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DCA312 Quench Current versus Temperature

DCA312 has an anomolously large dependence of quench current on ramp rate. It is claimed[1] that the inner coils are made from wire from the same billet as that used for short magnets DSA321 and 322 at Fermilab and DSA207 and 208 at BNL. DSA321 showed minimal ramp rate dependence[2,3]. (DSA322 was designated for assembly experiments and was never cold tested.) In this note I compare the low ramp rate quench currents as a function of temperature between DCA312 and DSA321, which indicate that ramp rate dependence is not the only difference between the quench characteristics of these two magnets.

Table I shows the quench currents and temperatures of all DCA312 quenches with ramp rates less than or equal to 4 Amps/sec. Since only a limited number of thermometers are recorded in the header of the quench file, and this set does not include the bypass thermometers which are closest to the magnets, I obtained the temperatures from the most recent pre-quench records in the CRYOLOG files. The time delay between the temperature measurements and the quench varies from a few seconds to 10 minutes. The notation is: GE is a germanium resistor, CG is a carbon-glass resistor and VPT is a vapor pressure thermometer; for the 1 phase bellows "uf" and "lf" refer to "upper feed" and "lower feed"; for the bypass hole thermometers "urf" refers to the "upper right feed end", etc.

Table II summarizes the average and maximum of all thermometer readings and of the bypass thermometer readings. The bypass thermometers are mounted in the helium channel holes in the end plates at the two ends of the magnet. Since they are the closest thermometers, I take them to give the most accurate estimate of the magnet temperature. For the sake of comparison with DSA321, I take the maximum of the four bypass thermometers as indicating the quench temperature. The maximum temperature is usually at the upper right turnaround box end (CGulr), but in 6 of the 18 quenches listed, one of the lead end thermometers reads equal to or greater than those at the return end.

Figure 1 is a plot of quench current versus temperature for all low ramp rate quenches for DCA312 (4 and 2 Amps/sec) and DSA321 (16 Amps/sec). For DSA321 the temperature given is the average of three 100 Ohm carbon resistor thermometers mounted on the outer shell of the magnet. Shown also are linear fits to the data, excluding one training quench in each magnet (at 4.3 K in DSA321 and 3.5 K in DCA312). The slopes of the temperature dependence of the two magnets are the same (-1265 Amps/K) to within 2%, but DSA321 quenches more than 300 Amps higher than DCA312. Bob Schermer[4] has noted that short 40 mm magnets (BNL built and tested, I think) quench on the average 2.7% above the short sample prediction but long magnets quench only 0.1% above prediction. This is usually attributed to the heat of vaporization available in boiling liquid (short magnet tests) but not in supercritical fluid (long magnet tests). The difference between the two magnets in Figure 1 is 4.3% at 4.35K. The dot-dashed line marked "I(fit-190A)" represents the DSA321 quench behavior shifted down by 2.6% at 4.35 K. It still lies significantly above the DCA312 data. The remaining difference corresponds to a temperature shift of 100 mK, which is larger than what we think is the accuracy of our temperature measurements. (Typically thermometers at the same location agree with each other to within 20-30 mK in both long and short magnet tests. The readout systems and algorithms for converting resistance to temperature are the same for the long and short magnet tests at Fermilab.)

REFERENCES

[1] A. Devred, private communication.

[2] S. Gourlay, DSA321 summary of quench performance, TS-SSC 91-029, 2/12/91.

[3] M. Wake, et al., Quench behavior of 1.5 m model SSC collider dipole magnets at Fermilab, submitted to MT12, Leningrad, USSR, July 1-5, 1991.

[4] R. Schermer, e-mail to Devred, Wanderer and Strait, 1/29/91.

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Table I

				All Thermometers			Bypass Thermometers			Feed Can		1 phase bellows		Bypass holes				Turnaround		VPT's	
			Iquench	<T>	Tmin	Tmax	<T>	Tmin	Tmax	GEf	CGf	CGuf	CGlf	CGurf	CGllf	CGulr	CGlrr	GEr	CGr	VPTf	VPTlr
Quench 1	DCA312.QB005	23 : 52 : 56	7280	4.37	4.30	4.54	4.33	4.32	4.35	4.47	4.30	4.47	4.31	4.33	4.32	4.35	4.33	4.32	4.36	4.30	4.54
Quench 2	DCA312.QB007	09 : 07 : 19	7285	4.36	4.30	4.47	4.34	4.33	4.36	4.42	4.30	4.47	4.31	4.34	4.33	4.36	4.35	4.34	4.37	4.32	4.43
Quench 3	DCA312.QB008	11 : 27 : 28	7354	4.34	4.26	4.58	4.29	4.28	4.30	4.45	4.26	4.43	4.28	4.30	4.28	4.30	4.30	4.28	4.32	4.28	4.58
Quench 4	DCA312.QB011	18 : 12 : 31	7305	4.29	4.15	4.68	4.21	4.15	4.29	4.43	4.24	4.46	4.25	4.29	4.23	4.18	4.15	4.15	4.18	4.25	4.68
Quench 5	DCA312.QB012	20 : 35 : 40	7276	4.36	4.25	4.65	4.30	4.25	4.36	4.52	4.29	4.53	4.31	4.36	4.26	4.32	4.25	4.26	4.30	4.30	4.65
Quench 10	DCA312.QB035	10 : 32 : 57	7275	4.30	4.25	4.43	4.30	4.29	4.31	4.25	4.27	4.43	4.28	4.30	4.30	4.31	4.29	4.26	4.30	4.28	4.34
Quench 11	DCA312.QB036	12 34 53	7388	4.38	4.14	5.12	4.21	4.19	4.24	4.14	4.17	4.33	4.18	4.20	4.19	4.24	4.22	4.49	4.63	5.12	4.70
Quench 12	DCA312.QB037	14 : 41 : 31	7266	4.40	4.28	4.81	4.37	4.33	4.42	4.28	4.30	4.46	4.31	4.33	4.33	4.42	4.40	4.39	4.43	4.32	4.81
Quench 13	DCA312.QB038	16 : 50 : 18	7325	4.32	4.21	4.75	4.28	4.26	4.30	4.21	4.24	4.40	4.24	4.27	4.26	4.30	4.29	4.28	4.32	4.25	4.75
Quench 14	DCA312.QB039	20 : 50 : 30	7305	4.33	4.25	4.56	4.31	4.29	4.32	4.25	4.27	4.43	4.28	4.30	4.29	4.32	4.31	4.29	4.33	4.28	4.56
Quench 18	DCA312.QB045	12 : 32 : 18	7887	3.91	3.82	4.22	3.86	3.85	3.88	3.82	3.84	3.99	3.85	3.88	3.85	3.86	3.85	3.85	3.88	3.96	4.22
Quench 19	DCA312.QB046	15 : 37 : 15	7926	3.90	3.78	4.60	3.82	3.79	3.84	3.80	3.82	3.95	3.82	3.84	3.84	3.80	3.79	3.78	3.82	3.94	4.60
Quench 20	DCA312.QB047	17 : 59 : 34	7921	3.93	3.79	4.75	3.85	3.84	3.86	3.79	3.81	3.94	3.82	3.84	3.84	3.86	3.85	3.85	3.88	3.94	4.75
Quench 21	DCA312.QB048	22 : 42 : 41	7906	3.91	3.80	4.42	3.85	3.85	3.86	3.80	3.83	3.96	3.83	3.85	3.85	3.86	3.86	3.85	3.88	3.94	4.42
Quench 22	DCA312.QB051	03 : 30 : 34	8161	3.60	3.46	4.35	3.51	3.49	3.52	3.46	3.48	3.59	3.48	3.49	3.49	3.52	3.51	3.51	3.54	3.81	4.35
Quench 23	DCA312.QB052	07 : 16 : 59	8327	3.62	3.45	4.59	3.50	3.49	3.50	3.45	3.48	3.59	3.49	3.49	3.50	3.50	3.50	3.50	3.53	3.81	4.59
Quench 24	DCA312.QB053	10 : 29 : 19	8347	3.61	3.43	4.69	3.47	3.47	3.48	3.43	3.45	3.56	3.46	3.47	3.47	3.48	3.48	3.48	3.51	3.80	4.69
Quench 25	DCA312.QB055	15 : 44 : 22	8385	3.61	3.43	4.69	3.47	3.47	3.48	3.43	3.45	3.56	3.46	3.47	3.47	3.48	3.48	3.48	3.51	3.80	4.69

Table II

Q#	Iq	<T(all)>	<T(byp)>	T(all)max	T(byp)max
1	7280	4.37	4.33	4.54	4.35
2	7285	4.36	4.34	4.47	4.36
3	7354	4.34	4.29	4.58	4.30
4	7305	4.29	4.21	4.68	4.29
5	7276	4.36	4.30	4.65	4.36
10	7275	4.30	4.30	4.43	4.31
11	7388	4.38	4.21	5.12	4.24
12	7266	4.40	4.37	4.81	4.42
13	7325	4.32	4.28	4.75	4.30
14	7305	4.33	4.31	4.56	4.32
18	7887	3.91	3.86	4.22	3.88
19	7926	3.90	3.82	4.60	3.84
20	7921	3.93	3.85	4.75	3.86
21	7906	3.91	3.85	4.42	3.86
22	8161	3.60	3.51	4.35	3.52
23	8327	3.62	3.50	4.59	3.50
24	8347	3.61	3.47	4.69	3.48
25	8385	3.61	3.47	4.69	3.48

Quench T vs I: DCA312 - DSA321 comparison