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Configuration Studies for a Low-Aspect-Ratio Liquid-Metal-Wall Sustained High-Power-Density Tokamak Facility

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Utilizing high-Z solid walls such as tungsten is challenging for next-step/Fusion Nuclear Science Facility (FNSF)/Pilot Plant applications due to a range of issues. These issues include Plasma-Facing Component (PFC) material damage from erosion and re-deposition and neutrons, high-Z impurity accumulation and associated core plasma radiative collapse, relatively low heat flux limits at the PFC, and thermal plasma pedestal energy confinement reduction. Liquid metal walls and divertors are increasingly being studied as a possible means of addressing these challenges. However, the impact of liquid metal systems on device configuration and core plasma performance at the Proof-of-Performance level (or higher) in a tokamak configuration has not yet been systematically investigated. In this work we explore possible configurations for a sustained high-power-density tokamak facility with lower aspect ratio (A = 1.8-2.5) dedicated to the study and development of a range of liquid metal divertor and first-wall concepts. Such a device would build upon past and expected results from liquid metal test-stands, the Lithium Tokamak Experiment (LTX), the National Spherical Torus Experiment Upgrade (NSTX-U), and the Experimental Advanced Superconducting Tokamak (EAST), but the device configuration is driven primarily by the needs (space, plumbing, thermal insulation, etc.) of liquid metal systems. Configuration studies build upon previous low-A High Temperature Superconductor (HTS) tokamak pilot plant studies that incorporated a liquid metal divertor for high-heat-flux mitigation and as a means of reducing poloidal field coil current and simplifying the magnet layout and maintenance scheme. Initial physics scenario and engineering configuration studies for a next-step liquid-metal wall and divertor toroidal confinement facility are described.

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