11-010726-CLN-01

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SUBJECT: HEATING POWER AND PULSE LENGTH VS TIME

REFERENCES:

[1] NSTX Divertor Heat Flux Estimates", S. Kaye, 10/24/96
[2] NSTX-RQMTS-GRD-018, “NSTX General Requirements Document”
[3] NSTX-CALC-11-05, “Thermal Analysis of NSTX Center Stack and Outboard Divertor Tiles”, P. Goranson

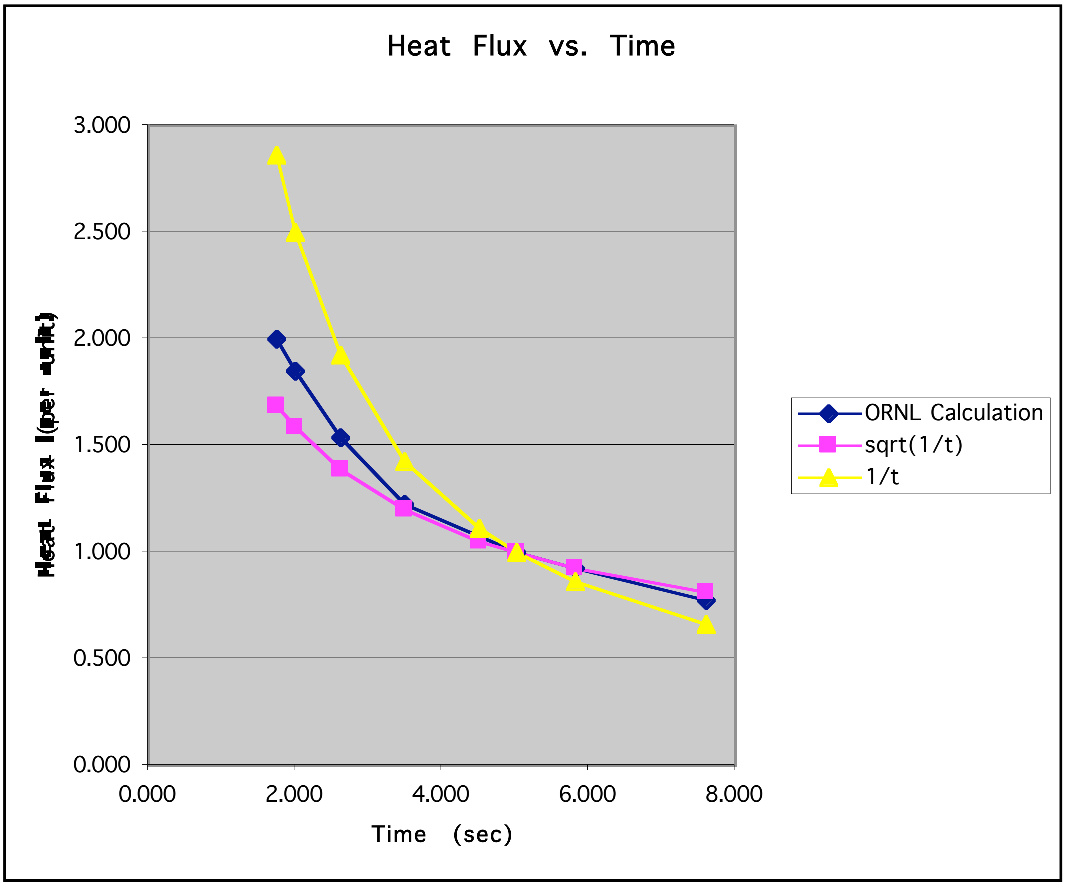
NSTX was designed to accommodate 6MW of RF heating/current drive power with a 5 second pulse length and a 300 second repetition period. Heat flux on the various PFC tile surfaces was projected for the three plasma shapes (single null, double null, and inboard limited) [1] and the power handling requirements were set accordingly [2]. Calculations were performed by ORNL to justify the design [3].

For pulse lengths less than the original 5 second requirement, or power levels in excess of the original 6MW requirement, a method of establishing safe limits is presented herein. It is assumed that RF power and NBI power are equivalent in terms of their heating effect on PFC surfaces. Also, the NBI armor is not considered, only the PFC tiles associated with the original NSTX device.

The following figure depicts a plot of heat flux vs. time for three cases, all normalized to the 5 second baseline pulse:

1) Simple 1/t relationship which would allow the same $\int P(t)dt$ = energy flux;
2) Commonly used sqrt(1/t) relationship to estimate power handling capability;
3) ORNL calculation [3] of allowable power flux vs. pulse length at 300 second repetition period using tile thermal conductivity characteristics.

The fact that curves 2) and 3) indicate a lower allowable power flux at short pulse lengths than curve 1) reflects the fact that, for short pulses, there is insufficient time for the heat deposited on the surface of the PFC tiles to diffuse into the body of the tiles and their backing plates.

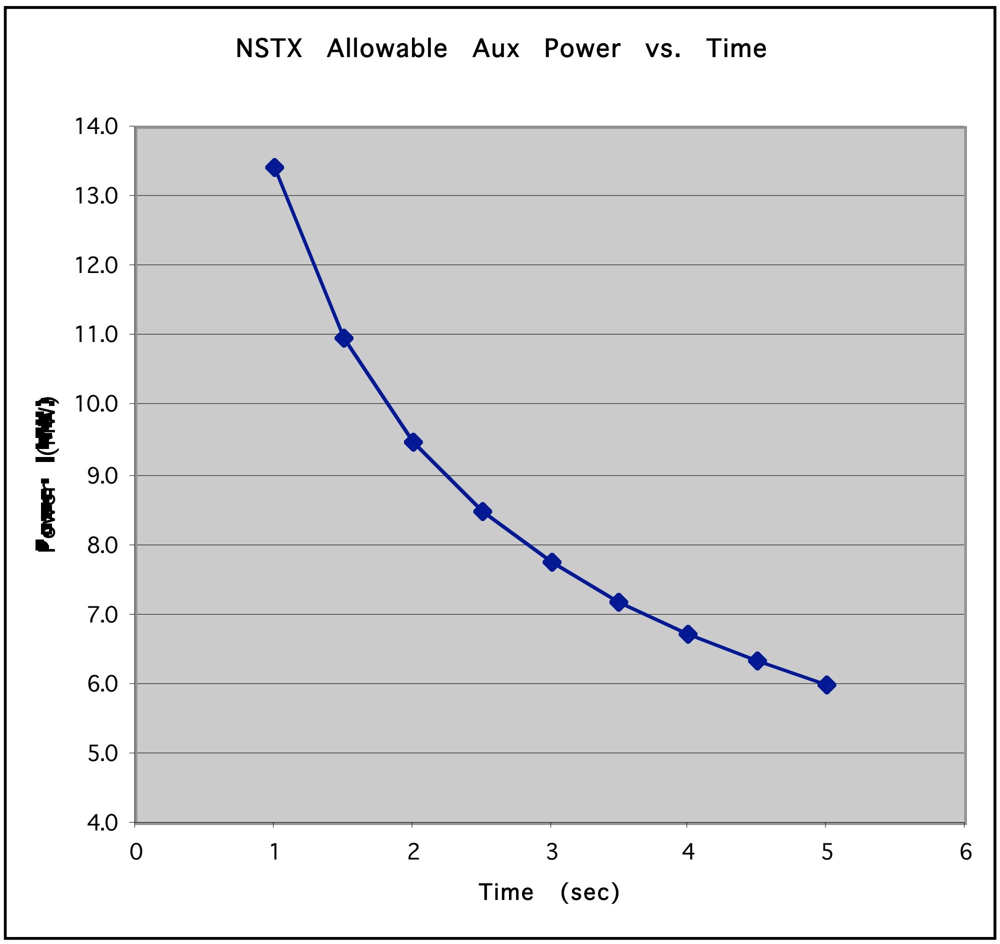


For NSTX it is recommended that auxiliary heating/current drive operations be limited such that the total RF+NBI power be constrained according to the sqrt(1/t) relationship where:

$$P_{aux} \leq \frac{6\sqrt{1/t_{pulse}}}{\sqrt{1/5}} MW$$

The recommended limit is given also in the following table and figure.

Tpulse (sec)	Paux (MW)
1	13.4
1.5	11.0
2	9.5
2.5	8.5
3	7.7
3.5	7.2
4	6.7
4.5	6.3
5	6.0



In practice, the deposition of power and the heating of the tile surfaces is complex, particularly in the diverted cases where the power deposition tends to become concentrated at the strikepoints. The strikepoint location and its variation with time, and the power flux width, are critical factors. Therefore as the power level is increased it becomes especially important that the t/c and IR camera diagnostics be utilized to monitor the situation. It may be necessary to invoke improved strikepoint position control and sweeping as the power level is increased.

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