13-001206-CLN-01

TO: DISTRIBUTION
FROM: C NEUMEYER
SUBJECT: TF OPERATION WITH WATER COOLING ABSENT FROM TURN SIX

A meeting was held on 12/5/00 to review the impact of issues related to TF operation with water cooling absent from turn 6, which has a water leak.

Following were present:

A. Brooks J. Chrzanowski L. Dudek H. FanM. Kalish M. Ono
C. NeumeyerA. Von Halle M. Williams

H.M. Fan presented the results of an ANSYS run which was used to estimate the insulation shear stress resulting from a condition where one turn is at a different temperature than its neighbors. Using a 2-d, two turn model of a cross sectional slice through the turn bundle, an insulation shear stress of approximately 2ksi was projected with a ΔT of 20C between turns. Although it was noted that compressive forces exist between turns (which enhances the insulation shear strength), it was decided not to take credit for this due to the fact that it varies with time and location as the coil goes through its heating/cooling cycle under the subject condition.

It was previously noted by C. Neumeyer, taking the data from the NSTX R&D Report 13-970430-JHC by J. Chrzanowski, that the average insulation shear failure stress of the TF inner leg bundle insulation (CTD-112P material w/o Kapton) was as follows, w/o compression:

Case	Average Failure Stress (psi)
All 25 samples	2808
6 samples tested at 100C	2381
19 samples tested below 100C (typically at ≈ 20C and 60C)	2942

A. Brooks presented the results of a thermal simulation which simulates water cooling of all turns except one which is radially cooled by its neighbors through the turn insulation. With cooling water flows at their present rates but with cooling absent from one turn, the cooling of the uncooled turn clearly is completed within a 10 minute period. It was further noted that the peak temperature differential between turns is limited to 70% of the peak temperature of the turns.

C. Neumeyer presented a spreadsheet which determines flat top time as a function of allowable adiabatic temperature rise of the TF inner leg bundle turns, assuming an L/R decay of current from the 4.5kG level.

Based on the information presented, it was decided to adopt an allowable adiabatic temperature rise of 20C. This allows roughly 500mS flat top at 4.5kG, yet only translates to as 14C temperature differential between turns, and a stress of 14/20*2000 = 1400 psi. Since the coil will be fairly cool this stress is most realistically comparable to R&D measurements at the lower temperatures, which exhibited an average strength of 2942 psi. So, on this basis we are at 1400/2942 = 48% of the ultimate shear strength.

In addition to the above it was decided to pass N_2 through the uncooled turn and to temporarily relocate one of the OH cooling water thermocouples on to the outlet of this gas stream as a means of measuring the temperature of the uncooled turn. Although it is recognized that this may not give a highly accurate reading of the copper temperature, it will still be useful to monitor the cooldown waveform and to confirm the absence of temperature ratcheting. It would also be desirable to monitor the temperature of one of the inner leg water stream outlets. However, since the water exists the inner legs at the top of the machine and then proceeds through the outer legs, this is not convenient, and therefore will not be pursued.

Follow-on action items are:

J. Chrzanowski to determine whether subject turn is, or is not, at the interface between TF bundle quadrants where the turn-turn insulation has an extra layer of material (and higher thermal resistance).

A. Brooks and H.M. Fan to continue to refine and document their analysis via memo.

P. Heitzenroeder to provide an independent check of the work by A. Brooks and H.M. Fan.

C. Neumeyer to develop appropriate protection settings, operational waveforms, and procedures to ensure that the allowable ΔT is not exceeded, and that the repetition rate is restricted to 10 minutes.

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		