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Wed-Mo-Or1-02: Overview and Assembly Strategy of the VNS Magnet System: Innovations and Challenges

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The Volumetric Neutron Source (VNS) is a steady-state tokamak designed to bridge the technological gap between ITER and DEMO by enabling full-scale testing of tritium breeding blankets and other fusion reactor components under DEMO-relevant conditions. The VNS magnet system features an innovative magnetic cage architecture, where the superconducting poloidal field (PF) coils are positioned inside the toroidal field (TF) coils. This novel configuration significantly improves plasma equilibrium and controllability, reducing the required PF currents and stored energy while enhancing machine compactness and plasma shaping efficiency. This work provides an overview of the entire VNS magnet system, including the toroidal field (TF), poloidal field (PF), and central solenoid (CS) systems. These systems utilize dry conductors with High-Temperature Superconductors (HTS), while the CS and PF systems are optimized for enhanced performance and reduced energy requirements. Emphasis is placed on the unique assembly strategy, which involves in-situ TF coil winding around pre-installed PF coils and vacuum vessel components. Although this assembly approach introduces notable mechanical challenges compared to conventional methods, it leverages HTS technology to provide a feasible solution for constructing compact tokamak systems.
The paper concludes with a comparison of VNS assembly approaches, highlighting the trade-offs between mechanical complexity, superconducting performance, and manufacturability. The magnetic cage and in-situ winding concepts represent promising strategies for achieving VNS objectives within a compact, robust, and efficient fusion device.

Author: GIANNINI, Lorenzo (EUROfusion)

Co-authors: LUONGO, Cesar (ITER); Mr BACHMANN, Christian (EUROfusion); Dr MAVIGLIA, Francesco (EUROfusion); Dr FEDERICI, Gianfranco (EUROfusion); Mr BAJARI, Janos (EUROfusion); Dr SICCINIO, Mattia (EUROfusion)

Presenter: GIANNINI, Lorenzo (EUROfusion)

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