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The Impact of ELMs on the ITER Divertor*

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Edge-Localized-Modes (ELMs) are expected to present a significant transient flux of energy and particles to the ITER divertor. The ITER divertor design requires the transient heat flux from individual ELMs to remain below the threshold for ablation of the divertor target surface. The threshold for ablation of the graphite target will be reached if the ELM transient exceeds $Q/t^{1/2}$~45 MJ-m^{-2}-s$^{-1/2}$ where Q is the ELM deposition energy density and t is the ELM deposition time. The ablation parameter in ITER can be determined by scaling four factors from present experiments: the ELM energy loss from the core plasma, the fraction of ELM energy deposited on the divertor target, the width of the ELM profile onto the target, and finally the time for the ELM deposition. ELM characteristics from JET, ASDEX-Upgrade, JT-60U, DIII–D and Compass-D have been analyzed and assembled into a database for the purpose of predicting these factors for ELMs in the ITER divertor.

For an individual Type I ELM, energy loss from the core plasma is typically 2%–6% of the main plasma stored energy. Scaling this data to ITER predicts an ELM energy loss of 20–60 MJ. The fraction of heating power crossing the separatrix due to ELMs is usually 20%–30% with an inverse relationship between ELM amplitude and frequency. External gas puffing for example often leads to higher frequency lower amplitude ELMs. Scaling of the frequency with application to ELM amplitude will be examined. Type III ELMs, existing in a different regime of edge operational space are also much smaller in amplitude. Measurements on DIII–D and ASDEX-Upgrade indicate that 50%–80% of the ELM energy is deposited on the target. There is currently no evidence for a large fraction of the ELM energy being dissipated through radiation. Modeling will be required to determine if a significant fraction of the ELM energy can be radiated in ITER. Profiles of the ELM heat flux are typically about twice the width of the steady heat flux between ELMs, with the ELM amplitude usually larger on the inboard target. On JET the inboard ELM heat flux can shift by 20 cm from the quiescent location. Such a shift in ITER could cause damage to surfaces not designed for such high heat flux. The ELM deposition time varies from about 0.1 ms in JET to 1.0 ms in ASDEX-Upgrade and DIII–D. The ELM deposition time for ITER will depend upon the level of conductive versus convective transport determined by the ratio of energy to particles released by the ELM. Preliminary analysis suggests that large Type I ELMs may exceed the ablation parameter by a factor of 2–4, while the smaller ELMs produced by gas puffing, or Type II ELMs appear to be tolerable. Finally, the regions of edge operational space which may lead to tolerable ELMs will be discussed.

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*Work supported by U.S. Department of Energy under Contract No. DE-AC03-89ER51114.