SQ23 – Inserts warm-up

**Sensors and actuators used:**

- Temperature: list in the tables from 8 to 11

- Heater: list in the tables from 8 to 11 and the current leads heaters for the magnet insert

- Level: LI660, LI670, LI680, LT682

|  |  |
| --- | --- |
| **The user chooses:** | **Initial conditions:** |
| - Temperature setpoint: list in the tables from 8 to 11 | - Sequences from 1 to 3 stopped  - Sequences 6 and 7 stopped  - Sequences from 10 to 20 stopped  - Sequence 8 in operation |
| - Flow: FT581limit, FT583limit  - Level: LI660mini, LI670mini, LI680mini |

This sequence drives the electrical heaters implicated in the warm-up of the inserts. 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 helium circuits warm-up, the program checks the helium level. As long as the cryostat or helium tank contains liquid helium, the heating is intermittent and allows evaporating the liquid stored in the cryostat or in the insert helium tank. The heating operates in continuous mode when the cryostat (helium tank) is empty (Liquid helium level<Liquid helium level mini).

The tables from 8 to 11 give the list of heaters implicated in the warm-up of the inserts.

The sequences 23.1 and 23.2 are started one after the other as described below:

**23-1:** Warm-up of the vacuum insert thermal shield

Warm-up of the

insert thermal shield

Start 23.1

Stop

Start 23.2

23.1 in operation

Warm-up of the helium circuits

Warm-up Liquid

Stop

Start 23.2

Warm-up of the helium circuits

Start 23.2

Warm-up of the helium circuits

Warm-up Magnet

Stop

Stop

Warm-up Vacuum

All thermal shield heaters are started

The sequence used for the warm-up of the vacuum insert thermal shield is similar to the warm-up of the valve box thermal shield sequence 21-1 and the cryostat thermal shield 22-1.

The sequence 23 in vacuum mode can start only when the cryostat thermal shield cooling (sequence 7) and the cryostat helium cooling sequences are stopped.

## Vacuum mode

Subsequence

Stop

Stop

To other heaters

Stop warm-up

Stop EH761AC

Warm-up

Start EH761AC

(TT761A OR TT761B OR TT761C) >TT761setpoint

(TT761A & TT761B & TT761C) < (TT761setpoint - 5°C)

Delay

Stop LN2

Sequence 7 stopped

Table 8: Insert warm-up – Thermal shield – Vacuum insert

|  |  |  |
| --- | --- | --- |
| Heater | Thermometer | Temperature setpoint |
| EH761AC  EH763AF  EH765AC | TT761AC  TT763AF  TT765AC | TT761setpoint  TT763setpoint  TT765setpoint |

**23-2:** Warm-up of the helium circuit

This sequence 23-2 is similar to the sequences Warm up Valve Box 21-2 and Warm-up Cryostat 22-2.

## Vacuum mode

Subsequence

TT661A or B or C >TT661setpoint

OR FT581>FT581limit

LI660 ≤LI660mini

Stop

Warm-up

Start EH661AC

CV581 opened

LI660 >LI660mini

Stop

Warm-up

Stop EH661AC

CV581 Opened

Stop

Warm-up

Start EH660AC

Stop

Warm-up

Stop EH660AC

TT660A OR B OR C > TT660setpoint

OR FT581>FT581limit

TT660A & B & C < (TT660setpoint – 5°C)

& FT581<FT581limit

TT661A & B & C < (TT661setpoint – 5°C)

& FT581<FT581limit

Stop

EH661AC running 5s, Delay 20s

Open CV581

Check liquid level

Delay

Sequence 10 to 20 are stopped

Table 9: Insert warm-up – Helium circuits – Vacuum insert

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Heater | Pt thermometer | Level | Temperature setpoint | CX thermometer | Temperature threshold |
| EH660AC  EH661AC | TT660AC  TT661AC | LI660  LI660 | TT660setpoint  TT661setpoint | TT663  TT663 | 50K  50K |

Stop

Stop

TT661A & B & C < (TT661setpoint – 5°C)

& FT581<FT581limit

TT660A & B & C < (TT660setpoint – 5°C)

& FT581<FT581limit

Subsequence

TT660A OR B OR C >TT660setpoint

OR FT581>FT581limit

LI670 ≤ LI670mini

Warm-up

Start EH660AC

CV581 opened

LI670 > LI670mini

Warm-up

Start EH661AC

TT661A OR B OR C > TT661setpoint

OR FT581>FT581limit

Stop

EH661AC running 5s, Delay 20s

Open CV581

Check liquid level

Delay

Sequence 10 to 20 are stopped

Stop

Warm-up

Stop EH660AC

CV581 opened

Stop

Warm-up

Stop EH661AC

## Liquid mode

Table 10: Insert Warm-up – Helium circuits – Liquid insert

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Heater | Pt thermometer | Level | Temperature setpoint | CX thermometer | Temperature threshold |
| EH660AC  EH661AC  EH670AC | TT660AC  TT661AC  TT670AC | LI670  LI670 | TT660setpoint  TT661setpoint  TT670setpoint | TT663  TT663 | 50K  50K |

## Magnet mode

Sequence 10 to 20 are stopped

Subsequence

TT661A or B or C >TT661setpoint

OR FT583>FT583limit

LI680 ≤ LI680limit

Stop

Warm-up

Start EH661AC

CV581, CV583 opened

FV680 opened

LI680 > LI680limit

Stop

Warm-up

Stop EH661AC

CV581, CV583 opened

FV680 opened

Stop

Warm-up

Start EH660AC

Stop

Warm-up

Stop EH660AC

TT660A or B or C > TT660setpoint

OR FT583>FT583limit

TT660A & B & C < (TT660setpoint – 5°C)

& FT583<FT583limit

TT661A and B and C < (TT661setpoint – 5°C)

& FT583<FT583limit

Stop

EH661AC running 5s, Delay 20s

Open CV581, CV583

Open FV680

Check liquid level

Close the Lambda plate valve

Close FV680

FV680 closed

Delay

Table 11: Insert Warm-up - Helium circuits – Magnet insert

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Heater | Pt thermometer | Level | Temperature setpoint | CX thermometer | Temperature threshold |
| EH660AC  EH661AC  EH680  EH681AC  EH682AC  EH689AC  EH670AC | TT660AC  TT661AC  TT680  TT681AC  TT682AC  TT689AC  TT670AC | LT682  LI680  LI680  LI680  LI680  LI680 | TT660setpoint  TT661setpoint  TT680setpoint  TT681setpoint  TT682setpoint  TT689setpoint  TT670setpoint | TT668  TT663  TT685  TT664  TT664  TT664 | 50K  50K  50K  50K  50K  50K |