SQ22 – Cryostat warm-up

**Sensors and actuators used:**

- Temperature: list in the tables from 5 to 7

- Heater: list in the tables from 5 to 7 and current leads heaters for magnet insert

- Level: LI670, LI680

- Valve: CV581

|  |  |
| --- | --- |
| **The user chooses:** | **Initial conditions:** |
| - Temperature setpoint: list in the tables from 5 to 7 | - Sequences from 1 to 3 stopped  - Sequences 6 and 7 stopped  - Sequences from 10 to 20 stopped  - Sequence 8 in operation |
| - Level: LI670mini, LI680mini  - Flow: FT581limit, FT583limit |

This sequence drives the electrical heaters implicated in the warm-up of the cryostat. Each set of heaters has its own cycle. To limit the current draw when starting the heater, the sequences work this way: each set of heaters starts its cycle 10 seconds after the previous. The sequential starting of heaters may take several minutes. The cycles of heater control run in parallel until the user decides to stop the warm-up. The cycles then all stop at the same time.

The sequences used to warm-up the thermal shield and the helium circuits are very similar, but for the pressure vessel warm-up, the program checks the helium level. As long as the cryostat contains liquid helium, the heating is intermittent and allows evaporating the liquid stored in the cryostat. The heating operates in continuous mode when the cryostat is empty (Liquid helium level<5%).

The sequence 22 can start only when the cryostat thermal shield cooling (sequence 6) and the cryostat helium cooling sequences are stopped.

The sequences 22.1 and 22.2 are started one after the other as described below:

**22-1:** Warm up of the cryostat thermal shield

All thermal shield heaters are started

Stop

Warm-up of the cryostat thermal shield

Start the current leads heaters

Start 22.1

Start 22.2

22.1 in operation

Warm-up of the pressure vessel

Stop

Warm-up Cryostat

The sequence used for the warm-up of the cryostat thermal shield is similar to the valve box thermal shield sequence 21-1.

Subsequence

(TT741A OR TT741B OR TT741C) >TT741setpoint

Stop

To other heaters

Stop warm-up

Stop EH741AC

Warm-up

Start EH741AC

(TT741A & TT741B & TT741C) < (TT741setpoint - 5°C)

Open CV740

GN2 circuits

opened

Close CV740

GN2 circuits

opened

Stop

CV740 closed

Delay

Sequence 6 stopped

Stop

## Vacuum or Liquid or Magnet mode

Table 5: Cryostat warm-up - Thermal shields

|  |  |  |
| --- | --- | --- |
| Heater | Thermometer | Temperature setpoint |
| EH741AC  EH742AC  EH743AF | TT741AC  TT742AC  TT743AF | TT741setpoint  TT742setpoint  TT743setpoint |

**22-2:** Warm-up of the pressure vessel

This sequence 22-2 is similar to the sequence Warm up Valve Box 21-2.

## Liquid mode

Subsequence

TT641A OR B OR C >TT641setpoint OR FT581<FT581limit

LI670 ≤ 5

Stop

Warm-up

Start EH641AC

CV581 opened

LI670 > 5

Stop

Warm-up

Stop EH641AC

CV581 opened

Stop

Warm-up

Start EH640AF

Stop

Warm-up

Stop EH640AF

TT640A OR B OR C OR D

OR E OR F > TT640setpoint OR FT581>FT581limit

TT640A OR B OR C OR D OR E

OR F < (TT640setpoint – 5°C)

& FT581<FT581limit

TT641A and B and C < (TT641setpoint – 5°C)

& FT581<FT581limit

EH641AC running 5s, Delay 20s

Open FV640, FV642

Open CV581

Check liquid level

Delay

All thermal shield heaters are started

Closing circuits

Close FV640, FV642

Stop

FV640 & FV642

closed

Table 6: Cryostat warm-up - Helium tank – Liquid mode

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Heater | Pt thermometer | Level | Temperature setpoint | CX thermometer | Temperature threshold |
| EH640AF  EH641AC | TT640AF  TT641AC | LI670  LI670 | TT640setpoint  TT641setpoint | TT644  TT644 | 120K  120K |

## Magnet mode

Stop

All thermal shield heaters are started

EH641AC running as set in commissioning parameters

Open CV581, CV583

Open FV680, Keep FT583<FT583limit

Check liquid level

Subsequence

LI680 > LI680 min

LI680 ≤ LI680 min

Warm-up

Start EH641AC

CV581, CV583 opened

FV680 opened

Delay

Warm-up

Start EH640AF

TT640A OR B OR C OR D

OR E OR F > TT640setpoint

OR FT583>FT583limit

TT641A OR B OR C >TT641setpoint

OR FT583>FT583limit

Stop

Warm-up

Stop EH641AC

CV581, CV583 opened

FV680 opened

Stop

Warm-up

Stop EH640AF

Stop

Stop

TT640A OR B OR C OR D

OR E OR F < (TT640setpoint – 5°C)

& FT583<FT583limit

Close the Lambda plate valve

Close FV680

Close FV640

Close FV642

FV680 closed

TT641A and B and C < (TT641setpoint – 5°C)

& FT583<FT583limit

Table 7: Cryostat warm-up - Helium tank – Magnet mode

|  |  |  |  |
| --- | --- | --- | --- |
| Heater | Thermometer | Level | Temperature setpoint |
| EH640AF  EH641AC | TT640AF  TT641AC | LI680  LI680 | TT640setpoint  TT641setpoint |

Step 12: Turn off EH641AC when FT583 >= FT583 limit.