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Peak Loop Pressure and Peak Temperature in the MAGCOOL-Subcooler Cryogenic System after Low Current Quenches of SSC Dipole DCA213

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ABSTRACT

The performance of the MAGCOOL cryogenic system after 2500, 3000 and 3500 ampere strip heater quenches of SSC dipole DCA213 was investigated to confirm that the peak pressure and temperature in the magnet cooling loop are linearly proportional to the energy released during a quench. As in all past studies, excellent agreement between total cooling provided and the magnetic stored energy is found.

INTRODUCTION

In a recent study of low current quenches of RHIC dipole DRD009 in MAGCOOL[1], the peak pressure and temperature in the magnet cooling loop were found to be linearly proportional to the energy released. Because of this result, data for quenches of an SSC quadrupole and dipoles in the MAGCOOL-Subcooler cryogenic system [2,3] was re-evaluated. This linear dependence was found for the quadrupole but not for the dipoles.

For SSC dipole DCA210, the peak loop pressures are 7.8, 14.1 and 17.5 atm for quench currents of 2000, 3000 and 4000 amperes respectively. The results for the 2000 and 3000 ampere quenches indicate a linear dependence. However, minor venting of the helium coolant is believed to give a lower peak pressure than would actually have been generated by the 4000 ampere quench.

Strip heater quenches for SSC dipole DCA213 at 2500, 3000 and 3500 amperes have been performed for verification. Results show both peak loop pressure and temperature increase linearly with the magnetic stored energy. The total cooling provided during quench recovery has been calculated for each current. Very good agreement between the total cooling and the magnetic stored energy is obtained for each current. Pressures, temperatures, flow rates, apparent cooling rates and total cooling provided are given as functions of time in the appendix for reference.

RESULTS

The present tests were obtained from quenches of the SSC DCA213 in MAGCOOL test stand A. The magnet is maintained at 4.3 K prior to a quench. Quenches are initiated at 2500, 3000 and 3500 amperes by a strip heater. The corresponding magnetic stored energy, $1/2\ LI^2$, is 255, 367 and 499 kilojoules respectively.

The peak loop pressure as a function of magnetic stored energy is given in Fig. 1. As seen, the value peak pressure increases linearly with the amount of energy released. The largest peak loop pressure obtained is 16.4 atm for the 3500 ampere quench. The nominal venting pressure is set at 15 atm for the MAGCOOL-Subcooler. Therefore the maximum operating current at which an SSC dipole may be quenched without venting is about 3200 ampere.

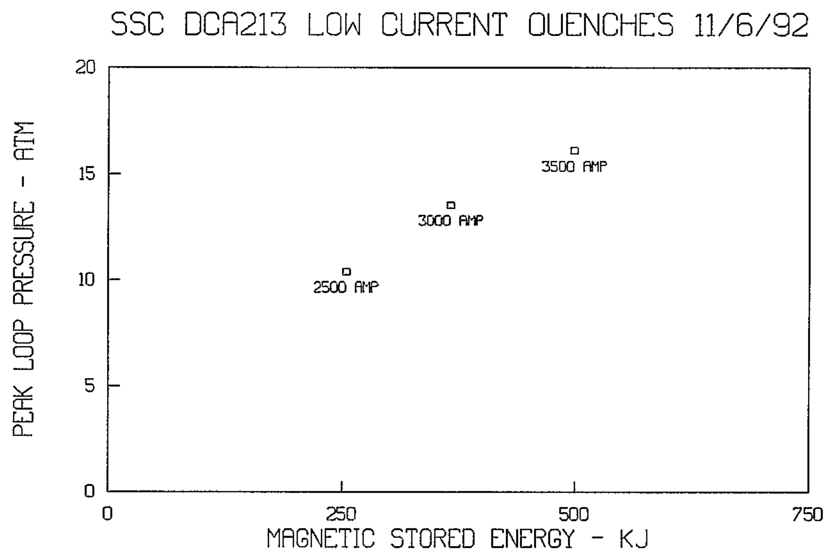

Fig. 1 Peak loop pressure versus magnetic stored energy

The peak loop temperature observed at the return to the Subcooler as a function of magnetic stored energy is shown in Fig. 2. As can be seen, the peak temperature also increases with the energy released.

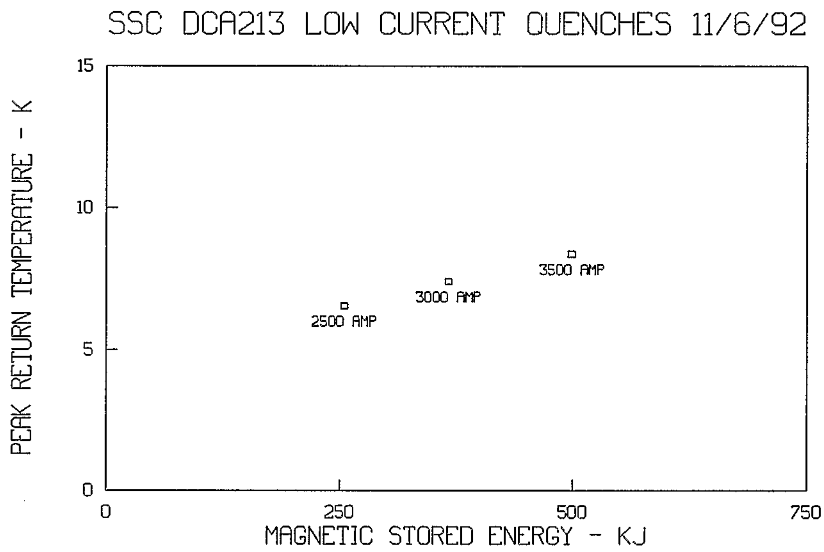

Fig. 2 Peak temperatures at the subcooler return

Other characteristics of the MAGCOOL-Subcooler after the 2500, 3000 and 3500 ampere quenches of DCA213 are summarized in Table 1. As shown, the agreement between total cooling provided and the magnetic stored energy is confirmed.

Table 1. Summary of results after quenches of DCA213

Quench Current	Peak Pressure	Time to Peak Press.	Peak Temp.	Time to Peak Temp.	Max. Cooling Rate	Total Cooling	$1/2\ L\ I^2$	Ratio
ampere	atm	sec.	K	sec.	KW	KJ	KJ	
2500	10.4	41	6.55	125	1.5	257	255	1.01
3000	13.5	50	7.41	122	2.0	365	367	1.00
3500	16.1	51	8.39	120	2.5	472	499	0.95

REFERENCES

1. K. C. Wu, "Thermal Behavior of MAGCOOL Cryogenic System After Low Current Quenches of RHIC Magnet DRD-009", RHIC Project Technical Note, AD/RHIC/RD-46, Brookhaven National Laboratory, November, 1992.

2. K. C. Wu, "Performance of the MAGCOOL-Subcooler Cryogenic System after 50 mm SSC Quadrupole Quenches", RHIC Project, AD/SSC Technical Note 102, Brookhaven National Laboratory, July, 1992.

3. K. C. Wu, "Comparison of Total Cooling Provided to the Energy Released after Low Current Quenches of SSC Dipoles in MAGCOOL", RHIC Project Technical Note, AD/RHIC/RD-39, Brookhaven National Laboratory, April, 1992.

APPENDIX: PRESSURES, TEMPERATURES, FLOW RATE, APPARENT COOLING RATE AND TOTAL COOLING FOR THE 2500, 3000 AND 3500 AMPERE QUENCHES

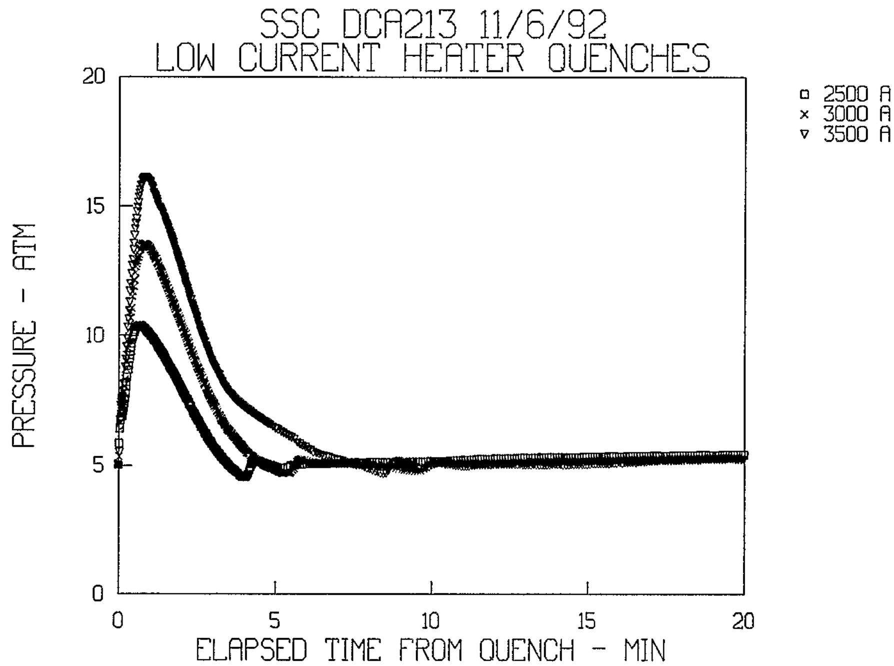

Fig. A1 Loop pressure after magnet quench

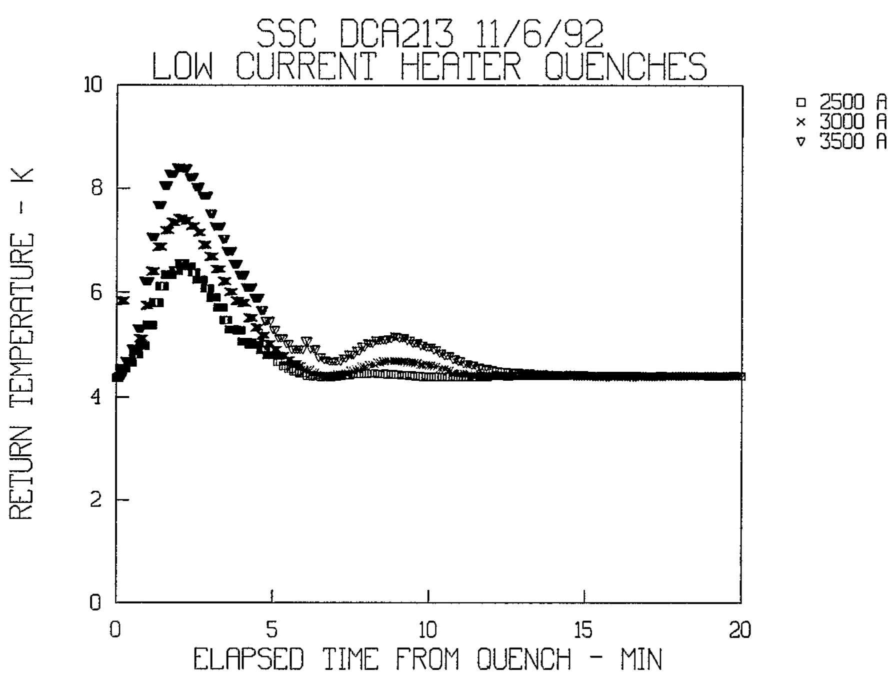

Fig. A2 Return temperature in the subcooler

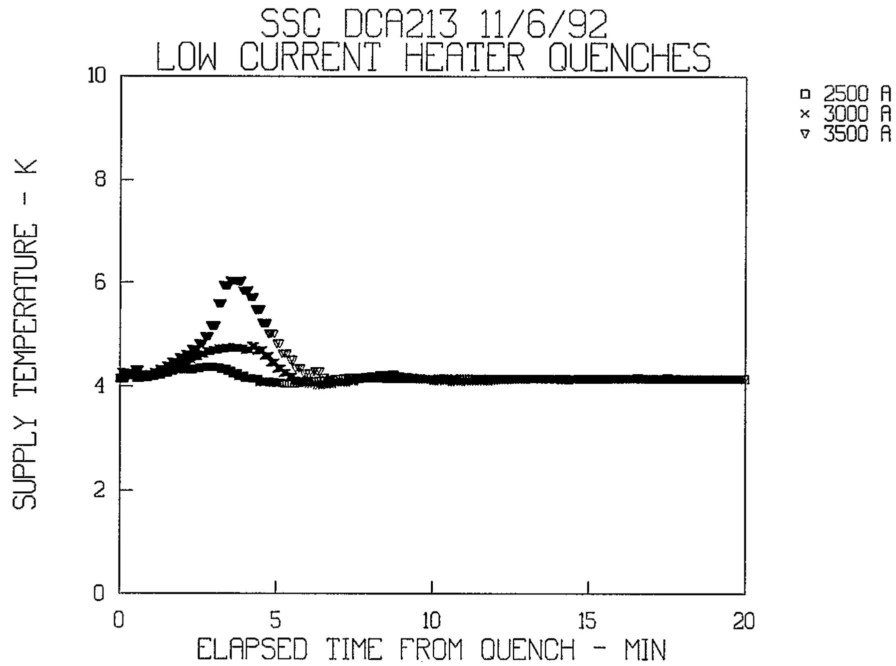

Fig. A3 Supply temperature from the subcooler

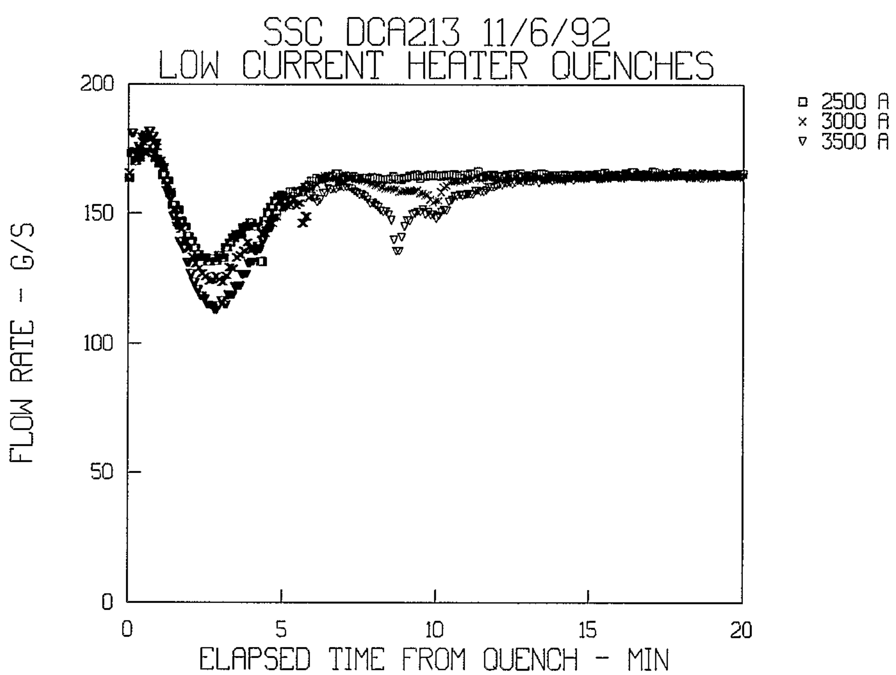

Fig. A4 Mass flow rate after magnet quench

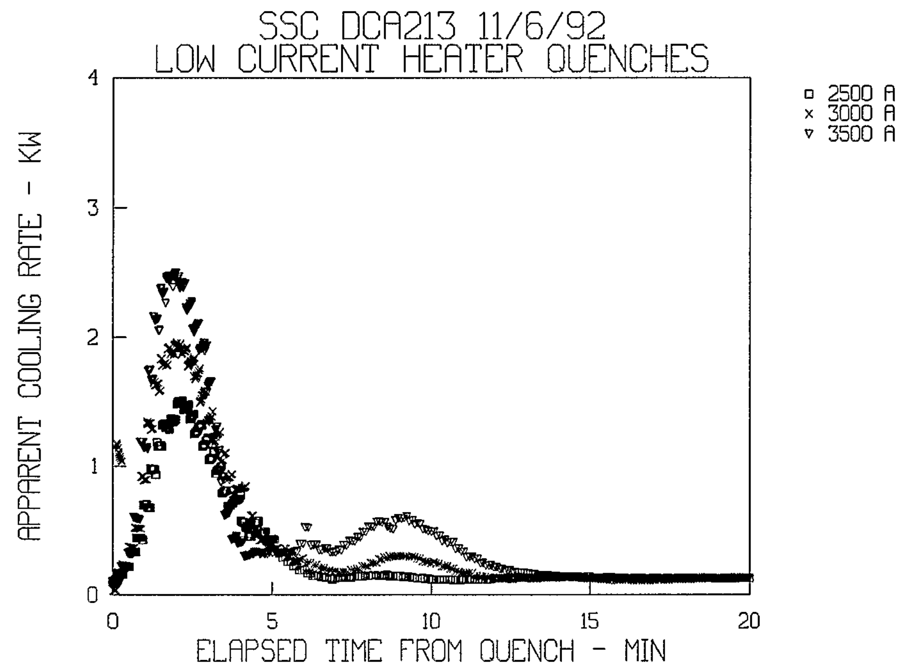

Fig. A5 Apparent cooling rate during quench recovery

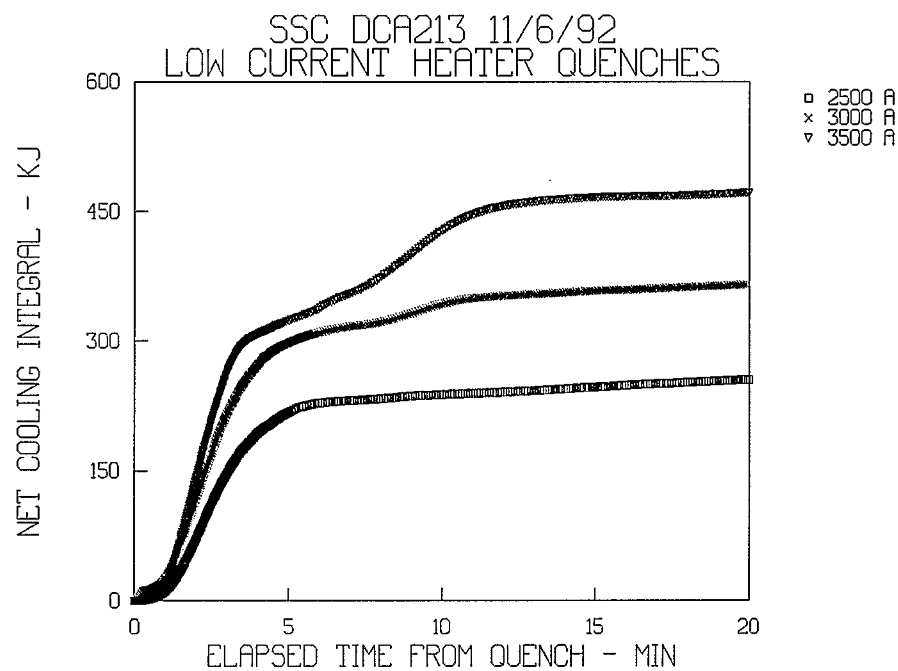

Fig. A6 Total cooling provided to the magnet