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Analysis of a Multi-Machine Database on Divertor Heat Fluxes[1]

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A coordinated effort to measure divertor heat flux characteristics in fully attached, similarly shaped H-mode plasmas on C-Mod, DIII-D and NSTX was carried out in 2010 in order to construct a predictive scaling relation applicable to next step devices including ITER, FNSF, and DEMO. Few published scaling laws are available and those that have been published were obtained under widely varying conditions and divertor geometries, leading to conflicting predictions for this critically important quantity. This study was designed to overcome these deficiencies. Corresponding plasma parameters were systematically varied in each tokamak, resulting in a combined data set in which I_p varies by a factor 3, B_t varies by a factor of 14.5, and major radius varies by a factor of 2.6. The derived scaling relation consistently predicts narrower heat flux widths than relations currently in use. Analysis of the combined data set reveals that the primary dependence of the parallel heat flux width is robustly inverse with I_p. All three tokamaks independently demonstrate this dependence. The midplane SOL profiles in DIII-D are also found to steepen with higher I_p, similar to the divertor heat flux profiles. Weaker dependencies on the toroidal field and normalized Greenwald density, f_{GW}, are also found, but vary across devices and with the measure of the heat flux width used, either FWHM or integral width. In the combined data set, the strongest size scaling is with minor radius resulting in an approximately linear dependence on a/I_p. This suggests a scaling correlated with the inverse of the poloidal field, as would be expected for critical gradient or drift-based transport.

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