication of wall-mounted cubicles for the service vacuum system

Hiden 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 Engineering (Danbury, CT): Radiation hardened piezo pressure transducer prototypes

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

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

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