**LERF Cooldown Procedure for LCLS-II Cryomodules**

**SCOPE**

Cool down procedure for LCLSII cryomodule testing in the LERF.

# Preliminary Steps

**Prerequisites**

1. Process lines are cleaned and purged
2. CHL shall be at 4 K during u-tube operations
3. FL02 is cold, providing 200W
4. ATLis created and approved by relevant parties

## Signal Verification

Ensure all signals are responding and data logged.

Valves

CPVCM01JT & CPVCM02JT (Cryomodule JT Valves)

CPVCM01CD & CPVCM02CD (Cryomodule Cooldown Valves)

CEVCM03CD (Cryo Can Cooldown Valve)

CEVCM03RT (U-Tube 2 K Return Valve)

CEVCM03SH (Shield Supply Valve)

Verify the following signals from the computer console

Table 1: Signal Verification

|  |  |
| --- | --- |
| **Description** | **PV** |
| CM Liquid Level | CLLCM0210  CLLCM0211  CLLCM0112  CLLCM0113 |
| Helium Pressure 0 – 5000 Torr | CPICMM0212  CPICMM0114 |
| Helium Pressure 0 – 100 Torr | CPICM0211  CPICM0113 |
| Beamline Vacuum | SRFCMTFBLVAC1 |
| Waveguide Vacuum | SRFCMTFWGVAC1 |
| Insulating Vacuum | SRFCMTFINSULVAC1 |
| Shield Supply Temperature | CTDCM0316 |
| Shield Return Temperature | CTDCM0366 |
| 2K Supply Temperature | CTDCM0322  CTDCM0120 |
| 2K Return Temperature | CTDCM0168  CTDCM0370 |
| 4K Supply Temperature | CTDCM0310 |
| 4K Return Temperature | CTDCM0362 |
| Shield Flow Rate | CFICM0311 |
| 4 K Supply Flow Rate | CFICM0310 |
| 2 K Supply Flow Rate | CFICM0312 |
| Primary Supply Temperature from Cryo Can | CTDCM0324 |
| GHRP Upstream Upper CM1 | srfccon:chb1 |
| GHRP Upstream Lower CM1 | srfccon:chc1 |
| GHRP Upstream Upper CM2 | srfccon:chb2 |
| GHRP Upstream Lower CM2 | srfccon:chc2 |

Record the Beamline, Insulating and Coupler Vacuums using the signals defined in Table 1 above, and make a log entry stating that cooldown is ready to begin

## Strip Charts

Plot the signals from Table 2 on a single, separate strip chart (Strip Chart 1). These are the temperature sensors on the GHRP, which is to gauge the cooling rate and the gradient.

Table 2: GHRP Diodes for Strip Chart 1

|  |  |
| --- | --- |
| **Description (Temperature Diodes)** | **PV** |
| GHRP Upstream Upper CM1 | srfccon:chb1 |
| GHRP Upstream Lower CM1 | srfccon:chc1 |
| GHRP Upstream Upper CM2 | srfccon:chb2 |
| GHRP Upstream Lower CM2 | srfccon:chc2 |

On another strip chart (Strip Chart 2), plot the signals shown in Table 3:

Table 3: CM2 Strip Chart 2 Signals

|  |  |
| --- | --- |
| **Description (CM2 Signals)** | **PV** |
| Helium Pressure 0 – 5000 Torr | CPICM0212 |
| Helium Pressure 0 – 100 Torr | CPICM0211 |
| Cryomodule Liquid Level | CLLCM0210 |
| Cryomodule Liquid Level | CLLCM0211 |
| Cryomodule Cooldown Valve | CPVCM02CD |
| Cryomodule JT Valve | CPVCM02JT |

On another strip chart (Strip Chart 3), plot the signals shown in Table 4:

Table 4: CM1 Strip Chart 3 Signals

|  |  |
| --- | --- |
| **Description (CM1 Signals)** | **PV** |
| Helium Pressure 0 – 5000 Torr | CPICM0114 |
| Helium Pressure 0 – 100 Torr | CPICM0113 |
| Cryomodule Liquid Level | CLLCM0112 |
| Cryomodule Liquid Level | CLLCM0113 |
| Cryomodule Cooldown Valve | CPVCM01CD |
| Cryomodule JT Valve | CPVCM01JT |

On another strip chart (Strip Chart 4), plot the signals shown in Table 5:

Table 5: Cryo Can Strip Chart 4 Signals

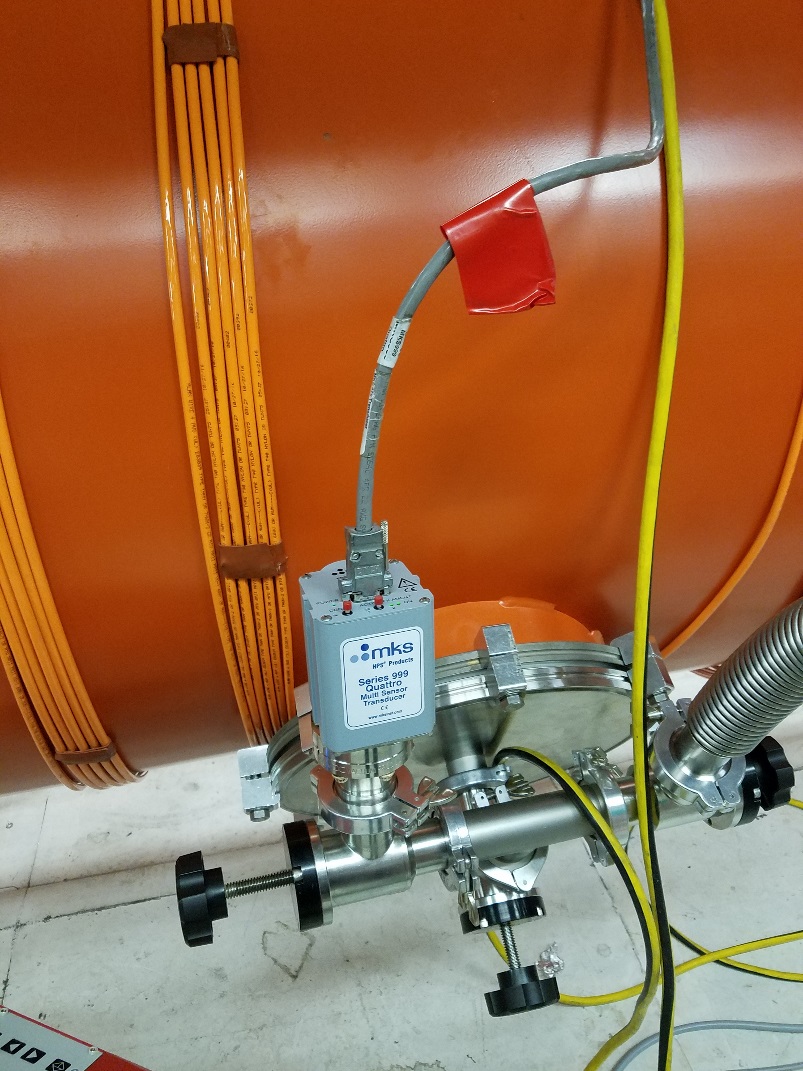
|  |  |
| --- | --- |
| **Description (CRYO Can Signals)** | **PV** |
| Primary Supply | CEVCM0312 |
| 4K Supply | CEVCM0313 |
| Shield Supply | CEVCM03SH |
| 2 K Return | CEVCM03RT |
| Cool Down Bypass Valve | CEVCM03CD |
| 2 K Supply Flow | CFICM0312 |
| 4 K Supply Flow | CFICM0310 |
| Shield Supply Flow | CFICM0311 |
| 4 K Supply Flow Rate | CFICM0310 |
| 2 K Supply Flow Rate | CFICM0312 |

## U-Tube Installation Checklist:

1. Established U-tube parameters and installation procedure

After U-Tube installation, determine that the following operations have been completed:

1. Check that the cable is connected to the gauge on the insulating vacuum pump manifold (see below)
2. Open the guard vacuum manual valve CMVCM0371
3. Open cool down manual valve CMVCM0366



**Figure 1: Vacuum gauge cables**

# Cryomodule Cooldown

1. Confirm that an ATLis entry for the Cooldown has been created and reviewed.
2. Contact the Cryo group and inform them that the Cooldown is about to start
3. Create a Log Entry in SRFLOG, CLOG and ATLis stating the time of Cooldown commencement

## Shield Cooldown

1. Fill out step 23 on the corresponding traveler (L2PRD-CM-ACTS-PREP)
2. Cool down the 50K circuit using the following steps:
3. Start flow into the shield line by opening valve CEVCM03\_SH to 100%. This should be done by setting the upper limit (Max Pos.) value to 100% and turning the controls to Automatic
4. Monitor the valve position, shield flow rate (CFICM0311) and shield temperature using Strip Chart 3 to ensure that cold flow as started.
5. The shield line will now begin flow at a rate of 1.5 – 2.5 g/s. This value will increase to 3.0 g/s once the line cools to its operating temperature (35K – 60K). The cooldown process will take 4 – 6 days. No further action needs to be taken on the shield line.

## Primary Cooldown

1. Begin with the following valve settings:
   1. CEVCM03\_12 Closed
   2. CEVCM03\_RT Closed
   3. CPVCM01\_CD Open
   4. CPVCM02\_CD Open
   5. CPVCM01\_JT Open
   6. CPVCM02\_JT Open
   7. CEVCM03\_13 Open
   8. CEVCM03\_CD Open
2. Slowly crack the Cryo Can Supply Valve (CEVCM0312) in steps of 10% every minute until it is fully open. The 2 K and 4.5 K supply mass flow meters (CFICM0312 & CFICM0310) will start to read a flow.
3. Monitor CM helium pressures (CPICM0212 & CPICM0114) to ensure that they do not exceed 1.5 atm. Back off on CEVCM0312 if necessary. When the 4K line temperatures are both at a max of 50K (CTDCM0362 & CTDCM0310), close CPVCM01JT and CPVCM02JT.
4. Monitor the temperatures of the GHRP diodes on Strip Chart 1 until the average temperature is below 80K. The criteria below should be met at all times. The values can be found on the Production Cryomodule Instrumentation Screen under GHRPDELTA, GHRPAVE and GHRPRATE.
   1. The temperature of the upper diodes should not exceed that of the lower diodes (GHRPDELTA2 & GHRPDELTA3) by more than 25K.
   2. The cooling rate of the diodes (GHRPRATE) shall not exceed 10 K/hr.

If any values exceed the threshold, dial back on CEVCM0312.

1. When the temperatures of the GHRPs fall below 80K, the stipulations outlined in Step 5 no longer apply. If CEVCM0312 is not fully open, open it fully.
2. Continue allowing the CM to cool until the HOM Tuner Nb diodes on the number 5 cavities (srfccon3:chd1 & srfccon3:chd2) reach 4K. Fill out step 24 in the traveler.
3. Continue to flow cold gas through the module. Keep CEVCM0312 completely open until liquid starts to form. This will be indicated by the liquid level (CLLCM0113 & CLLCM0211) suddenly rising. Allow the upstream liquid levels to rise to 78% (CLLCM0112 & CLLCM0210).
4. Set JT valves to control upstream liquid levels (CLLCM0112 & CLLCM0210) at 78%
5. Fill out step 25 of the traveler
6. Close CPVCM01CD & CPVCM02CD.
7. The cryomodule will soak at 4K for at least 24 hours. Use the following settings to control the liquid level at 78%
   1. Close CPVCM01JT & CPVCM02JT.
   2. Monitor return pressure at CMs (CPICM0211, CPICM0212, CPICM0113 & CPICM0114)
   3. Slowly open CEVCM03RT while Cryo Group monitors key CHL parameters in order to avoid tripping CHL
   4. Once return pressure is below 0.045 atm, slowly open CPVCM01JT & CPVCM02JT to control the liquid level
   5. Seek Cryo Group’s assistance to set up CEVCM03RT for steady state operations
8. Configure valves with following settings:
   1. CEVCM03RT – Automatic, with following settings:

|  |  |  |  |
| --- | --- | --- | --- |
| **CEVCMXX\_RT** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

* 1. CPVCM01CD & CPVCM02CD – Closed
  2. CEVCM0312 – Automatic, with following settings:

|  |  |  |  |
| --- | --- | --- | --- |
| **CEVCMXX\_12** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

* 1. CPVCM01JT & CPVCM02JT – Automatic, with following settings:

|  |  |  |  |
| --- | --- | --- | --- |
| **CPVCM01JT** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

|  |  |  |  |
| --- | --- | --- | --- |
| **CPVCM02JT** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

1. After the soak, inform the cryo group that the CMs are ready to be pumped down to 2K. Once pumpdown is initiated, the pressure will be monitored on the 0 – 5000 torr transducers (CPICM0114 & CPICM0212). When pressure drops below 100 torr, the 0 – 100 torr gauges (CPIM0113 & CPIM0211) will then start reading. Ensure that its scale on the Strip Chart is between 0.020 and 0.050 atm.
2. Verify that the Guard Vacuum manual valve CMVCM0371 is open.
3. When the pressure on the 0 – 100 torr transducers go below 0.048 atm, the liquid levels will initially drop, but then will start to rise again. Fill in step 26 of the traveler.
4. Liquid will start collecting and the signal will be noisy due to boil-off. Wait until the readings are steady. Once the level (CLLCM0112 & CLLCM0210) is above 78% and steady, record the time and details in the traveler in step 27.
5. Set the Cryo Can Supply Valve (CEVCM0312) to 100%, and set CM JT Valves (CPVCM01JT & CPVCM02JT) to automatic with a set point of **96%.**

|  |  |  |  |
| --- | --- | --- | --- |
| **CPVCM01JT** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

|  |  |  |  |
| --- | --- | --- | --- |
| **CPVCM02JT** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

1. The following settings should be used when leaving the CM when idling overnight:
   1. CEVCM0312 – Automatic, with following settings:

|  |  |  |  |
| --- | --- | --- | --- |
| **CEVCM0312** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

* 1. CPVCM01JT – Automatic, with following settings:

|  |  |  |  |
| --- | --- | --- | --- |
| **CPVCM01JT** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

* 1. CPVCM02JT – Automatic, with following settings:

|  |  |  |  |
| --- | --- | --- | --- |
| **CPVCM02JT** | | | |
| **Quantity** | **Value** | **Quantity** | **Value** |
| **Max Pos** |  | **ST** |  |
| **Min Pos** |  | **Gp** |  |
| **Max Chg** |  | **Gi** |  |
| **Min Chg** |  | **Gd** |  |
| **Input** | |  | |
| **Set Value** | |  | |

**Note:** When leaving at the end of the swing shift, or when no other cryo-operator will be taking over, avoid leaving any valve in Manual mode. Instead, set the Max Pos and Min Pos settings to the desired value and set the valve to Automatic. This will have the same effect as having the valve set to a manual value.

**Troubleshooting:**

**Non-functioning valves**

There have been instances of valves not moving for extended periods of time when using the Min and Max values to open a valve from a closed position. If this issue arises, open the valve control box and check the “Cur Out” reading. This value may be inadvertently set too low (e.g. -100%) while the “Cur Pos” – which is the actual position of the valve – stops at ~0%. When attempting to open the valve again, the PID instructs the valve to open from the very negative value using the Max Change and Step Time to control. For example, if a valve is sitting at -100% in the “Cur Out” and the Step Time is 10 seconds and the max change is 2%, it will take over 8 minutes for the valve to start to open. If there is still no movement, and using the manual function also does not function, call the SME.

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