The Role of JET for the Preparation of the ITER Exploitation

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JET, the fusion experiment closest in size, capabilities and normalised plasma parameters to ITER, has a unique role in the scientific and technical preparation for the exploitation of the next-generation device. This is reflected in a programme focused on topics with direct bearing on the design and operation of ITER, like the beryllium wall and tungsten divertor presently being installed. From 2011 this new ITER-like wall (ILW) will allow key questions on plasma-wall interactions, fuel retention and plasma impurity control with Be/W plasma facing components (PFCs) to be addressed, using a large number of reference discharges in ILW-compatible scenarios to bridge from the existing database with carbon PFCs.

Operating ITER-relevant, high-performance, plasmas place high demands on the plasma control systems. For the upgraded JET vertical stability system a model-based approach was adopted that allowed the time and risk inherent in commissioning a critical system to be minimised. For ITER, this kind of accurate electromagnetic models of the interaction between the plasma and surrounding structures will be key to designing robust plasma control systems and to safely and timely commission them for plasma operation.

The viability of the current ITER poloidal field coil design has been verified for deuterium and helium operation in plasma breakdown, current ramp-up and ramp-down studies. Unassisted breakdown in deuterium is achieved well below the ITER central electric fields of 0.33V/m whereas the requirement in helium is higher. Flux consumption during the current rise is the same for both gasses. To keep the internal inductance within the range required for vertical stability and x-point control current ramps need to be in H-mode.

Vessel forces and heat loads from convective losses and from runaway electrons must be controlled during plasma disruptions to ensure the integrity and longevity of the ITER PFCs. Massive Gas Injection (MGI) with argon/deuterium and neon/deuterium gas mixtures into the flat-top of JET discharges increases the fraction of the thermal energy lost by radiation in the resulting disruption and suppresses runaway electron generation. Up to 50% of the initial thermal energy can be radiated before, and ~20% during, the thermal quench with good poloidal wall radiation symmetry. Compared to a pure Vertical Displacement Event disruption (VDE) halo currents can be reduced by 60%.

Most objectives of the ITER-like RF antenna (ILA) have been demonstrated; matching with closely packed straps, resilience to Edge Localised Modes (ELMs), Scattering Matrix Arc Detection (SMAD) and operation at high power density (6.2MW/m^2) and antenna strap voltage (44kV). Dedicated ILA coupling studies with antenna strap to separatrix distances between 11cm and 15cm show good agreement with TOPICA modelling for L-mode plasmas, increasing confidence in TOPICA predictions for ITER.

Finally, feasibility studies have confirmed the option of installing a 170GHz/10MW Electron Cyclotron Resonance Heating system based on ITER technology and 32 in-vessel coils for ELM control, a system capable of meeting the Chirikov criteria for n=3 and n=4 and for plasma currents in excess of 5MA. If realized these upgrades would allow JET to advance preparations for ITER operations in conditions, and with technical capabilities, as close to those of ITER as possible - saving time and reducing risk from the ITER programme.

[*] See the Appendix of F. Romanelli et al., Proceedings of the 22nd IAEA FEC 2008, Geneva, Switzerland