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SUBJECT: MODIFICATION OF HEAT FLUX REQUIREMENTS FOR CSAS

Recommendation
In NSTX-U-RQMT-SRD-003:

A. Add to Table 4.5-1 an Extent of 8 cm for all rows.

B. Add to Table 4.5-1 a Range of Application of |Z| > 1.1 for all rows.

C. Eliminate Case #2 in Table 4.5-1

D. Eliminate Requirement 4.5-b and the Energy row from Table 4.5-1

Background
Similar to motivations for the OBD heat loads discussed in PFCR-MEMO-011, the present version of the PFC Requirements, NSTX-U-RQMT-SRD-003-00, specifies heat fluxes by region and implies that heat flux should be applied over the full surface. This results in much higher energy influx into the PFC than is possible and stress states in T-bar slot and shear pins may be much higher than is expected to be required to support the real plasma scenario. While a requirement was added (4.5-b) which allowed the an 'Extent' to be used based on the Energy data given, but this resulted in an asymmetric and ambiguous requirement compared to other PFC regions.

In addition, the CSAS tile that interfaces with the CSFW (CSAS Row 6) was shown in the PFC High Heat Flux PDR to be a region where a stress concentration can develop if the heat fluxes presently in the SRD are applied.

Reasoning
The lower single null L-mode plasmas explored in PFCR-MEMO-008 set the SRD requirements for the CSAS. The two driving are shown in Figure 1 (Case #3) and Figure 2 (Case #1). These represent the highest heat flux and highest angle of incidence, respectively. In addition Case #3 is also the simulation, TT_2_04a, corresponding to the largest lower triangularity of the L-mode scan at TRIBOT=0.415 and the strike point with the smallest |Z|. The Case #2 in the SRD for the CSAS (Table 4.5-1) does not correspond to a scenario which should drive or challenge the design. It is a shallow angle of incidence case at low power. If, after adjustment of designs following these new flux requirements, 'fishscaling' is still deemed to be necessary any shallow angle of incidence cases where there may be shadowing be evaluated post-FDR when developing operational guidance for CSAS operation.

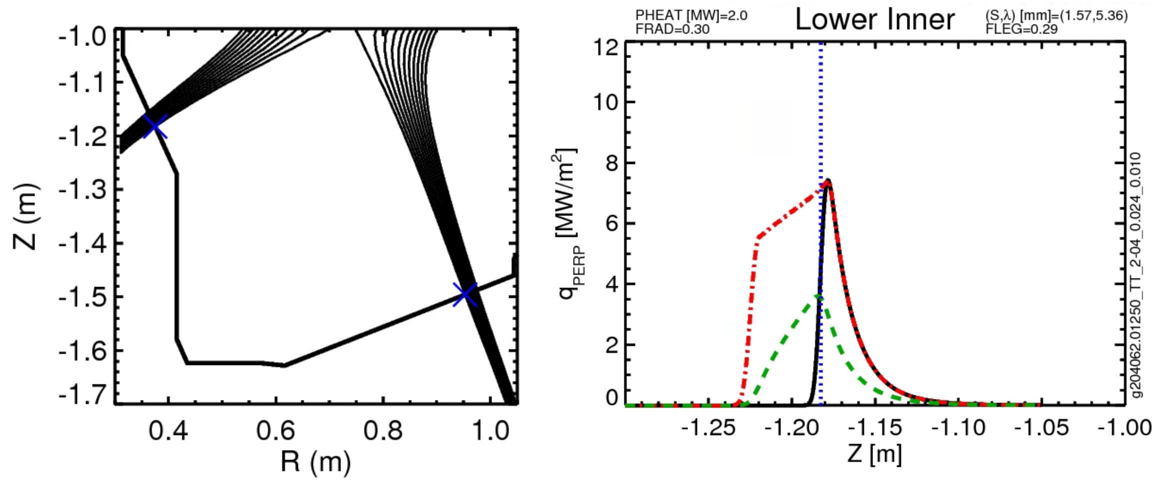

Figure 1: Equilibrium and heat flux simulation for TT 2-04a, which forms the basis for CASE #3 in the CSAS heat flux requirements. This has the strike point the farthest up the CSAS and the highest angle of incidence

Each CSAS, combining both the Row 5 and Row 6, is estimated to have a surface area of 0.61 m^2. Thus, for the Case #1, where 0.63 MW of power is directed to the inner target (assuming P_{NBI}=3 MW, 30% radiated, 30% to the inner target), an assumption 5.2 MW/m^2 over the whole surface vastly over estimates the input power. In addition, the Case #3 shown in Figure 2 shows that this power is unlikely to load the region near the top of Row 6 near the CSAS/FW interface. This implies the heat flux requirements for tiles that are limited not by surface temperature but by sub-surface stress states driven by energy input, e.g. 'bowing', are extremely conservative and should be relaxed.

The shape of the time averaged profiles shown in Figure 1 and Figure 2 do not well match the 'Extent' feature used to specify spatially localized heat fluxes. In fact they are closer to isosceles triangles instead of right triangles, but these simulations do not reflect empirically realizable scans.

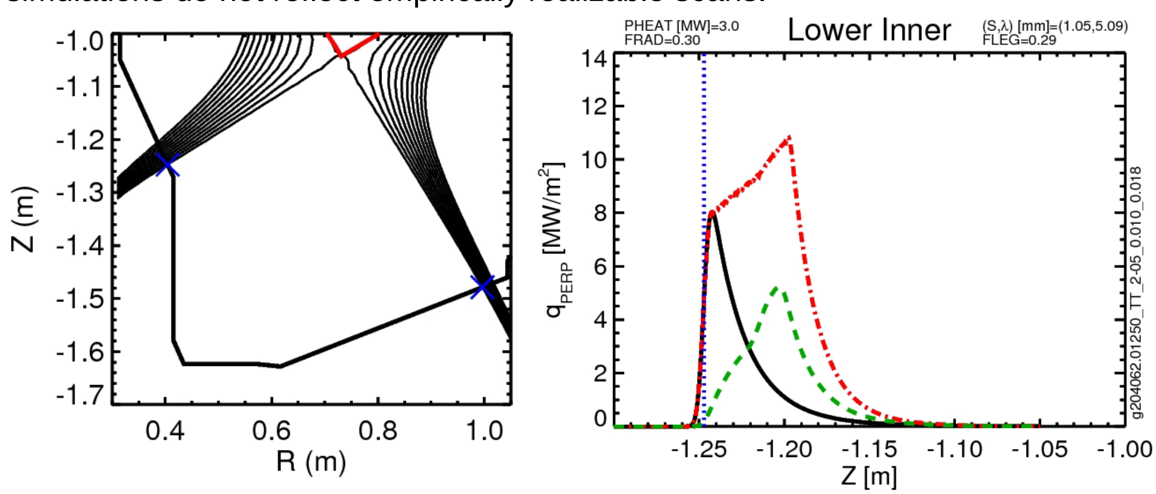

Figure 2: Equilibrium and heat flux simulation for TT 2-05b, which forms the basis for CASE #1 in the CSAS heat flux requirements. This has the highest time averaged heat flux.

Never-the-less, it is suggested that an extent of 8 cm be used, which for CSAS tiles of poloidal length of 13-14 cm results in a more than a factor of three reduction in energy. This is still conservative, but is expected to eliminate engineering challenges in present designs identified at the PDR. Future detailed modeling post-FDR will be done to help establish operational limits including scenarios that have ‘spillover’ heat flux from the IBDV which as discussed in PFCR-MEMO-008 “should not drive PFC requirements, they represent a usage scenario for which the compatibility should be evaluated based on delivered CSAS designs”. Note that this ‘Extent’ is assumed to be in the common flux direction, e.g. the heat flux profile extends to smaller |Z|, and should be measured along the surface.

Furthermore, a range of application is necessary as TSG requests did not seem to reflect the need to pull the strike point substantially onto Row 6. A Range of Application requirement should be added that keeps operational flexibility and the possible desire to extend the triangularity range while avoiding a stress concentration that is unlikely to be encountered experimentally. This is suggested to be the |Z| > 1.1 meters which would still lead to some minor heat loading of the CSFW/CSAS interface, but far less than is presenting being required.

Record of Changes

Rev.	Date	Description of Changes
0	3/23/18	Initial release for review
1	3/28/18	Fixed type that Recommendation of Range was |Z| < 1.1 when it should be |Z| > 1.1.