The Path to High Field Utilization in the PEGASUS Toroidal Experiment*

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The PEGASUS Toroidal Experiment is an ultra-low aspect ratio ST. Its mission is to study the limits of magnetohydrodynamic stability at extremely low aspect ratio and high toroidal beta and to explore the transition region between the tokamak and spheromak configurations. Major parameters are R=0.25-0.45 m, A=1.15–1.4, κ<3.5, I_p<0.16 MA, and RB_t<0.03 T-m. Values of toroidal beta up to 20% and normalized beta up to 5 have been achieved ohmically with the use of the high-strength solenoid magnet. The toroidal field utilization factor (I_p/I_{tf}) is a useful figure of merit for the ST, indicating the degree to which the large inboard toroidal field is used to stabilize current-driven modes. Values of the toroidal field utilization up to unity have been achieved, but an operational limit on this quantity is observed due to the early appearance of low-order tearing modes. External kink modes have been observed at the highest values of I_p/I_{tf}, and are associated with q_{95} crossing below 5. Calculations with the DCON code indicate that the most unstable eigenmode is the m/n=5/1 mode. Upgrades are currently being conducted which will allow the device to access significantly larger values of β_t and I_p/I_{tf}. All of the coil power supplies are being replaced by capacitor banks actively switched to provide waveform control. Control over the loop voltage will be available for the first time, and the deliverable volt-seconds will increase from 40 to 90 mV-s—these changes will provide significant control over the startup and current ramp, which will ameliorate the tearing instabilities. The 60-turn toroidal field bundle is being replaced with a low-inductance 12-turn centerstack. The toroidal field will be increased by a factor of 3 and will be capable of fast ramp-downs—these changes will allow improved stability to tearing modes during the current ramp and time-variable toroidal field later in the discharge. The equilibrium field coils will be driven by five independent power supplies, which will allow for much greater control over plasma shape and position. In addition, a pair of divertor coils have been installed to allow separatrix operation. The net effect of these upgrades will be to allow operation at significantly higher field utilization and beta by ameliorating the current-driven instabilities, and to enable more detailed studies of stability boundaries.

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