

## **International Progress and Korean Strategy on Codes and Standards Development for Fusion Energy under a sub-project of the Global TOP Research Lab.**

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This presentation provides a comprehensive overview of recent international and domestic developments in Codes and Standards (C&S) for fusion energy systems, with particular emphasis on the status of ASME Section III Division 4 (Fusion Energy Devices, FE) and the Korean initiative to establish a KEPIC framework for fusion applications.

Fusion reactors based on the D-T reaction continuously generate 14 MeV high-energy neutrons and operate under extreme conditions, including ultra-high temperature plasma, intense heat flux, strong electromagnetic forces, and severe neutron irradiation damage reaching tens to hundreds of dpa. Key components such as superconducting magnets, vacuum vessels, in-vessel components (divertor, breeding blanket, and first wall), support structures, and reduced-activation materials must ensure structural integrity and safety under combined thermal, mechanical, and radiation loads. These operating environments differ fundamentally from those of conventional fission reactors and industrial plants, highlighting the limitations of directly applying existing nuclear codes without modification.

During ITER construction, applicable provisions of RCC-MRx and ASME BPVC were adopted wherever feasible. However, challenges remain in component classification, safety categorization, quality assurance requirements, inspection criteria, and the establishment of fusion-specific material databases. In response, ASME established BPVC Section III Division 4, "Fusion Energy Devices (FE)," and organized dedicated working groups addressing General Requirements, Materials, Magnets, Vacuum Vessels, and In-Vessel Components. Following the publication of the 2023 Edition, a phased roadmap has been implemented with planned updates toward the 2027 and 2029 editions to further refine technical provisions.

Internationally, the IAEA has initiated consultancy meetings and collaborative activities related to fusion

C&S. Programs such as UKAEA's STEP, EU DEMO safety design discussions, and private-sector initiatives in the United States (e.g., SPARC/ARC) demonstrate the increasing need for a coherent regulatory philosophy and a structured codes framework tailored to fusion energy. As private investment accelerates fusion development, identifying gaps in existing standards and establishing rational, risk-informed code systems have become essential to reducing cost, schedule, and technical uncertainties.

In Korea, the KEPIC Fusion Special Committee has initiated systematic efforts to establish a domestic fusion C&S framework. Key activities include analysis of fusion reactor concepts and component characteristics, review and translation of ASME FE draft provisions, and the formation of subgroups for materials and in-vessel components. A structured code framework has been proposed within KEPIC, including FAA (General Requirements), FAB (Magnetic Confinement Fusion), FBB (Vacuum Vessel), FC (In-Vessel Components), and FD (Materials). This approach aims not only to align with ASME FE but also to develop a phased, self-reliant domestic code system reflecting Korea's technical capabilities and industrial infrastructure.

Future efforts will focus on strengthening alignment with ASME FE, incorporating lessons learned from ITER and DEMO, establishing design allowables based on material data, and developing quality assurance, inspection, and certification systems. Through these activities, Korea seeks to support the growth of its domestic fusion industry and enhance global competitiveness in the era of fusion commercialization.

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