E951 Cryogenics

A high field copper conductor magnet is proposed for experiment 951. The present magnet geometry is solenoidal, with a 20 cm ID, 80 cm OD, length of 100 cm, and mass equal to 3,375 kg. The cooling arrangement will utilize forced flow helium gas through axial magnet channels. Helium gas will be circulated via a centrifugal compressor and heat removal is via heat exchange with liquid nitrogen or hydrogen depending on the operating mode. The design temperature for helium delivery to the magnet with LN2 cooling is 66 K (sub-cooled LN2) and 22 K for LH2 cooling.

A dual tube-in-shell style heat exchanger, recovered from SSC surplus, is available at BNL. It was originally used to cool circulating supercritical helium with pool boiling liquid helium. This heat exchanger arrangement was evaluated for helium circulation for the E951 Magnet, with LN2 or LH2 as the cooling medium, and a circulating pump capable of circulating 100 g/s helium at 1- 1.5 atm head pressure.

Cooldown performance for this combination, assuming a heat exchange efficiency of 1, is shown in three plots for three cases, I- magnet pulse at 84 K with temperature excursion to ~ 89 K (~3.75 MJ transferred), II- magnet pulse at 74 K with temperature excursion to ~89 K (~ 10.6 MJ transferred), and III- magnet pulse at 30 K with temperature excursion to ~83 K (~21.9 MJ transferred).

Cooldown case legend descriptions; Qrate is the magnet cooldown rate (J/s) assigning a heat exchange efficiency of 1 at the helium flow to magnet interface, Qmag is the heat transferred (J) from the magnet through the cooldown cycle from start to finish temperatures, Qhxlim is an estimate of the heat exchanger performance upper limit (J/s) considering nucleate or film boiling, and the temperature is given in degrees Kelvin. All are plotted as a function of time. It should be noted that the estimate shows the heat exchanger to have 5- 10 times the required performance for the given arrangement.