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SPIRE Cryostat Operating Manual

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1 INTRODUCTION

1.1 Safety

1.1.1 Liquid Cryogens

Great care should be taken when handling liquid nitrogen and helium. Please refer to the relevant CLRC procedures for the use of liquid cryogens.

1.1.2 Lifting

Should the cryostat need to be lifted we would recommend the use of attaching suitable lifting straps around the vessel body in addition to using the 4 lifting eyes provided on the top of the vessel.

1.2 General Description

The SPIRE Calibration Cryostat has four levels of cooling. These levels are described below with reference to Figure 1 that shows the position of the ports and services on the top flange of the cryostat.

1.2.1 Nitrogen vessel

This acts as a radiation shield and a means of pre-cooling for the inner vessels. It can contain a volume of over 240 litres of liquid nitrogen.
The vessel has three ports. It is filled via the LN_2 fill port, which gives access to an internal tube that extends to the base of the can. The LN_2 vent port should be open at all times, and the exhaust gas vented outside the room.
The level of nitrogen in the vessel is monitored by the level probe that is situated in the third port. The level probe has four PT100 temperature sensors, the positions of which are shown in drawing PR2-9164 SHT 2 that is included in the Appendix. The lowest sensor is level with the base of the filter flange. The level probe may be powered by a 12 V supply (with a pull-up series resistance of 120 ohms).

1.2.2 4.2 K helium vessel

The main helium vessel has a capacity of approximately 110 litres. The vessel is filled by the supplied syphon through the LHe syphon entry. The vessel is protected by a burst disk, and by two 10 psi relief valves. It has one flexible cold strap connected to the base of the vessel. The exhaust gas from the vessel may vent through either the LHe vessel vent ball valve or through the '9 K' shield.
The helium level probe is positioned in the vessel vent. The end of the probe is 15 mm above the base of the helium can. It requires a 100 mA input and should be calibrated before first use.

1.2.3 '9 K' shield

This is cooled by the exhaust gas from the main helium vessel. The temperature of the shield is dependent on the rate of evaporation of helium. If the boil off is too low, it may have to be increased by applying heat to H2 on the base of the helium can. This will increase the flow of cold gas through the shield and lower the temperature. Conversely if the temperature of the shield is too low, heater H1 can be used to apply heat to the gas inlet tube. Twelve gold-plated braids thermally link the instrument to copper blocks brazed to the inside of the shield.

1.2.4 '1.7 K' Vessel

This is fed with liquid helium from the main can via a needle valve and capillary tube. A sufficient head of helium in the main can is necessary for liquid to flow through into the '1.7 K' vessel.

When the '1.7 K' vessel is full the temperature of the liquid helium in the vessel is reduced by pumping through the ISO-K 63 pumping port. The needle valve may be closed and the '1.7 K' vessel operated as a 'single shot' system, or the valve may be cracked open and liquid fed continuously into the vessel during pumping. As it passes through the capillary the incoming liquid is pre-cooled as it flows through a coil inside the top flange of the '1.7 K' vessel. The base temperature attainable depends on the capacity of the pump used and on the rate of flow of helium through the needle valve.

The '1.7 K' vessel also feeds three flexible cold straps.

2 SENSOR AND HEATER LOCATIONS

The cryostat contains the following heaters:

Sensor/Heater	Location	Type
H1	Shield Inlet Pipe	CO-AXIAL
		50V, 50W
H2	Helium Can	CARTRIDGE
		120V, 20W
H3	FPU Level 1 Strap Int.	CO-AXIAL
	(4.2 K flexible)	50V, 50W
H4	FPU Level 1 Strap Int.	CARTRIDGE
	(4.2 K flexible)	40V, 40W
H5	FPU Box Strap Int.	CO-AXIAL
	(CSTR 3 flex.)	50V, 50W
H6	FPU Pump Strap Int.	CO-AXIAL
	(CSTR 2 flex.)	50V, 50W
H7	FPU Evap Strap Int.	CO-AXIAL
	(CSTR 1 flex.)	50V, 50W
H8	FPU Box Strap Int.	CARTRIDGE
	(CSTR 3 flex.)	40V, 40W
H9	FPU Pump Strap Int.	CARTRIDGE
	(CSTR 2 flex.)	40V, 40W
H10	FPU Evap Strap Int.	CARTRIDGE
	(CSTR 1 flex.)	40V, 40W
H11	1.7 K Vessel Heater	CO-AXIAL
		110V, 750W
H12	Capillary Heater	CONSTANTAN
		24V, 12W

The locations of these are shown in Figure 1.

The temperature sensors installed for testing are shown in the following table.

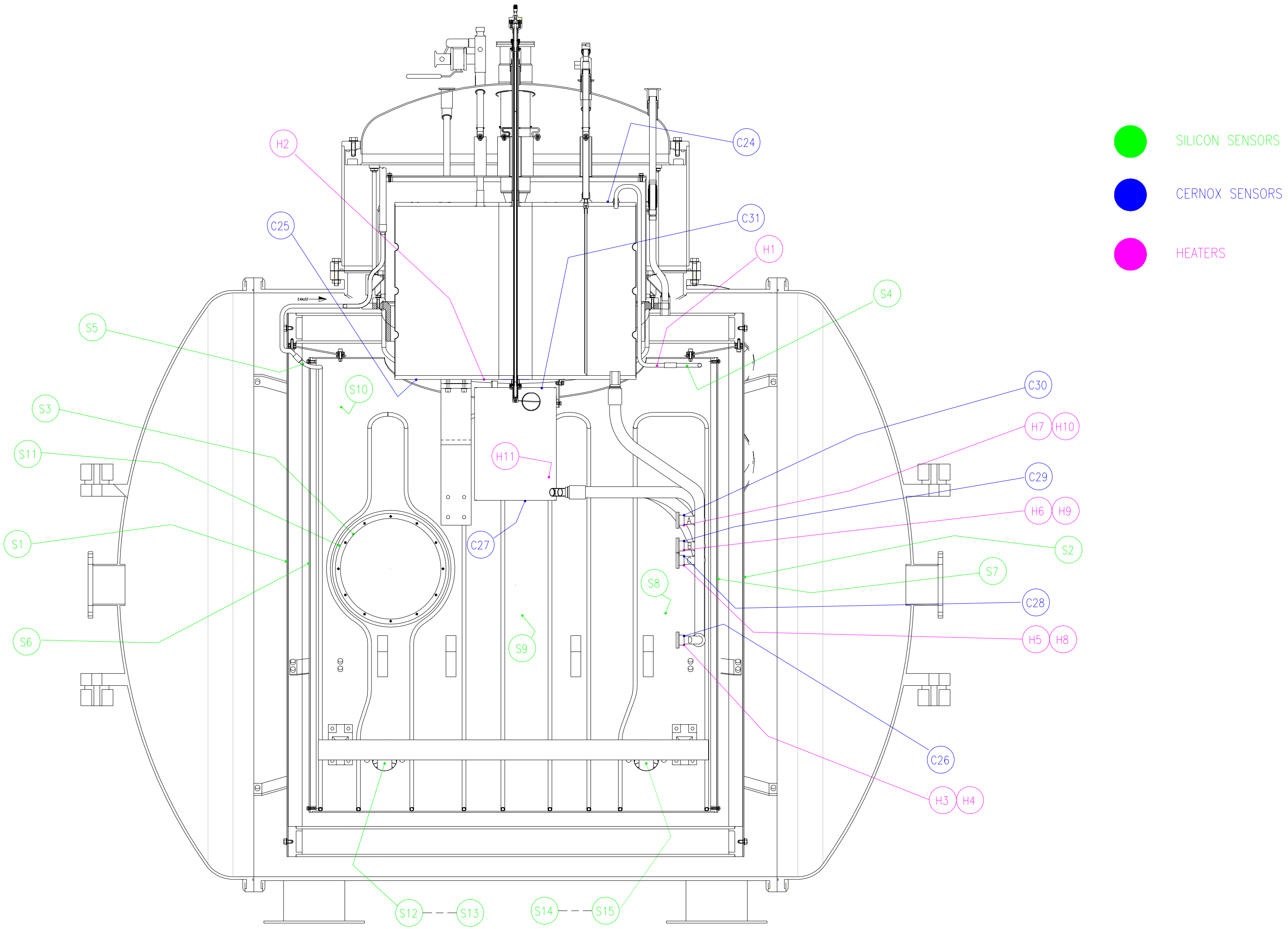

Figure 1 Sensor and heater locations in the Calibration Cryostat

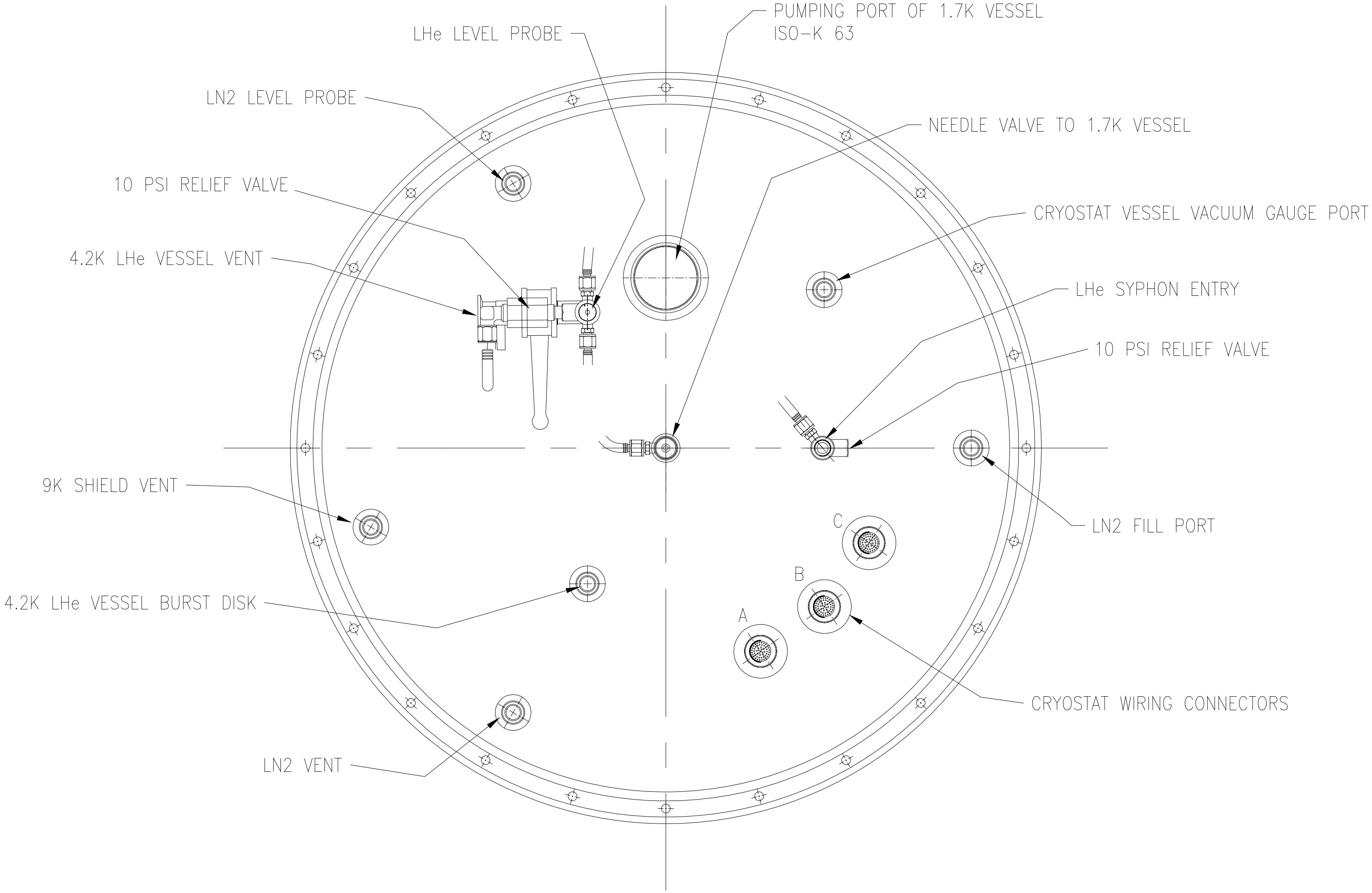

Figure 2 Position of services on the top spinning of the Calibration Cryostat

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3 COOLDOWN PROCEDURE

3.1 Connections

Please refer to Figure 2 for the locations of the cryostat services.

3.1.1 Inside vacuum vessel

Connections should be made to the instrument, as required.
The flexible cold straps to the interface pads should be kept as flat as possible to prevent gas locks occurring.

3.1.2 Electrical

Attach the cryostat wiring electrical leads to the Fischer sockets A, B and C on top of the cryostat as shown in Figure 2.

Verify that all temperature sensors and heaters are connected.

Connect the nitrogen and helium level probes to appropriate controllers.

3.1.3 Gas/Vacuum

Attach a suitable pump to the gate valve on the vacuum vessel.

Attach a suitable pump, control valve, 4psi vent valve and pressure gauge to the ISO-K 63 outlet of the 1.7K vessel.

Attach a vent line to the 9 K shield.

Attach an exhaust line to the LN_2 vessel vent. The end of this line should be taken outside the room.
Another line may be connected to the KF25 port on the level probe port, but this is likely to cause cooling and ice build-up at the level probe.

All valves should be initially shut.

Ensure the doors of the vacuum vessel are shut and clamped and that all vessel flanges are properly sealed.

3.2 Pumping and purging

CAUTION:

The main helium can should not be pumped without a vacuum in the outer vessel.

The 1.7 K vessel should not be pressured to more than 0.3 bar gauge (5 psi).

The main helium vessel has been designed to take a maximum pressure of 1 bar (15 psi) gauge.

It is essential that neither the needle valve nor capillary be allowed to become blocked at any stage during the cooldown. For this reason they should be pumped and purged at each stage of cooling, as described below.

Attach a supply of warm, dry, high purity helium gas to the ball valve on the main helium vessel vent and purge with gas. Check that the 1.7 K vessel is protected by a 4 psi pressure relief valve.
Open the needle valve and allow gas to enter the 1.7 K vessel until a pressure of a few psi (gauge) is shown on the gauge. It is advisable to measure the flow rate through the needle valve and capillary at this point. Close the vent valve and remove the helium supply.
This overpressure should be maintained in the helium vessels until they are filled with liquid nitrogen.

Evacuate the vacuum vessel with a suitable pump. As a guide, the pressure in the vacuum vessel should be below 10^{-3} mbar before commencing a liquid nitrogen fill.

3.3 Filling with liquid nitrogen

Cooling the entire cryostat with liquid nitrogen is likely to use in the region of 450 litres liquid nitrogen.

3.3.1 Nitrogen vessel

Ensure that the nitrogen vessel is vented.

Fill the nitrogen vessel through the fill port until the level probe shows that the vessel is full.

After filling connect the fill port to a suitable vent line.

3.3.2 Helium vessels

3.3.2.1 Filling

Verify that the helium vessels still contain an overpressure of helium gas. If not, re-purge with helium gas as described above.

Close the needle valve. Begin the transfer of liquid nitrogen into the helium can through the syphon inlet.

Crack open the ball valve on the helium can. This should allow the cold nitrogen gas to flow through, and cool, the 9 K shield as well as cooling the top fittings of the helium can.
Note: It may be necessary to pump on the 9 K shield vent line, and/or to apply heat to H2 on the base of the helium can, to draw sufficient nitrogen gas through the shield.

Fill the helium can with nitrogen. Open the needle valve and ensure that there is a flow through into the 1.7 K vessel, indicated by gas opening the 4 psi relief valve.

Monitor temperature sensors S27-30 to ensure that nitrogen is cooling the 1.7 K vessel and straps. Regularly check that there is a flow through the capillary and needle valve.

Continue to fill the 1.7 K vessel until sensors S27-30 are reading below 100 K. (It should not be overfilled to reduce the time required to boil off the liquid nitrogen before helium filling.) Close the needle valve.

3.3.2.2 Emptying

When the helium vessels have cooled sufficiently the liquid nitrogen should be removed. Pressurise the top of the main helium vessel with helium gas and syphon out as much liquid as possible into the nitrogen vessel. If the vessel is full, syphon the liquid into a dewar. Check the level of nitrogen in the helium can (for example, by dipping through the burst disk port) to ensure all the nitrogen has been syphoned off. If there is still a level of liquid nitrogen remaining, use a longer syphon through the burst disk port.

The remaining liquid should be evaporated using the heaters. Apply appropriate power to heaters H2, 4, 8, 9, 10 and 11 (and possibly H 5-7) until the temperature of the four cold straps and both helium vessels is above 100 K indicating that all the liquid nitrogen has been evaporated.

When sure that the liquid nitrogen has been removed purge the helium vessels with helium gas. Switch on the capillary heater. Purge through the helium can vent valve until the relief valves on the 1.7 K vessel and the 9 K shield are venting, and continue purging for at least an hour.
When fully purged, pump out the helium vessels through the 1.7 K vessel outlet. Check the flow through the valve and capillary.
Re-purge the vessels with helium gas as above. Shut the vent valve and remove the helium gas supply.
Repeat pumping and purging.
Close the needle valve.

The vessels may now be filled with liquid helium.

3.4 Filling with liquid helium

Cooling and filling both helium vessels in the cryostat is likely to use in the region of 200 litres of liquid helium.

Insert the helium syphon into the helium dewar. Ensure there is a flow of gas through the syphon and then insert the other end of the syphon into the helium inlet. Ensure that the syphon is seated tightly in the syphon housing. Transfer liquid helium.

Open the ball vent valve on the helium can for initial cooling, then close and vent through the 9 K shield for the remainder of the fill.

Fill the helium can. Again, either pump on the 9 K shield or apply heat to H2 on the base of the helium can to increase the flow through the shield. During tests an applied heat of 1.8 W was sufficient to give a shield temperature of 14 K. More power will be required to initially cool the shield, but this should be reduced as the shield cools.

Re-fill the main can with liquid helium until the level probe indicates the can is full.

Pump on the helium in the 1.7 K vessel. If the temperature falls below that required the pumping speed should be reduced by closing down the valve to the pump. The needle valve may be cracked open to continuously fill the vessel. This is also likely to have the effect of raising the vessel temperature slightly.

Note:
The best way to prevent blockages occurring in the capillary and needle valve is to use helium to purge and cool the helium vessels throughout, and not to use liquid nitrogen.

3.5 Warming Up

Any remaining liquid helium and nitrogen in the vessels should be syphoned out into dewars.

Heaters may be used to increase the rate of warming, but care should be taken to monitor the temperatures reached. Temperatures should not exceed room temperature, as this is the upper limit of the majority of the sensor calibrations.

The vacuum in the outer vessel should be let up using clean nitrogen gas. Ensure that the vessel does not become over pressured.

The vessel doors should not be opened until all the temperature sensors are steady and at room temperature, to prevent condensation.

4 CRYOSTAT WIRING

4.1 External

The following pages contain wiring diagrams for the Fischer plugs, leads and D-type connectors external to the cryostat.

4.2 Internal

The following pages contain wiring diagrams for the Fischer connectors and leads inside the cryostat.

Please refer also to the sketch of the cryostat wiring in the Appendix.

5 APPENDIX

PR2-9679	LN_2 Level Probe Assembly
PR2-9164 SHT2	LN_2 Level Probe PT100 Positions
--	Sketch of SPIRE Cryostat Wiring