A Fresh Look at Electron Cyclotron Current Drive Power Requirements for Stabilization of Tearing Modes in ITER*

R.J. La Haye[1, a)] for the DIII-D Electron Cyclotron Operations and Dynamics & Control Groups

[1]*General Atomics, P.O. Box 85608, San Diego, California 92186-5608 USA*

[a)]Corresponding author: lahaye@fusion.gat.com

Abstract. ITER is an international project to design and build an experimental fusion reactor based on the "tokamak" concept. ITER relies upon localized electron cyclotron current drive (ECCD) at the rational safety factor q=2 to suppress or stabilize the expected poloidal mode m=2, toroidal mode n=1 neoclassical tearing mode (NTM) islands. Such islands if unmitigated degrade energy confinement, lock to the resistive wall (stop rotating), cause loss of "H-mode" and induce disruption. The International Tokamak Physics Activity (ITPA) on MHD, Disruptions and Magnetic Control joint experiment group MDC-8 on Current Drive Prevention/Stabilization of Neoclassical Tearing Modes started in 2005, after which assessments were made for the requirements for ECCD needed in ITER, particularly that of rf power and alignment on q=2 [1]. Narrow well-aligned rf current parallel to and of order of one percent of the total plasma current is needed to replace the "missing" current in the island O-points and heal or preempt (avoid destabilization by applying ECCD on q=2 in absence of the mode) the island [2-4]. This paper updates the advances in ECCD stabilization on NTMs learned in DIII-D experiments and modeling during the last 5 to 10 years as applies to stabilization by localized ECCD of tearing modes in ITER. This includes the ECCD (inside the q=1 radius) stabilization of the NTM "seeding" instability known as sawteeth (m/n=1/1) [5]. Recent measurements in DIII-D show that the ITER-similar current profile is classically *unstable*, curvature stabilization *must not* be neglected, and the small island width stabilization effect from helical ion polarization currents is *stronger* than was previously thought [6]. The consequences of updated assumptions in ITER modeling of the minimum well-aligned ECCD power needed are all-in-all favorable (and well-within the ITER 24 gyrotron capability) when all effects are included. However, a "wild card" may be broadening of the localized ECCD by the presence of the island; various theories predict broadening could occur and there is experimental evidence for broadening in DIII-D. Wider than now expected ECCD in ITER would make alignment easier to do but weaken the stabilization and thus require more rf power. In addition to updated modeling for ITER, advances in the ITER-relevant DIII-D ECCD gyrotron launch mirror control system hardware and real-time plasma control system have been made [7] and there are plans for application in DIII-D ITER demonstration discharges.

*This work was supported by the US Department of Energy under DE-FC02-04ER54698, DE-SC0008520, DE-AC02-09CH11466, and DE-FG02-04ER54761.