Introduction

The cryostat Miss Piggy has been rebuilt. Only the outer vacuum jacket, the Ti sample tube and the transfer line are left from the original cryostat. The various parts of the cryostat and external pluming are shown in Fig. 1. Helium from the transfer line enters the phase separator, under normal running conditions liquid collects at the bottom and gas at the top. The gas from the phase separator is used to cool the various shields in the following order: the phase separator inner shield, the sample tube outer shield, the phase separator outer shield, the sample tube close to its anchor point and the transfer line shield. The gas is pumped using the small pump and the flow is controlled from CAMP with the Omega Mass Flow (M.F.) controller and valve. The liquid goes through the Needle Valve (N.V.) and diffuser before it expands to cool the sample and inner sample shield. The sample space is pumped on with the large He pump and the N.V. is controlled from CAMP. The cryostat in this configuration was tested in March 2002, the following few pages describe the result of this test and the best way to operate this cryostat.

Base Temperature 1.65 K

The initial cool down time from room temperature to base takes about two to three hours. After flushing the cryostat close the N.V. and open wide the M.F. (100 %) when liquid starts to collect in the phase separator open the N.V (about 2 turns) to cool the sample space. When the temperature reaches below 20 K one can close the N.V and slowly close the M.F. It is possible to control the temperature below 20 K during cool down but keep the Mass Flow more open than normal until all the radiation shields are cold. After the shields are cold the operating conditions at base temperature are given in Table 1. To cool down from 200 K to few Kelvin it takes about 1/2 an hour and to base temperature about 1 hour.

Higher temperature

At all temperatures it is best to keep the M.F. at 40 %, this insures that liquid He is always present in the phase separator and that the shields are cold. This will make it easier to operate the cryostat and will take less time to cool down the system again. The price of running the cryostat with the M.F. at 40 % all the time is an increase in the amount of He consumed. But this might not be as high when considering the amount of He needed to again cool down all the shields. Yes if one is staying at high temperature all day then run the cryostat without liquid in the phase separator (M.F. below 20 %) and save He, when closing the M.F. you might have to open the N.V. to keep the temperature stable.

All the test results described here were done with the M.F. set at 40 %. There are seven temperature zones between base and 300 K. Table 2 defines the zones and the parameters used to control the temperature in a particular zone. If the final temperature is in a different zone than the current temperature then change the control parameters to those of the final temperature zone at the start of the temperature change.

Temperature Control between base and 29 K

Between base and 19 K only the diffuser heater is needed. Below 10 K temperature changes are very quick. Above 10 K close the N.V. and change the P and I as given in Table 2. Note that under these conditions the sample temperature is about half a degree below the diffuser set point. Between 20 and 29 K use the window heater with the window Ptr set point equal the diffuser set point and P,I and heat as given in Table 2. Figure 2 clearly shows the advantage of using the extra window heater.

Warming up above 30 K

The simple way of setting the diffuser and window Ptr to the required set point and waiting for the sample temperature to become stable is slow, broken line in Fig. 3. It is possible to change the temperature more quickly, solid line Fig. 3, if one follows this procedure (the control parameters should be set to the values of the final temperature zone Table 2):

1. Set the N.V. to the required value, Table 2.
2. Set the diffuser to the required control set point, P, I and heat as given in Table 2.
3. Set the window Ptr to the quick warm up set point Table 3, P, I and heat Table 2.
4. When sample temperature is within ΔT (Table 3) from the diffuser set the window Ptr control set point as given in Table 3.

Example 1 (Figure 4) change temperature from 40 K to 60 K in about 10 min.

1. N.V. 0.19 turns
2. Diffuser set point 60 K, P=500, I=20, Heat= High
3. Window Ptr quick warm up set point 70 K, P=500, I=20, Heat=Med
4. When sample temperature is 58 K then change window Ptr set point 62 K.

Example 2 Change temperature from 100 K to 150 K in about 15 min.

1. N.V. 0.19 turns
2. Diffuser set point 150 K, P=500, I=20, Heat= high
3. Window Ptr quick warm up set point 170 K, P=500, I=20, Heat=High
4. When sample temperature is 146 K then change window Ptr set point to 154 K.

Cool down RT to 30 K

It is possible to cool down the sample in 10 to 15 min if the following procedure is used.

1. If the start temperature is above 60 K then open the N.V. to the value used to obtain base temperature. Below 60 K this step is not necessary.

2. Set the diffuser to the quick cool down set point which is 20 deg. below the control temperature when starting above 130 K and 10 deg. below the control temperature when starting below 130 K (Table 4) and the P, I and heat according to Table 2.

3. Set the window Ptr to the quick cool down set point which is 10 deg. below the control temperature when starting above 130 K and 5 deg. below the control temperature when starting below 130 (Table 4) and the P, I and heat according to Table 2.

4. If the N.V. was opened then close it to the value given in Table 2 when the diffuser is within 1 K from the control temperature. This results in a little bump in the temperature plot.

5. Set the diffuser to the control temperature either when the sample is within 1 K if the N.V. was not opened for cool down or when the temperature starts to drop again after the N.V. is closed.

6. Set the window Ptr to the window Ptr control set point Table 3 when the window temperature is equal to the the diffuser temperature.

Example 3 change temperature from 60 K to 40 K in about 10 min.

1. N.V. keep at 0.19 turns

2. Diffuser quick cool down set point 30 K, P=30, I=200, Heat= High

3. Window Ptr quick cool down set point 35 K, P=500, I=20, Heat=Med

4. No change to the N.V

5. Set the diffuser set point to 40 K when sample is at 41 K (arrow A Fig. 8).

6. Set the window Ptr set point to 41 K when window temperature is almost equal to the the diffuser temperature.

Example 4 (Figure 5) change temperature from 150 K to 100 K in about 15 min.

1. Open N.V. 0.22 turns

2. Diffuser quick cool down set point 80 K, P=500, I=20, Heat= High

3. Window Ptr quick cool down set point 90 K, P=500, I=20, Heat=High

4. Close N.V to 0.18 turns when sample is at 101 K (arrow A)
5. Set the diffuser set point to 100 K when sample temperature starts to drop again after N.V. is closed (arrow B).
6. Set the window Ptr set point to 102 K when window temperature is almost equal to the the diffuser temperature.

He consumption

M.F. 40 % = 14.6 lpm He gas
N.V. 0.2 turns = 15.5 lpm He gas at 200 K
N.V. 0.19 turns = 12.3 lpm He gas at 200 K
30 lpm He gas ≈ 2.25 lph Liq. He
350 l Liq. He 2.25 = 155 hours = 6.5 days

Changing samples

In the counting room

1. Turn off the high voltage - to protect the photomultiplier tubes.
2. Open needle valve to 1 turn - to speed up increasing the He pressure in the cryostat.

In the experimental area

1. Close the valve on the Mass flow pump (small pump) - speeds He pressure buildup in the cryostat.
2. Close He pumping valve, turn pump off and watch the pressure gage.
3. When pressure in the cryostat is slightly above one atm open the He pumping valve and open the bypass(little green valve) - to protect the cryostat window from over pressure and keep slight He flow through the cryostat.
4. Disconnect the thermometry cable, pull away the plug PLEASE DO NOT TURN THE NUT and spoil the cryostat vacuum.
5. Turn the locking screws and pull the insert out, it is long and cold so use gloves.
6. Put in the plug, move the O-ring a few mm forward (this makes it easier to insert the plug) push both ends of the plug in and make sure it is properly seated (no gap between the brass plug and the Al plate).

7. lock tightly the screws

Before inserting the sample rod back into the cryostat make sure it is dry, remove the plug and insert the rod as described in step 6 above. Then connect the thermometer cable, close the bypass valve and turn the large He pump on, open the valve on the mass flow, adjust the needle valve and finally turn the high voltage on.

What to do if the sample rod is stuck

If when removing the sample rod it gets stuck half way out - do not force it out. This happens because of some air leak into the system and ice forming in the rods track. To clear the ice turn all the heaters on, in particular the heater on the back of the sample tube. This heater should be connected to a Lakeshore temperature controller in the experimental area.

How to check if the transfer line or needle valve is blocked

If the transfer line is cold and it is not possible to maintain the set point on the mass flow then the transfer line is either blocked or it is above the liquid He level. When the transfer line is warm the flow will be low but will increase slowly toward the set point as the transfer line gets colder.

To test if the needle valve is blocked open the needle valve and close both the mass flow valve and the valve on the large He pump. Watch the pressure gage if the marker moves toward 1 atm (0 on the gage) then He is flowing but if it does not move then there is a blockage in the cryostat or transfer line.

In either case it is best to pull the transfer line out and warm it up. If there is a blockage in the cryostat then it needs to be cleared. Turn the heaters on and flow warm helium gas through the system, this can be done through the mass flow and needle valve into the sample space and monitored by the pressure gage on the large He pump.

Table 1: Base temp

Needle Valve N.V.	0.22 turns
Mass Flow M.F.	40 %
Inner Sample Shield	4 K
Phase Separator Outer Shield	33 K
Phase Separator	4.22 K
Window Ptr	16 K (does not work below 20 K)
Sample	1.65 K
Diffuser	1.72 K
Gas Return to Trans. Line	26 K

Table 2: zone and P I Heat

Zone(K)	N.V. (turns)	M.F. (%)	Diffuser			Window		
			P	I	Heat	P	I	Heat
Base – 9	0.22	40	1	900	Med			
10 – 19	0.19	40	15	500	Med			
20 – 29	0.19	40	15	500	Med	200	20	Med
30 – 39	0.19	40	30	200	High	200	20	Med
40 – 59	0.19	40	60	200	High	500	20	Med
60 – 79	0.19	40	500	20	High	500	20	Med
Above 80	0.18	40	500	20	High	500	20	High

Table 3: Warm up

Zone(K)	Window Ptr quick warm up set point = diffuser set point +	ΔT	Window Ptr control set point = diffuser set point +
30 – 59	5	1	1
60 – 129	10	2	2
130 – 199	20	4	4
200 – RT	20	4	6

Table 4: Cool down

Zone(K)	Diffuser Quick cool down set point = control T -	Window Ptr Quick cool down set point = control T -
59 to 30 K	10	5
129 to 60 K	10	5
above 130	20	10