

## **Running the Dilution Fridge**

### Before starting a run:

Pump out insert (condenser and still lines) overnight with turbo pump

Make sure LN and LHe traps are clean – pump out with He4 rotary pump

Start He3 rotary pump the night before to warm it up

Make sure you pump out the pump line firstly before you open the valves in the fridge, when you use pump to vacuum the inset or everything else. Otherwise the air residing in the pump line will enter the fridge.

### Sealing the IVC

1. Use 1mm Indium wire
2. See figure
3. Tighten the screws (There're numbers from 1 to 8. Tighten like 1->1->2->2-> ...->8->8.)
4. Pump out the IVC for 0.5 – 1.5 hours.
5. Tighten the screws again.
6. Fix the cold trap and pick-tube with a metallic tape.
7. Attach the sliding seal to the fridge.
8. Remove a blank on the sliding seal.

### Putting exchange gas in the IVC and flowing He gas through 1K pot

1. Regulate He gas flow (less than 1 digit).
2. Push out the air in the small space of the elbow of the IVC. Pinch the tube about 1 inch from the elbow and open the IVC valve all the way and close it. Then you can put a small amount of exchange gas (He gas) into the IVC.
3. Make sure the needle valve is close.
4. Pump out 1K pot with turbo pump (standby mode is fine) for a couple of minutes.
5. Push out the air in the small space of the speedivalve of the 1K pot.
6. Fill He gas up in the 1K pot. It just needs 30 seconds.
7. Open the needle valve (1 or 2 turns) and flow He gas through the 1K pot. Make sure bubbling from the pick-up tube using alcohol in a small lid. Keep flowing He gas during cooling down until temperature goes down below 200K.
8. Put the sliding seal on

### Cooling down

1. Start VI. Name the file "cooldown".
2. Lower a couple of inches every 5 or 10 minutes.
3. Close the 1K pot valve after temperature goes down below 200K

4. After lowering the fridge all the way, fix the fridge on the magnet with the screws.

#### Pumping out the IVC

1. Hook up the bellows to the IVC.
2. Set 15K
3. Set still power 100mW
4. Set still shutoff temp 20K
5. Set manual output 50mW
6. Pump out the IVC with turbo pump and leave it overnight.

#### Pump out the system

1. Attach the condenser line to the small speedivalve.
2. Attach the He4 pumping line to the speedivalve just below the gate valve on the wall
3. Attach the still line to the large gate valve on the fridge
4. Pump out the condenser line with 4He rotary pump opening the valves 5A, 2A, 7, 2, and 1. Don't open the speedivalve.
5. Pump out the LN trap with 4He rotary pump using the valve 11A.
6. Pump out still line (1 m length) using 4He rotary pump, opening v4 and butterfly valve (on the wall).
7. Tighten quick coupling of the large gate valve on the still line after starting pumping
8. Keep pumping them out overnight.
9. Turn on 3He rotary pump and leave overnight (at least 2h) to warm it up.

Never open the condenser line, the still line, and the gate valve on the wall

#### Stop pumping out the IVC

1. Close IVC and turn off/remove pump.
2. Set still power 10 mW
3. Set still shutoff temp 0.3K
4. Turn off manual output

## Cleaning out the Dilution mixture:

### Step 1: run the mixture through the nitrogen trap

1. Open valves 1 and 3
  - hold valve button down and press the “raise” button
2. open valve 13A
3. slowly open valve 12A
  - best to start with 0.5% opening, following with an opening rate of about 1% every minute. Do this until the “G2” pressure reading reaches 550
4. when “G2” pressure reading reaches 550, close valve 13A
5. open valve 6
  - valve 6 does not actually open until the “percent open” reading reaches around 12-13%
  - the valve works very slowly. Yellow light means the valve is currently changing. Amber light means the valve is partially open. Green light means the valve is fully open
  - when opening valve 6, open slowly until, as Mr Kirshenbaum puts it, “the rattling stops” and the G2 pressure reading starts to go up. (Note from *Dr. Kirshenbaum* – the “rattling” refers to the sound that you can hear coming from the He3 pump when it is pumping on a vacuum. When gas starts flowing through the pump this rattling/clicking noise stops, though the slow grinding sound continues. It’s very subtle, so the best bet is to watch G2 and just open V6 slowly.)
6. Open valve 12A completely
7. Slowly open valve 6 completely
  - Open it roughly 0.5% every minute until it reaches 20% open, or until pressure reading “P1” is  $< 1$  (or when there is  $< 1$  mbar left in the system).
8. After it reaches this value, open valve 6 completely
9. Wait for the G2 pressure to reach 602 (609) again
10. Once the pressures have gone back to their beginning values, close all valves but valve 9
  - The ideal order in which to close the valves is 12A, 1, 3, 6.
  - Always close valve 6 last

### Step 2: run the mixture through the helium trap

11. Insert the Helium cold trap slowly into the system
  - The helium cold trap will only slide all the way into the tube at a specific orientation
12. Open valve 1
13. Open valve 13A
14. Slowly open valve 12A (roughly 1% a minute)
  - The pressure reading on G1 will shoot up fairly quickly, because valve 3 is closed
15. When the G1 reading reaches 200, open valve 3
16. Continue to open 12A slowly, until the G2 reading reaches 550
17. Repeat steps 4 through 10.

## Starting circulation:

### Step 3: condensing the mixture

1. All valves should be closed except for valve 9
2. Open the manual valves on the fridge that lead into the physical system in the insert
3. Open valve 1
4. Open valve 13A
5. Open valve 12A **VERY SLOWLY** (DO NOT open it past 5% until P1 starts to go up)
  - \* See side note about condensing the mixture
6. Continue to open 12A slowly (DO NOT open it past 15% until the system temperature starts to drop and the pressure G1 begins to drop – This is the sign of condensation of the mixture. Make sure to step the T setpoint down in intervals to minimize noise)
7. Continue to open 12A a little more quickly (steps of 2-4% every few minutes)
8. If P1 has reached 1000, continue on to step 4: circulation

### Step 4: Begin circulation

1. Wait until P1 reading reaches 1000 (remember 1000 is not accurate, it just means P1 is at a high pressure. See side note about pressure gauges)
2. Once P1 has reached 1000 and condensation has started, open valves 6 and 12A
  - Open valve 6 very slowly. G1 and G2 readings should both be steadily decreasing
  - At the moment that the valve 6 opening is increased, the G2 reading will increase a small amount. So it becomes an interplay of slightly increasing valve 6 opening and waiting for the G2 reading to bounce up a bit and begin dropping back down.
  - Every time open valve 6 more, also open valve 12A more. The step sizes of opening valve 12A (~3%) can be larger than those for valve 6 (~0.2%).
3. Continue to open V6 until it reaches 80% and V12A until it reaches 100%. V9 should still be open.
4. Once G2 gets below about 200, you must close V9. You should then proceed to pull the rest of the mixture through V14.
  - Pulse open V14 until all the mixture is removed (open the valve, then close it again when G2 reaches about 300 mbar. Repeat, cycling between 200 and 300mbar)
  - Remember to lower the temperature set point or the LS370 will apply heat and never let the mixture cool.
5. (Pretty much the end) Once you remove the entirety of the mixture from the dump (P1 reads 5 mbar when V14 is open), you must close V14, dependent upon that valve which was opened during the previous step.
6. (Lied to from above) Turn on the ROOTS pump when temperature is below 400 mK.
7. (On first cooldown) set resistance ranges on LS370 to match their pre-Tc values.

Side notes:

- ❖ Pressure gauges: there are 5 pressure gauges
  - the units of the gauges are in millibar
  - 3 are labeled “G”: they are high pressure gauges
    - they are accurate above 2 millibar
  - 2 are labeled “P”: they are low pressure gauges
    - They are accurate below 2 millibar
- ❖ 1K pot:
  - There is a thermometer on the 1K pot, but it is not connected to the system, so we cannot read it.
    - Therefore we do not know the temperature of the 1K pot.
    - We do know that when the pressure reading “G3” - which is the pressure of the 1K pot - is between 5 and 10, the temperature of the 1K pot is roughly 2 Kelvin.
- ❖ Condensation of the mixture
  - You want to make sure there are no blockages, leave valve 6 closed
  - When P1 begins to raise in pressure, that is a good sign, meaning we have no blockage
  - While opening valve 12A, if the G3 reading starts to go up (past 11 or 12), then 12A is being opened too quickly

Removing the fridge:

Step 1: Removing the mixture

1. Open valve 9
2. Close valve 13A
3. Close the needle valve to the 1K pot
4. Set the mixing chamber temperature to 20 K (“set point” in LS370\_Tcontrol)
5. Open V3 and V5 (not used now) if you want to remove the mixture more quickly
6. Wait until G2 reads the same value as when you started and P1 is less than 0.020 (it should be able to get to 0.017)
7. Wait another ½ hour, then close all **4 (four)** of the valves on the fridge: the small speedivalve for the condenser line, the large gate valve for the still, the large speedivalve for the 1K pot and the big gate valve on the still line attached to the wall.
8. Close all of the valves except V9
9. Close the green manual valve (bellows valve) that leads to the dump (it should screw closed)

## 10. Close V9

### Step 2: removing the fridge insert

1. Before starting make sure every valve in the system is closed
2. Pull out the He trap
3. Warm up the He trap with the heat gun. It doesn't need to be hot, just enough so that it does not condense water on the outside of it.
4. Disconnect the condenser line from the insert and cap it off with a blank
5. The large gate valve on the still line should be closed, so you should be able to open the speed valve and let air ONLY into the 1 meter section of still line. DO NOT let air into the main still line.
6. Remove the still line from the fridge insert
7. Close the butterfly valve at the top of the 1 K pot.
8. Remove the 1K pot pumping line from the fridge insert
9. Remove the bellows from the front of the fridge (the tube that leads to the 1 way valve) and cap off the fridge insert and the bellows tube.
10. Turn off the compressor for the cold head
11. Pull the fridge out up to black marker line and wait until He gas fills up the new volume. You can tell this has happened when the 1 way valve is releasing gas or read the pressure meter for the reliquefier
12. Remove the fridge all the way and put the baffles in the dewar
13. Turn the compressor for the cold head back on

### Step 3: cleaning the traps:

1. Remove and warm up the liquid nitrogen trap
2. Once the LN and LHe traps are warm use the He4 rotary pump (going through the vent, 5A, 2A, 7, 2, 1, and 12A or 11A) to pump out the air from the traps. Pump overnight
3. Once the fridge insert has warmed up to room temperature, use the connector to pump out the fridge insert from the still and condenser lines simultaneously. Pump overnight

### Where to Find Labview Vis:

To measure resistivity as a function of temperature or field using the LS370:

D:\LABVIEW\TC\_IDR\_multiscan\_LS370\TCHC\_IDR\_multiscan\_LS370\_main\_V5.vi

From this you can browse sub vi's to get to T Control or H control

To view the front panel of the IGH:

On the desktop, open "Shortcut to OIMENU.LLB", click on oimenu.vi

Change the Menu Group to "Applications" and click on "IGH Front Panel".

To view the liquid helium level using the ILM:

D:\LABVIEW\misc\ILMread.vi

### **Liquid helium level**

Liquid helium boils off at a rate of 15%/day (7.5L / day) for the 15 T magnet.