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DESIGN "D" FULL RING QUENCH PRESSURE RISE

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INTRODUCTION

The pressure rises in the magnet consist of a number of different phenomena with vastly different time constants:

1. Helium displaced from inter conductor spaces into bore tube.

2. Helium displaced from bore tube region into outer helium chamber (and ends).

3. Helium flow through outer helium chamber to relief valves.

4. Pressure drop in relief lines and valves.

5. Pressure drop in collection header (20K shield).

The factors that control each of these five items respectively are:

1. Conductor percent void, conductor insulation, voids between conductors.

2. Conductor insulation, bore helium gap, end volumes.

3. Number and shape of outer helium chambers, ends, conductor insulation, coil ground rap, gap between collars and iron, thermal conductivity of iron, heat capacity of conductor, heat capacity of iron.

4. Small: 1 1/2" cold relief line. (This was the dominant effect in the Tevatron since it was a warm line; peak pressure was at 200 msec.)

5. Small: 3.00" ID 20K header, primary vent stack every 1.2 km, secondary relief every 100m.

CONDUCTOR HELIUM DISPLACEMENT

We can assume this is instantaneous. Starting at 4.5K 4 ATM with an adiabatic compression of 10% we get 15 ATM at 5.3K.

BORE TUBE FLOW

The coil temperature will go to ~30K in 200. msec. and then start to cool off. With .006" of Kapton and .001" of static helium, we calculate a heat flux of 23. watts/cm length into the bore region, giving us a time constant of 2. sec. The initial heat flux into the iron is less, due to the ground rap on the coils (12 watts/cm).

Assuming a 2 mm bore gap we can push 500 g/sec per end at 10K with 20 ATM at the center of the magnet and 15 ATM at the ends. This gives us a 0.6 sec time constant.

Assuming the magnet ends are filled with a spacer material (i.e. small volume), without relieving, and using an adiabatic compression model, we calculate 20 ATM pressure in the single phase with the bore gas at 30K, the displaced bore gas at 15K, and the adiabatic compressed outer at 5.58K.

HELIUM VENTING FROM 10

After the helium has been pushed from the bore region, the heat must now flow through the iron. The time constant of the iron warming up is 10 sec due to the presence of the ground rap and several static helium gaps.

The outer passages can flow 16,000K g/sec at 10K with the center of a half cell at 20 ATM and the spools at 10 ATM. This gives us a 2.5 sec time constant. Since this is much faster than the time constant of the iron heating up, the pressure in this phase is decaying.

CONCLUSIONS

The magnet pressure rating of 20 ATM appears to be adequate but clearly needs to be experimentally measured as it was in the Tevatron. (This is one of the critical tests in the "Long String Test - PHASE I & II"). The two largest uncertainties in the pressure rise are the bore tube gap and the detailed design of the ends. If one were to use a smaller bore gap one would need a higher pressure rated bore tube (e.g. The HERA bore tube is rated

for 80 ATM). The helium volume in the ends causes a variety of effects depending on the amount of helium mixing that occurs, in general a smaller volume is desirable.

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