

He battery: Operation manual

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1 Work Safety

It important to remember:

- No magnet operation allowed during the operation of the helium battery.
- No LN2 precooling loop operation allowed during the operation of the helium battery.
- No probe movements allowed during operation of the helium battery.

2 Preparations Before a Cooldown

The helium battery should be under vacuum before starting a cooldown. If you are not sure if that is the case or the battery has not been used for a while, it should be pumped.

1. Make sure the battery filling line is connected to the He Battery in/out port and to AUX port. The filling line has a 6mm Swagelok connector on one end and KF25 flange on the other. Connect the battery Swagelok valve at the top of the cryostat (see Figure 1). Filling line should be connected after the black needle valve. The plug on the T-piece next to the overpressure release valve can be replaced with a pressure sensor to monitor battery pressure. On the GHS side, the filling line is connected to the AUX port in the gas-handling system (Figure 2).
2. Start Scroll 2 and wait 30 seconds.
3. Open V21 and V20 (AUX) and wait for the pressure (P6) to go down.
4. Open needle valve on the battery in/out line (at the top of the cryostat).
5. Pump for at least 30 minutes.
6. Close battery needle valve.
7. Close all other valves before starting a cooldown.

3 Filling the Battery from a Helium Bottle

The helium battery can be filled from a pressurized He bottle (N42 or greater purity) equipped with a regulator (output range recommend from 0-1bar). Helium bottle can be connected to Vent or Test ports. Connect the battery Swagelok valve at the top of the fridge (see Figure 1) to the AUX port in the gas-handling system (Figure 2). Keep the manual valve to the battery closed, pump the filling line empty, and leak test the connections.

1. Make sure the battery filling line is connected to the He Battery in/out port and to AUX port. The filling line has a 6mm Swagelok connector on one end and KF25 flange on the other.
2. Make sure the helium battery manual valve is closed (Figure 1).

3. Make sure that the He bottle is closed and pressure gauges at regulator are both at zero.
4. Rotate the regulator knob all the way to the left, counter-clockwise to close it.
5. If there is any pressure in the regulator, release it by opening (and closing) the output valve.
6. Connect He bottle line either to Vent port (KF16) or Test port (KF25) of GHS. From this point onwards, it is assumed that the helium bottle is connected to Vent port.



Figure 1: Top of helium battery.

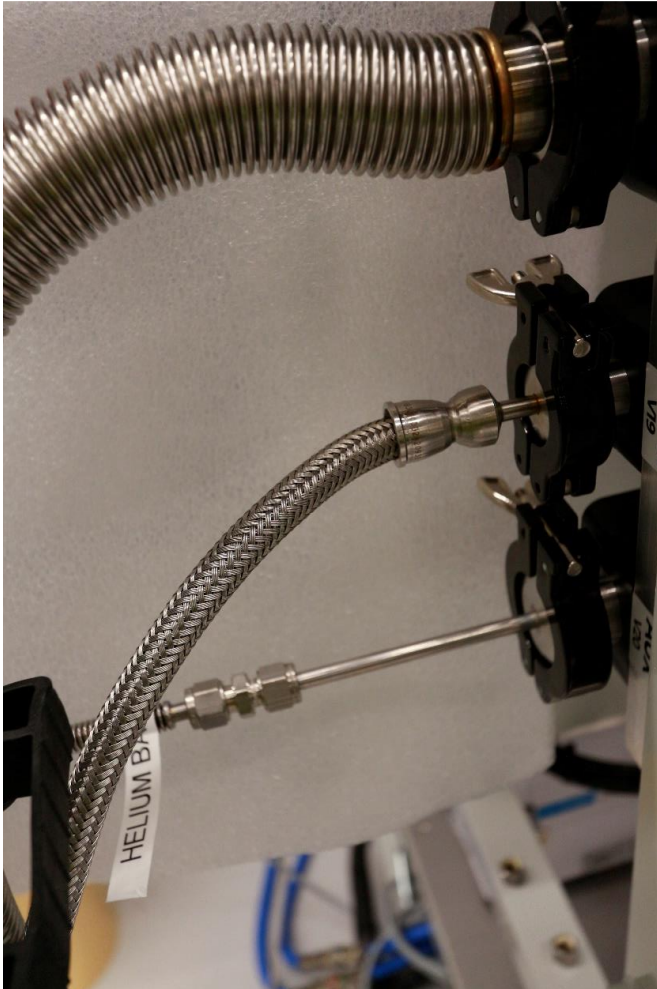


Figure 2: GHS connections.

7. Start pumping the lines

- Start Scroll 2 and wait 30 seconds.
- Open V21 and wait for the pressure (P6) to go down.
- Open V20 and wait for the pressure (P6) to go down.

8. If you have disconnected the battery filling line after the last leak check, it is recommended to leak test the connections at this point.

- Connect a helium leak detector to the Test port.
- Pump the leak detector line and the volume between V16 and the manual test valve empty.
- Close V21 to Scroll 2 and open V16 to the leak detector.
- Spray helium to all connections.
- Switch back to pumping with scroll after leak testing is completed.

9. Open V19 (to He bottle) and wait for the pressure (P6) to go down.

10. Close V21.

11. Open helium bottle main valve.

12. Open the output valve of the regulator.

13. Start adjusting the pressure regulator, observing the P6 value. Set pressure to ~ 200 mbar.
14. Set Still heater power to zero for the duration of the fill.
15. Open battery manual valve on top of the cryostat to let the gas flow in. 4K temperature will increase to 5-7 K and P3 will creep up.
 - If P3 goes above 1 bar, open V13 briefly to let some of the mixture back to the tanks.
16. After 4K flange temperature starts to stabilize towards 4 K, the filling pressure can be slowly increased to 1 bar (in increments). Do not set the pressure higher than 1 bar. If it goes by itself, adjust the He bottle regulator accordingly.
 - It takes roughly 8 hours to condense 1000 liters NTP of gas into the battery.
 - By closing V19 briefly, it can be checked that helium is going into the battery. P6 pressure should decrease without He bottle supply.
 - Example of battery filling is illustrated in Figure 3. Please note that during the testing, a separate filling line was used.

NOTE: The He battery is slow to cool down (the stainless-steel can may remain hot). If the flow into the battery in the beginning goes small/zero and 4K flange temperature is stuck at around 4.5 K, the battery is too hot to condense. This might happen if the system has not been in base temperature for 1-2 days.

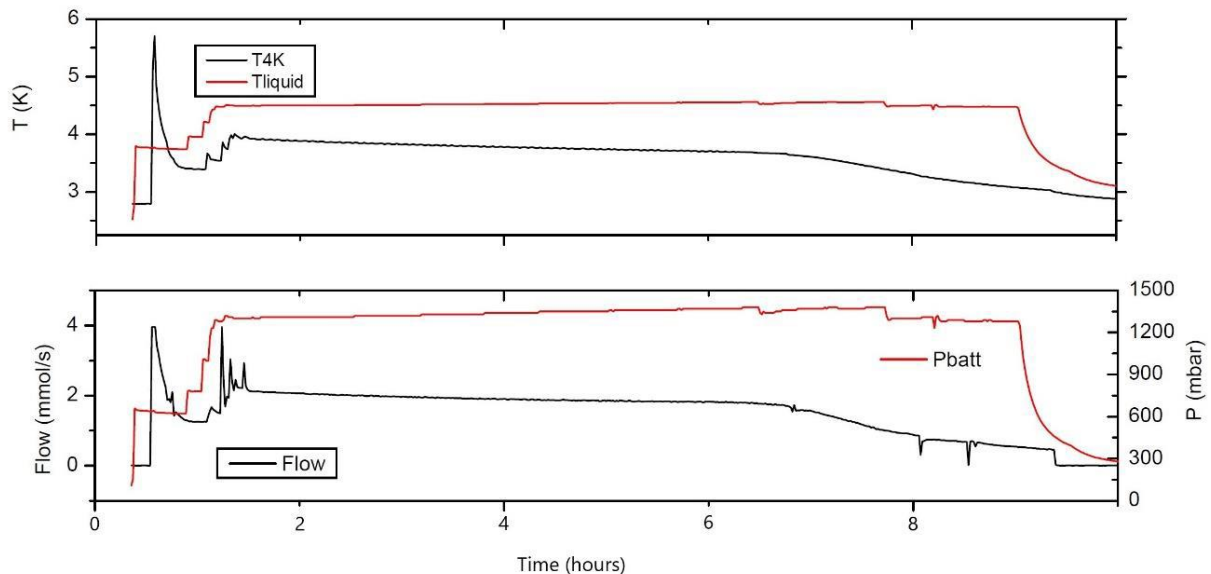


Figure 3: Top frame: Temperature of the 4K flange and the helium liquid during the liquefaction phase. Bottom frame: Helium flow rate and the pressure inside the He-battery.

4 Operating the Battery – Hybrid Cooling Mode

When the battery is full and 4K flange temperature settles towards 3 K, charging should be stopped.

1. First close the regulator output valve.
2. Close V19 and observe the drop in P6.
3. Set still heater towards the normal flow regime (6 – 10 mW).

Start pumping the battery.

4. Start Scroll 2 and wait 30 seconds.
5. Open V21 and wait ~10 – 15 seconds until P6 drops into a relatively stable value.

Stop the pulse tube. The hold time is usually 2-3 hours depending on the wiring configuration etc. in the fridge. Towards the end of the battery run, the Still heat might need adjusting downwards as the 4K flange temperature rises close to 4 K and p3 rises towards 1 bar, as illustrated in Figure 4. Observe carefully when the battery gets empty, since the 4K temperature rises very sharply after the liquid helium has been depleted.

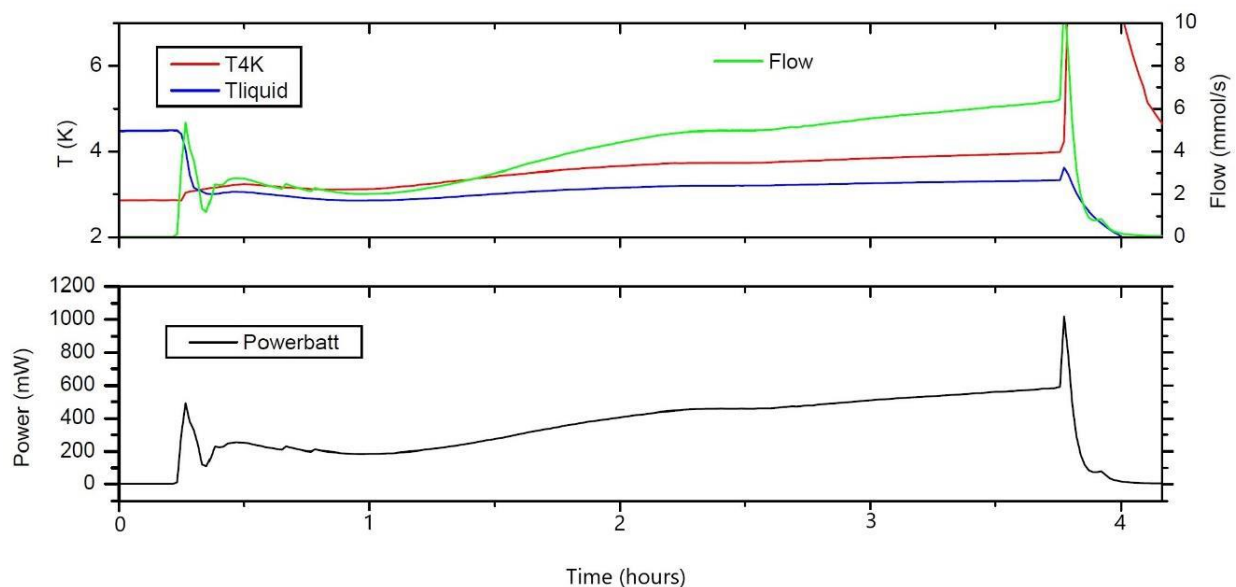


Figure 4: Top frame: Temperature of the 4K flange and the liquid helium in the battery during the hybrid cooling mode. Bottom frame: Cooling power extracted from the battery.

When the battery is empty, restart the pulse tube. Typically, the 4K temperature peaks around 10 K, which means the dilution circulation must be stopped until the system is cold again (Turbo1 off, v13 open).

After operating the battery, make sure that the battery is empty. The battery is equipped with a high-pressure valve, that will release the pressure from the battery at 2 bars. If the high-pressure valve is activated, it should be leak checked before the battery can be operated.

1. Continue pumping the battery for at least 2 hours to get all the liquid out.
2. Close the battery needle valve once pumping is finished.
3. Close V20, V21 and stop Scroll 2.