TS-SSC-92-032
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DSA328 Quench Protection Heater Test Results_II

This is a follow dup note on DSA328 heater tests. There are eight heaters in DSA328, two in each quadrant for quench protection.
The purpose of heater tests during the second cooldown was to measure the minimum energy required to produce a heater induced quench. Heater test results from the first thermal cycle of DSA328 are given in detail in TS-SSC92-025, which shows the effect of insulation thickness between the coil and the heater and its effect on the energy requirement to produce a heater induced quench.
The heaters were fired, in different combinations, at two different magnet currents i.e. 2000 A and 5000 A. The test were conducted under the same conditions as before.
The minimum energy required to quench the magnet, at 2 kA, with the heater combination of data set 1 and 3 is about 19.7 and 26.8 joules with 90 and 105 Vhfu respectively. I have added these results in the table from previous test results.

There is an estimated 10 msec uncertainty in finding quench start (Tq) and a ~5 percent variation in heater voltages which translates to roughly 10 percent variation in energy deposition, which is well within the range of errors for this test.The differences in heater response time T_fn are consistent with measurement uncertainties.

DATA SET 1:
DSA328 Heaters 1B and 3B in series, were fired together, with one 5-mil kapton between the heater and the coil

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R_tot =5.1 ohm; C =35 mF; Rh =.71 ohm;

Tfn (msec)	Imag (A)	VHFU (v)	Edep (joule)	
110	2003.	175.	74.4	
160	2003.	150.	54.6	
210	2003.	135.	44.2	
215	2003.	115.	32.1	
220	2003.	125.	37.9	
380	2003.	100.	24.2	
390	2003.	90.	19.7	minimum energy required to quench the magnet

NOTE: Imag=5000 A, heater did not fire below 85 Vhfu

87	5003.	160.	62.1	
115	5005.	130.	41.0	
130	5006.	115.	32.1	
170	5002.	107.	27.8	
232	5004.	100.	24.3	
342	5002.	85.	17.5	minimum energy required to quench the magnet

DATA SET 2:
DSA328 Heaters 2A and 4A in series, were fired together, with two 5-mil kapton between the heater and the coil

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R_tot =5.1 ohm; C =35 mF; Rh =.71 ohm;

Tfn (msec)	Imag (A)	VHFU (v)	Edep (joule)
255	2002.	150.	54.6
195	2002.	205.	102.0

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 145 2002. 250.          151.7
 140 2002. 280.          190.3
 120 2002. 300.          218.5
 560 2003  105            26.8 minimum energy required to quench the magnet

 (Imag=5000 A
 125 5004. 220.          117.5
 165 5000. 180.          78.6
 202 5004. 140.          47.6
 366 5003. 105           26.8
 310 5003. 82.5          16.5 minimum energy required to quench the magnet

DATA SET 3:
   DSA328 Heaters 2B and 4B in series, with two 5-mil kapton between
   the heater and the coil
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R_tot =5.1 ohm; C =35 mF; Rh =.71 ohm;

 Tfn  Imag  VHFU        Edep
(msec) (A)  (v)        (joule)
 120 2003. 300.          218.5
 155 2003. 240.          139.8
 175 2002. 200.          97.1
 205 2003. 175.          74.3
 275 2003. 141.          48.3
 450 2002. 110.          29.4
 560 2004  105           26.8    minimum energy required to quench the magnet

NOTE: Imag=5000 A, heater did not fire below 95 Vhfu
(Imag=5000 A
 90  5004. 260.          164
 107 5004. 220.          117
 125 5000. 180.          78.6
 135 5004. 160.          62.1
 180 5000. 140.          47.6
 373 5000. 105.          29.4
 530 5005. 95.           21.9 minimum energy required to quench the magnet

DATA SET 4:
 Individual heater test results
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R_tot =4.5 ohm; C =35 mF; Rh =.71 ohm; Edep=110 joules

(Tfn  Imag  VHFU  T_hfu  Tq     Heater
(msec) (A)  (v)   (joule)
150   2002  200   230    80     ;2B
150   2002  200   240    90     ;4B
145   2002  200   265    120    ;2A
150   2002  200   270    120    ;4A

90    2002  200   165    75     ;1B
90    2002  200   175    85     ;3B
90    2002  200   200    110    ;1A
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