13-001206-CLN-02

TO: DISTRIBUTION
FROM: C NEUMEYER
SUBJECT: TF LIMITS vs. TEMPERATURE

References

[1] 13-001206-CLN-01, "TF Operation with Water Cooling Absent from Turn Six"
[2] NSTX-CALC-13-2, "TF Coil Parameters"
[3] NSTX-CALC-13-18, "TF As-Built Circuit Parameters"

In order to quantify operating limits as a function of allowable adiabatic temperature rise (as called out in the ref. [1]) a spreadsheet was developed as described herein.

First, the G function is used per ref. [2] to determine the ΔJ2T which will heat the coil to the temperature limit, starting from a given inlet water temperature (nominally 12C). Then, a peak allowable field is chosen (in this case 3.5kG) which establishes the ΔJ2T associated with current decay, in case a trip occurs at peak field. The final allowable ΔJ2T minus the ΔJ2T attributable to current decay sets the RIS I2T trip level. Then, given the trip level, and the I2T associated with current rise and current fall, the allowable flat top duration at different field levels can be set such that the current, with power supply ramp down, goes to zero without raising the I2T to the RIS trip level.

Results are given in the attached tables and figure with 3.5kG and ΔT=20C max. chosen as the governing conditions. It is noted that a flat top time of order 600mS can be achieved at 3.5kG, including current ramp down, without an I2T trip. Should an I2T trip occur at the end of flat top, at any field up to 3.5kG, the maximum allowable temperature rise will not be exceeded.

These limits are to be enforced in hardware by the RIS and ACP overcurrent settings, the RIS I2T setting, and in software by the PSRTC overcurrent, temperature, and I2T settings.

cc:

E. Baker	M. Bell	W. Blanchard	A. Brooks
J. Chrzanowski	L. Dudek	H. Fan	R. Hatcher
R. Hawyrluk	P. Heitzenroeder	M. Kalish	R. Marsala
M. Ono	G. Pearson	S. Ramakrishnan	A. Von Halle
M. Williams	NSTX File		

Allowable Adiabatic ΔT	20	deg C
T0	12	deg C
G0	2.53E+15	(A/m^2)^2-sec
Tmax	32	deg C
Gmax	6.47E+15	(A/m^2)^2-sec
ΔGmax=J2Tmax	3.93E+15	(A/m^2)^2-sec
L	4.37E-03	Henry
Rcircuit (cold)	7.81E-03	Ohm
Rcircuit (hot)	8.19E-03	Ohm
Rpsequiv	4.03E-03	Ohm
∑R (cold)	1.18E-02	Ohm
∑R (hot)	1.22E-02	Ohm
CSA inner leg	6.74E-04	m^2
Bt	3.5	kG
Iflat	4.15E+04	Amp
J2T L/R decay	1.06E+15	(A/m^2)^2-sec
J2T Trip (RIS)	2.87E+15	(A/m^2)^2-sec
I2T Trip (RIS)	1.31E+09	A^2-sec
Trise	0.245	sec
J2T Rise	3.62E+14	(A/m^2)^2-sec
Tfall	0.202	sec
J2T Fall	2.55E+14	(A/m^2)^2-sec
J2T Flat	2.26E+15	(A/m^2)^2-sec
Tflat	0.595	sec
Gfinal	5.41E+15	(A/m^2)^2-sec
Tfinal	26.3	deg C
ΔTfinal	14.3	deg C
Gfinal (fault)	6.47E+15	(A/m^2)^2-sec
Tfinal (fault)	31.8	deg C

Bt	Iflat	Trise	Tfall	Tflat	∑T	Tfinal	ΔT
(kG)	(Amp)	(sec)	(sec)	(sec)	(sec)	(deg C)	(deg C)
3.0	35580.00	0.198	0.179	0.897	1.274	26.3	14.3
3.1	36766.00	0.207	0.184	0.826	1.217	26.3	14.3
3.2	37952.00	0.216	0.188	0.761	1.166	26.3	14.3
3.3	39138.00	0.225	0.193	0.702	1.120	26.3	14.3
3.4	40324.00	0.235	0.197	0.646	1.079	26.3	14.3
3.5	41510.00	0.245	0.202	0.595	1.042	26.3	14.3