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Diagnostics and Control for Steady State and Pulsed Tokamak DEMO

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This paper reports work done for EFDA PPPT in 2013. It includes the constraints of neutron fluence and Tritium Breeding Ratio(TBR) on diagnostics installation; the technology readiness level of a minimum diagnostics set for control (including burn control);an extended set of diagnostics for control code training; results on diagnostics technology; burn and divertor control. Two DEMO devices (2GW power) are considered:a long pulse inductive device (PLS) based on H-mode and a steady state(SS) fully non-inductive device. The differences in parameters and operational constraints lead to different requirements for the diagnosis and control of the devices. The space available is limited by cost constraints regarding blanket thickness and Li6 enrichment to achieve the necessary TBR>1, so in DEMO only 3-5m2 can be available. The DEMO neutron wall loading on the first wall (FW) is 1.82MW/m2 corresponding to �20dpa (displacement per atom) in 2FPY (Full Power Year), ~7 times the ITER damage level on FW. The damage due to neutrons is maximum on the outboard equatorial side, and at a distance of 50cm from the first wall (FW) is 0.5dpa in 1FPY for DEMO1, while the damage decreases to 5x10-3dpa in 1FPY at 100cm from First Wall. Calculations are performed for EUROFER. As consequence, using tungsten recrystalized mirrors (resistant to 3dpa damage) is possible. So Microwave and IR(infrared) diagnostics are feasible on DEMO as well as direct line-of-sight techniques like neutronics and X-rays. These findings open up the possibility of polarimetry for plasma density and current control since Steady-state DEMO needs additional control on current and pressure profiles. Both devices(PLS and SS) need burn control at high electron temperature and the MHD control on neoclassical tearing modes. The divertor control must be considered implying the measurements of radiated power fraction, plasma temperature, density and composition. The extrapolation from ITER to DEMO is large but several promising techniques have been identified despite the nuclear and erosion-deposition problems.

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