Application of the radiating divertor approach to innovative tokamak concepts *

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We show the compatibility of applying a deuterium (D_2)/neon-based radiating divertor (*RD*) to three innovative tokamak concepts: (1) high performance double-null divertor (*DND*) plasmas, (2) high performance "snowflake" (*SF*) plasmas, and (3) H-mode plasmas isolated from their divertor targets, e.g., as in the Super X-like concept. As applied to high performance *DND* plasmas (i.e., $\beta_N \cong 3.0$, $H_{98(Y,2)} \cong 1.4$, $q_{min} \cong 1.5$ with a slight "symmetrizing" magnetic bias toward the divertor opposite the ion $\boldsymbol{B}x\nabla\boldsymbol{B}$ drift direction), the *RD* reduced peak heat flux ($q_{\perp,P}$) in the primary divertor by more than 50%, while maintaining β_N and $H_{98(Y,2)}$. On the other hand, due to a much stronger edge radiated emissivity, the current density profile became more peaked, so that q_{min} was driven toward 1.0; fuel dilution in the core was ≅30%. Less than 20% of the power input was radiated in the core and more than 40% from outside the core. The location for impurity injection was critical to the success of the *DND* under *RD* conditions, with impurities injected into the private flux region of the primary divertor yielding the most favorable result in terms of maintaining elevated β_N and $H_{98(Y,2)}$. We show that the constraint of maintaining a constant β_N as the D_2 and neon injection rates were increased required higher power input and this, in turn, resulted in a surprising *increase* in $q_{\perp,P}$ at the secondary outer divertor target. Transforming the primary divertor from the standard *DND* to the *SF* configuration produced little change from the elevated values of β_N and $H_{98(Y,2)}$ observed in *DND* under similar *RD* conditions. While the *RD* had a stronger effect on peak heat flux reduction at the outer target ($q_{\perp,P,OT}$) in the DND case, $q_{\perp,P,OT}$ was still 35% lower in the *SF* case during *RD* operation, and both *SF* and *DND* showed similar peak heat flux reduction at their *inner* target during *RD*. One potential drawback: neon build up in the *SF* core was 15-20% higher than *DND* under similar *RD* conditions. Finally, recent experiments studied the changes to $q_{\perp,P,OT}$ under unpumped, pumped, and *RD* environments when the parallel connection length ($L_{//}$) along the outer divertor leg was raised. For example, an *additional* 25% reduction in $q_{\perp,P,OT}$ was achieved by increasing $L_{//}$ by 45% during *RD*. In general, our results support the attractiveness of these three concepts as applied to future tokamaks under *RD* conditions, e.g., as in combining high performance *DND* with Super-X.

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