Cooling balance

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September 9, 2010

1 Helium and nitrogen budget

We present some estimates of the volume of crygenic fluids needed to cool down the bucket dewar, reentrant shields, and bottom plate. Table 1 shows the number of liters of liquid nitrogen needed to cool down the shields and bottom plate from 300 K to 80 K. The total amount of LN is around 225 l (1.5 tanks). This is consistent with the number of tanks we need to cool down to 80-90 K(3 tanks). Table 2 shows the amount of liters need to cooldown the helium shields to 5 K using the cooling power of Helium gas from 80 K to 5 K. The amount needed is around 30 liters.

2 Cooling budget

Figures 1 and 2 show several cooling sequences using liquid helium. The cooling rates are indicated in each figure. The data corresponds to the temperature of the reentrant helium shield. Table 3 shows the corresponding cooling power observed for all of the cooling rates marked in the figures.

The amount of liquid He used during the complete cooling cycle is 250 L in 20 hours. This gives a transport rate of 12.5 L/hr. Almost all of the cooling will be performed not by vaporization of the liquid but by cold helium gas. Let's assume that the temperature of the gas changes from 4 K to 80 K with a corresponding specific enthalpy change of 400 J/g. Hence the total input power

	Vol [m^3]	ρ [kg/m^3]	M [kg]	LN [l]
BD LHe	0 .014	8000	110	60
R LHe	0.015	2700	40	42
BD LN	0.013	8000	102	54
R LN	0.008	2700	22	23
B. plate	0.016	2700	43	45

Table 1: Liters of LN needed for cool down and other physical properties of the shields. The word shield has been omitted for the first four entries. Legend for table: BD: bucket dewar, R: reentrant, B: bottom.

	LHe [l]
BD LHe	14
R LHe	8
B. plate	9

Table 2: Liters of LHe needed for cool down.The word shield has been omitted for the first two entries. Legend for table: BD: bucket dewar, R: reentrant, B: bottom.

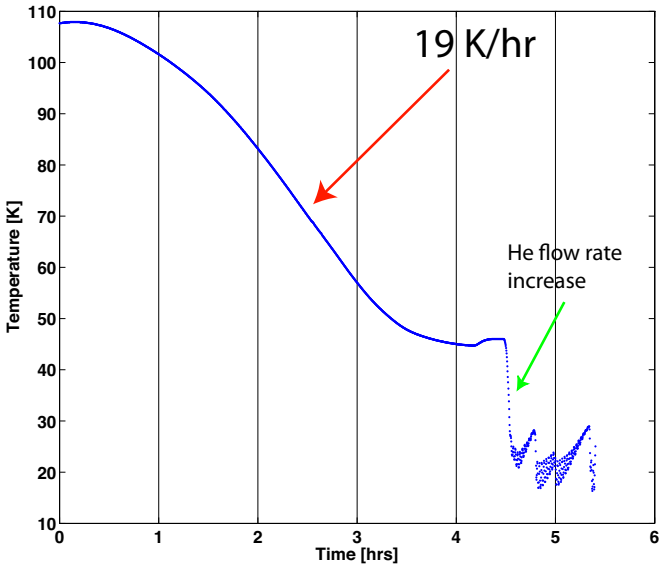

Figure 1: Cooldown sequence of reentrant He shield using LHe.

from the flow of cold gas is 170 W, around the same order of magnitude as the observed cooling. Of course, 12.5 L/hr is a somewhat conservative estimate and the instantaneous value might be larger *e.g.* Fig. 1 shows an increase in cooling rate after the flow was increased.

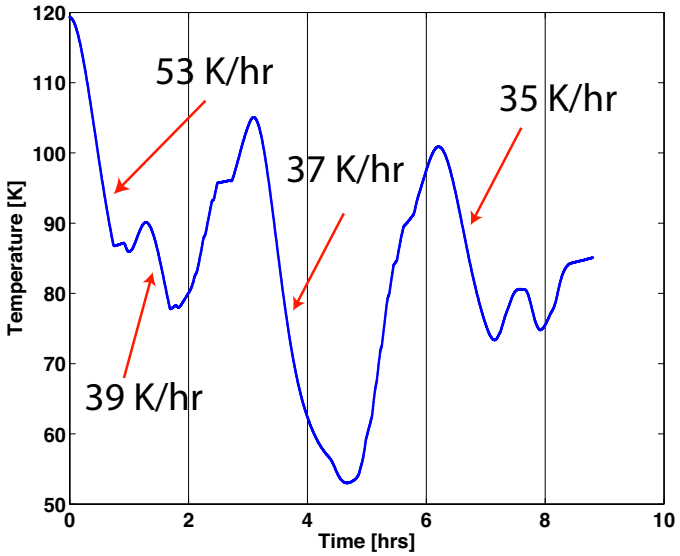

Figure 2: Cooldown sequence of reentrant He shield using LHe.

Cooling rate [K/hr]	C_{avg} [J/Kg K]	Cooling Power [W]
19	360	76
53	517	304
39	401	173
37	363	149
35	416	161

Table 3: Set of cooldown cycles of reentrant He shield using LHe.