Fusion Nuclear Science Facility – Advanced Tokamak Option

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A Fusion Nuclear Science Facility (FNSF) is needed to make possible a DEMO of the ARIES-Advanced Tokamak (AT) type after ITER. One candidate, FNSF-AT or Fusion Development Facility (FDF), should have neutron wall loading of 1-2 MW/m^2, continuous operation for periods up to two weeks, a duty factor goal of 0.3 on a year and fluences of 3-6 MW-yr/m^2 in ten years to enable development of blankets suitable for tritium and electricity production while demonstrating all the critical elements necessary for the qualification and design of a DEMO.

FNSF-AT should develop fusion's energy applications and the operating modes needed in DEMO. It should produce its own tritium and build a supply to start up DEMO. The size of FNSF-AT (R = 2.7 m) and the significant level of fusion power produced (290 MW) require that it be self-sufficient in tritium. FNSF-AT will provide the necessary test ports and facilities to test different blanket concepts over a 10 year time period for tritium and electricity production.

With neutron fluence of 3-6 MW-yr/m^2 (30-60 dpa in 10 years) onto complete blanket structures and port material sample exposure stations (1 m^3), FNSF-AT can enable irradiation qualification of materials and components necessary for the qualification of DEMO design and operation. The chamber components will be subject to a high fluence of neutrons having a representative D-T fusion neutron energy spectrum. FNSF-AT will be a first demonstration of the operation of an all ferritic steel chamber tokamak. It will also be the critical facility for providing operational data on chamber component performance needed prior to building DEMO.

FNSF-AT should demonstrate advanced physics operation of a tokamak in steady-state with burn. FNSF-AT will be designed using conservative implementations of all elements of AT physics to produce 150-300 MW fusion power with modest energy gain ($Q < 7$) in a modest sized device. Conservative AT physics will enable full non-inductive, high bootstrap operation to demonstrate robust continuous operation of a tokamak for periods up to two weeks. It will address and demonstrate the necessary tritium recycling and safety control issues. It will also demonstrate the necessary design and cooling of the first wall chamber and divertor components needed for the qualification of the DEMO design.

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[1] R.D. Stambaugh, et al., submitted for publication in Fusion Sci. Technol. (2010).