SSC-N-73

SSC Operation Task Force

FNAL SSC CRYO 85-5

QUENCH RESPONSE

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INTRODUCTION

SSC Quench Response consist of two parts first relieving the displaced mass and then re-cooldown. The first has two goals: to keep the pressure below a maximum limit and to minimize the upset to the refrigeration system. All cryogenic designs have chosen to dump the quench gas into a 10 to 20K header in order to minimize vent line cooldown pressure drops and also to minimize re-liquefication power.

The 200. millsecond transients are very difficult if not impossible to calculate. One can scale from existing data and then must follow it up with full scale testing (SSC Long String Phase I).

The re-cooldown is actually more related to whether one uses active or passive quench protection than to magnet style. The active protection effectively warms a half cell to a uniform temperature, while the passive has a "hot spot" about 10 to 20% of the half cell length.

There is one potential problem with the "Cryo-coupled" and "Dual" Magnet Design (Fig. 1). If one has parallel cooling for the two coils, the coil that didn't quench or that quenched second will steal all the flow from the hot coil; lengthening the re-cooldown by up to several hours. This is not a problem in Design "C" since the cooling channels are on midplane and the coils are cooled by conduction. For Design "Y,L & R" there is no detailed cryogenic design.

PASSIVE QUENCH RESPONSE

The "hot spot" in a given direction is separated by up to almost two half cells of cold magnet from the relief valve (1Ø to He header). This means that before one can relieve the gas one must displace the liquid.

1. Permit the liquid to be pushed out of the half cell back to the dewar through the liquid return line.

2. When the far relief reaches >8K, open it, (or if the pressure gets too high). Stop the liquid return line flow.

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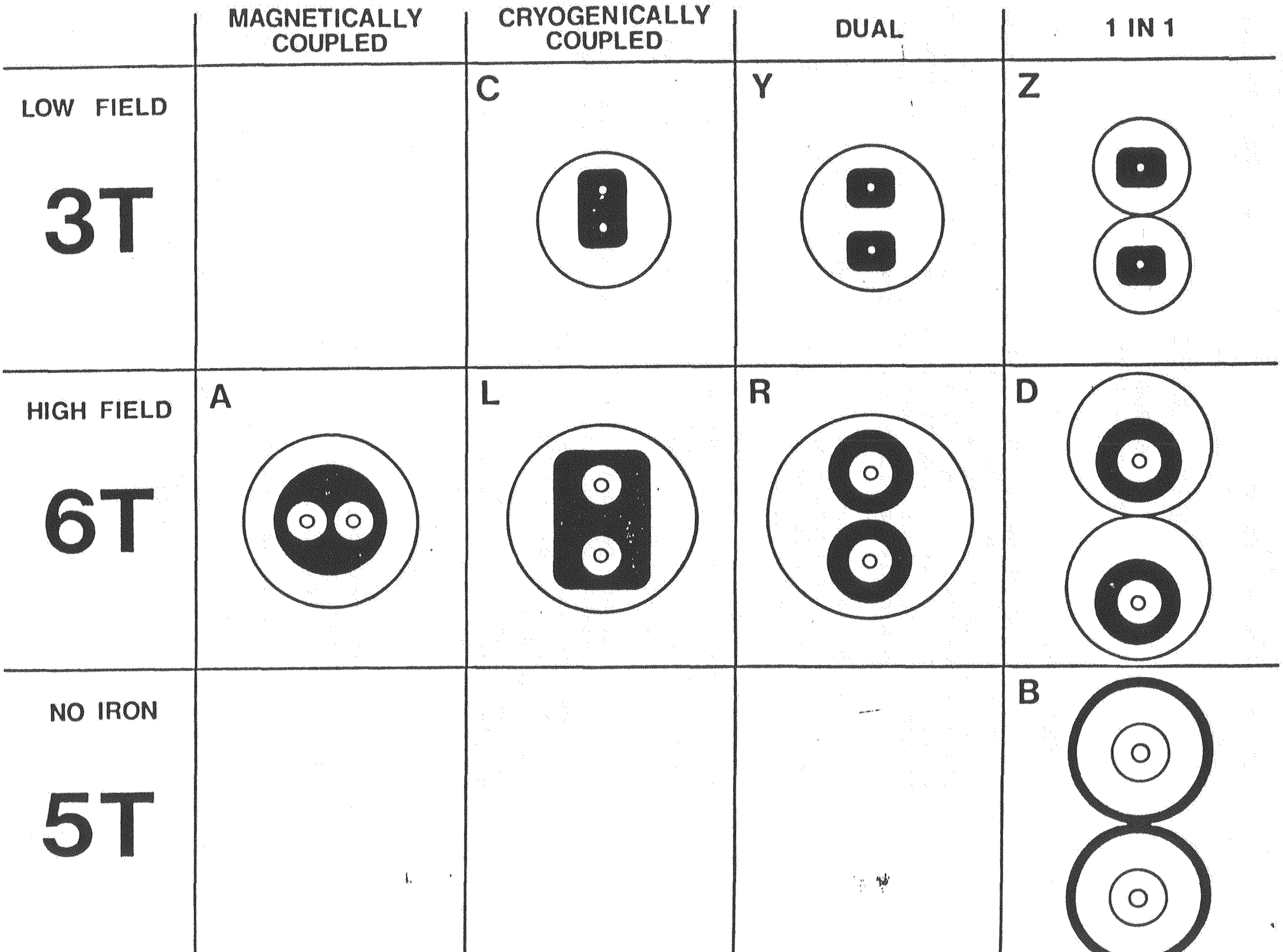
MAGNETICALLY COUPLED
CRYOGENICALLY COUPLED
DUAL
1 IN 1
LOW FIELD
3T
HIGH FIELD
6T
NO IRON
5T
C
Y
Z
A
L
R
D
B

3. If the near relief reaches >20K, open it, (or if the pressure gets too high), Goal: trap gas in the quenched half cell.

4. Close the near relief as soon as possible.

5. Push the maximum 1Ø flow through the half cell, using a liquid pump in addition, if it exists.

6. Vent the gas bubble out the far relief, closing it when the temperature is less than 7K. Re-establish 1Ø flow back through the liquid return.

7. When the output temperature reaches 4.5K cut the flow back to normal.

ACTIVE QUENCH RESPONSE

The response is much simpler since the bubble reaches both the near and far relief valves.

1. Open the far relief valve and shut off the return liquid flow at the turnaround box.

2. Open the near relief only if the pressure gets too high.

3. Push the maximum 1Ø flow.

4. Close the far relief valve when the temperature out of the half cell reaches 6K, and re-establish 1Ø flow.

5. When the output temperature reaches 4.5K cut the flow back to normal.

CONCLUSIONS

1. From the power supply standpoint quench recovery is absolutely trivial. After a high energy half cell quench the power supply can be back on in less than 20 min.; since this is a slow cycling machine the quench recovery can be completed during the ramp up.

2. From the beam optics and persistent currents standpoint, it is an entirely different matter. If one requires system stability to the level of 25 mK, quench recovery may take an hour or two.

This leads to the need to design the correction system to deal with temperature transients of up to .2K. The strength of correction elements for this appears to be smaller than that needed for the production variances in J_c. The determination of the control algorithms is the major problem; this may take a great deal of theoritical and experimental effort.

3. The "Cryo-coupled" and "Dual" cooling systems must not use parallel coil cooling channels.

4. The system must be able to relocate large amounts of liquid in short periods especially for passive quench protection.

5. The refrigerator must be able to deal with shield temperature fluctuation from 5 to 50K.

6. The Long String Phase I tests will provide detailed information on how fast He is pushed out of the coils and how much energy it adsorbes. The Phase II tests will proivde information on how the system responds and specific design criteria for the refrigeration system.

	B	Y,Z	C	A	D,R	L
STORED ENERGY						
Per half cell per ring (MJ)	6.2	.72	.72	4.8	∼5.	∼5.
Factor for 2nd ring energy	1.00	1.00	∼1.6	2.00	1.00	∼1.3
Half cell length (M)	106	150	150	100	100	100
Quench Recovery Unit (M)	106		150	200	100	
Subcooler Spacing (M)	212	300	300	200	200	200
Normal Subcooler transit time (M)	.2		∼.5	∼.8		
PASSIVE QUENCH PROTECTION						
Quench Length (M)	12		150	17	17	
"Hot Spot" length (M)	12		∼15	17	17	
"Hot Spot" temperature (K)	∼45		∼45	∼30	∼30	
Recovery Time to <4.7K (hr)						
Recovery Time to <4.5K (hr)			∼.5			
Recovery Flow (g/sec)			>60			
ACTIVE QUENCH PROTECTION						
Quench Length	106		--	100	100	
Temperature (K)	∼45		--	∼30	∼30	
Recovery Time to <4.7K (hr)	.2		--		.2	
Recovery Time to <4.5K (hr)	.4		--	∼.5	.6	
Recovery Flow (g/sec)	200		--	>140	200	

TABLE I FULL ENERGY QUENCHES, ONE QUENCH PROTECTION UNIT