

4. Operating Procedures

When starting the system for the first time it is necessary to follow the procedures described in this section. It has been assumed that the system has been installed correctly and all lines are connected. Before filling the system with liquid nitrogen it is advisable to roughly pump out all parts of the cryo-cooler (pipework and vessel) through the high pressure fill valve, V3 and the low pressure fill valve, V4 and back fill with nitrogen gas. Figure 3.1-2 shows a schematic flow diagram for the cryo-cooler.

4.1 Switching on the Control Rack

4.1.1 Connecting the control rack.

Connect one end of the 50w D connector cable to the signals box mounted on the cryocooler vessel. Connect the other end to SK4 on the rear panel of the rack control unit inside the control rack.

Connect one end of the Harting power cable to the mains box mounted on the cryocooler

Connect the other end to SK1 on the connector panel at the rear of the control rack.

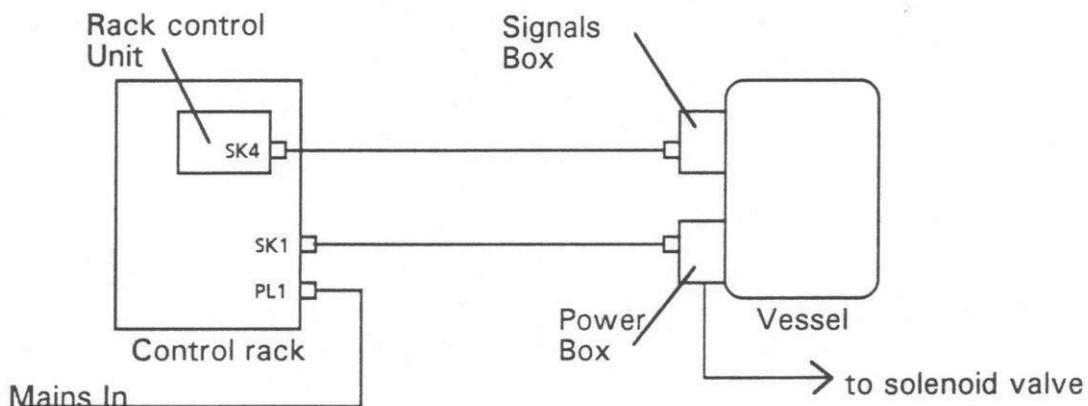


Figure 4.1-1 Cryocooler connection Diagram

4.1.2 Powering the control rack

Plug in the mains supply to PL1 on the rear connector panel of the control rack

Turn on the breakers on the distribution panel at the rear of the rack

The **MAINS ON** lamp on the control unit front panel should be lit

Press the **ON** button on the control unit front panel

The **RACK ACTIVE** lamp should light, and the control units should power up.

To turn the control rack off to standby press the **OFF** button on the control rack front panel.

The **RACK ACTIVE** lamp should turn off, but the **MAINS ON** lamp should still be lit

To isolate the system completely - pull out the mains connector from PL1 on the rack.

4.2 Initial Cooldown and Fill

To cool down the system for the first time, follow the steps given below.

1. Turn on the rack power and check that the control units power up. Set the pressure to atmospheric pressure (0 PSI). Check the level set points for each of the probes (the vessel setpoint is 50% and the high pressure reservoir setpoint is 75%).
2. Pump out both the low pressure circuit and the closed loop by connecting a roughing pump to the liquid nitrogen fill line, (ie the junction of Valve V4 and Valve V3), and evacuating to about 10^{-3} mbar. Isolate the roughing pump from the system. Connect a cylinder of dry nitrogen gas to the liquid nitrogen fill line and open valve V3 (closed loop) and valve V4 (low pressure circuit) and back fill both the closed loop and the low pressure circuit to atmospheric pressure.
3. Purge the system for a few hours with nitrogen gas. This is done by circulating nitrogen gas through the system at a just over 1 atmosphere pressure via valve V3. After this purging, the vessel can be filled with liquid nitrogen.
4. Connect the liquid nitrogen supply to the liquid nitrogen fill line and open valve V4 to set the liquid flowing through the vessel. This will begin cooling down the vessel. The gas is vented through the vessel relief valve (Valve V8).
5. Check that valves V1 and V2 are shut
6. Open Bypass Valve V10.
7. When the low pressure system is full, open Valve V3. Lift the low pressure nitrogen level probe to open the solenoid valve on the top of the dewar.
8. Start filling the high pressure circuit

9. Open valve V12 first to vent the gas.
10. When spots of liquid start to appear, close valve V12 and open valve V6 so that gas is now vented from the reservoir.
11. The level will rise in the high pressure circuit. At the 80% level close valve V6.
12. Stop filling the high pressure circuit with liquid nitrogen. Close valve V3.
13. Allow the system time to settle
14. Repeat steps 7, 8, 9, 10, 11, 12 several times.
15. Start cooling the lines and the load
16. Open valve V3, valve V2 and valve V5. Wait for liquid to appear.
17. Close valve V2 and open valve V1. Wait for liquid to appear. When liquid appears there is liquid in the system and lines.
18. Open valve V1 and valve V2 fully. Set the motor frequency to 30 Hz. Close the bypass valve V10.
19. Start venting gas pockets in this order:
 - Open valve V12, wait for liquid and no gas to appear. Close V12.
 - Open valve V5, wait for liquid and no gas to appear. Close V5.
 - Open valve V6 (reservoir). Wait for the level to rise to approximately 80%. Close valve V6 and valve V3.
 - Repeat Step 18 several times.
20. Re-connect the supply line to the vessel top-up line and replace the low pressure level probe to replace any liquid boiled away from the vessel while the pipework is cooling down to liquid temperature.

4.3 Initial Start-Up

Once the system is cold and filled with liquid nitrogen, follow the steps given below.

1. It is important to drive out any gas from the high pressure circuit. During the initial filling most of the gas will have been pushed out although there may well still be pockets of gas around the system. This remaining gas is best removed by running the pump. Ensure that there is at least

75% level in the high pressure reservoir before attempting to run the pump motor.

2. Close off the supply and return valves to the optic but OPEN THE MANUAL VENT VALVE V5. This is most important. The lines will be almost full of liquid and so it is necessary to vent boil off gas from the line. Open the bypass valve V10.

CAUTION: Whenever the isolation valves V1 and V2 to the optic are closed, always ensure that the manual vent valve V5 is open.

CAUTION: Whenever the isolation valve V1 or V2 is closed, always ensure that the by-pass valve V10 is open.

3. Start the motor and set the frequency of the controller to 40 Hz. This will circulate the liquid around the by-pass. Vent gas from the sub-cooler vent valve V12 and high pressure reservoir vent V6. This will establish flow in through the by-pass.
4. Continue running in this mode until all gas is vented from V12.
5. Slowly open the return valve from the optic V2 but no more than one or two turns.
6. Slowly open the feed valve V1 to the optic but again only one or two turns. The flow will then be directed through the by-pass and optic in parallel but with most of the flow going through the by-pass.
7. Continue venting gas through V5 until liquid appears. It may be necessary to run for at least 30 minutes to be certain of removing all gas from the high pressure loop.
8. When liquid appears at the vent close off the by-pass valve V10 and the vent valve V5. Flow to the optic will then be established. The feed and return valves can be opened a few more turns to increase the flow. It may be necessary to fully open V1 and V2, while venting from V5, to remove any trapped pockets of gas in the valve body.

4.4 Raising the Closed Loop Pressure

With the system filled and the pump running, the pressure in the closed loop can then be raised to the operating pressure. The following steps describe how to change the pressure setpoint. More detailed information is given in the operators instructions on the Dwyer 1600 series controllers.

1. Press the INDEX button I on the pump inlet pressure controller until SP1 is seen in the lower half of the display.
2. Set the required pressure setpoint (minimum value 35 psi at 2.5 kW, maximum value 75 psi), shown in the upper half of the display, by increasing or decreasing the value using the UP-ARROW or DOWN-ARROW buttons.
3. When the required pressure setpoint is reached, press the ENTER button E.
4. Press the INDEX button I twice to return to monitoring mode.
5. If the setpoint is raised, the heater in the high pressure reservoir will be energised to boil off gas to raise the system pressure. The controller will then pulse the heater power to maintain the pressure at its setpoint.

4.5 Operational Mode

After following the steps above, the cryo-cooler will be fully operational. Ensure that there is adequate liquid supply to the vessel top-up line to replace liquid boiled away. The vessel will fill automatically from the liquid nitrogen top up dewar, as a solenoid valve on the top of the dewar will open when the nitrogen level in the vessel falls below the setpoint (50%). Even with no optic heat load there is residual heat input to the system which will boil away the liquid in the vessel. The cryocooler is likely to consume up to 1600 litres per day with the cryocooler operating at full power.

If the liquid supply to the vessel is stopped, the vessel will drain and the heat taken up by the circulating liquid cannot be dissipated. This will raise the closed loop system pressure until relief valves open.

Caution: Always ensure there is an adequate supply of liquid nitrogen to the vessel to cover the operating time planned. Approximately 600l is required for 8 hours operation at 2.5kW

Note 1: It is not advisable to run the motor if there is no liquid level shown on the high pressure reservoir meter. Running the motor without liquid present may result in damage to the pump.

Note 2: The level probe in the high pressure buffer is captive. The black nut must be unscrewed

completely to remove the high pressure buffer level sensor.

4.6 Lowering the Closed Loop Pressure

To lower the pressure in the system:

1. Change the setpoint on the controller to 15 psi absolute pressure.
2. Gradually open valve V6 whilst monitoring the pressure.
3. When the system has reached 15psi, close valve V6

4.7 Warming up the Optic

1. Follow the procedure given in section 4.6 for lowering the system pressure to atmospheric pressure.
2. Open bypass valve, V10.
3. Open vent valve V5.

Caution: Never leave valves V1 and V2 closed at the same time that valve V5 is closed.

4. Close valves V1 and V2, to isolate the optic from the cryocooler high pressure circuit.
5. Remove the transfer line from V1.
6. Connect a supply of warm nitrogen gas to V5.
7. Circulate warm nitrogen gas through the optic, to warm it up.

