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Evolution and control of tungsten transport in the termination phase of JET H-mode discharges and implications for ITER

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Operation of tokamaks with W PFCs presents specific challenges for impurity control. Lack of impurity control can lead to a radiative collapse due to W accumulation and increased disruptivity. W accumulation in stationary H-mode can be avoided by controlled ELM triggering and central RF heating. Such schemes are also expected to be effective in ITER. However, the control of W transport can be more challenging in the transition from stationary H-mode to L-mode. Long-ELM free phases could arise and lead to an uncontrolled increase of the edge W density and core density peaking causing W accumulation.

To address W control issues in the H-mode termination phase a series of dedicated experiments to be supported by JINTRAC modelling have been performed at JET including the variation of the decrease of the power ramp rate, gas fueling and central ICRH, and applying active ELM control by vertical kicks and pellets. The experimental results obtained demonstrate the key role of maintaining ELM control and ICRH to control the W concentration in the exit phase of H-modes with slow (ITER-like) ramp-down of the NBI power in JET. Without ELM control, long ELM-free phases occur and W accumulation takes place even with central ICRH (~1 MW). The required level of ELM control can be achieved at JET through adjustment of gas fueling or by active ELM control at levels of gas fueling for which W accumulation occurs when kicks are not applied. The latter scenario provides an integrated solution regarding the control of W concentration and plasma energy evolution in the termination of H-modes that can be readily extrapolated to the corresponding phase of 15 MA Q = 10 plasmas in ITER.

Modelling studies performed with JINTRAC have shown that the existing models can appropriately reproduce the accumulation of W in the termination phase of JET H-modes. In this respect the lengthening of the H-mode termination phase by maintaining a low level of NBI heating, which provides a sizeable core particle source and peaks the core density profile, and ICRH are the key to differences in W behavior found in the experiment.

The paper will describe the results of the JET experiments, the comparison with JINTRAC modelling and the adequacy of the models to reproduce the experimental results and draw conclusions regarding the extrapolation of the results and of the applied techniques to ITER.

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