Document Title	**Detailed Specification for the SIS100 Local Current Leads Heaters**
Description	PSP-Code: 2.8.2.10.2 This document defines the requirements on heaters for the local current lead of SIS100 quadrupole doublet modules
Division/ Organization	SCM \ MES
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Document History

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Abstract

This document defines the requirements to the heaters for the local current leads of SIS100 quadrupole doublet modules.

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1. Purpose and Classification of the Document

The purpose of this document is to specify the technical requirements for the production of the heaters (AID:0003090; SIS100 LCL anti-icing heaters) for the 250 A current leads for installation in the SIS100 quadrupole doublet modules.

2. Abbreviations, Terms and Definitions

Abbreviation	Meaning
SIS	Schwerionensynchrotron
SIS 100	SIS with maximum bending power of 100 Tm
FoS	First of series
SAT	Site acceptance test
FAT	Factory acceptance test
HTS	High temperature superconductor
EDMS	CERN's Engineering Data Management Service

3. Scope of the Technical System

3.1. System Overview

The superconducting corrector magnets of the SIS100 synchrotron are individually powered by means of the 250 A current leads (Local Current Leads) installed inside the Quadrupole Doublet Module. The Local Current Leads are rated to 250 A DC and are designed by use of HTS material cooled by the thermal contact to the thermal radiation shield of the Quadrupole Doublet Modules

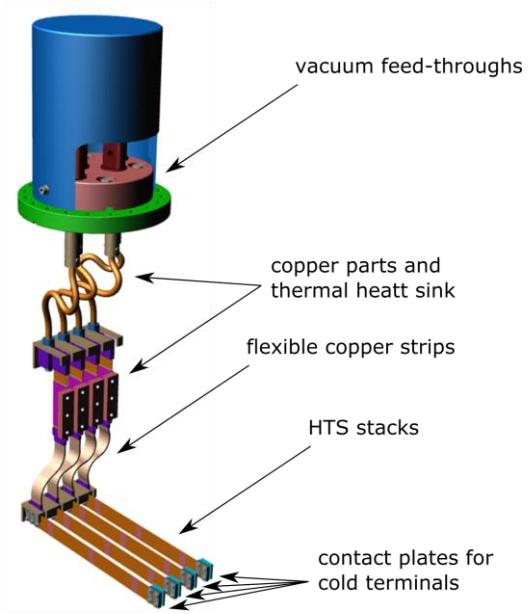


Figure 1. *Local Current Lead assembly for steering magnets with two coils, horizontal and vertical.*

(50 – 80 K). Each current lead (Figure 1) consists of the copper part, HTS interception and cold terminal assembly.

The copper part of the LCL requires a cartridge heater to be installed within it. The purpose of the heater is to regulate the temperature of the copper exposed to the room temperature and to avoid any water condensation and sublimation on its surface.

3.2. Scope of Delivery

1200 pieces of heaters must be delivered. This includes:

- 168 for sextupole correctors;
- 664 for steerer correctors;
- 144 for multipole correctors;
- 32 for low-current quadrupole magnets;
- 60 for the QDM testing;
- 132 spares;
- Proper documentation of used materials, production (procedures and personnel) and conducted tests in electronic form

3.3. Spare Parts

The delivery scope presented in paragraph 3.2 includes 132 spare pieces. This amount is >10% of the amount needed for the SIS100 accelerator.

4. System Specification

To properly heat up the LCL copper blocks at the vacuum feedthrough, heaters have to meet the requirements elaborated in the following sections.

4.1. Technical Requirements for System Components

- The housing of a heater must be machined from brass (CuZn40Pb2). It must be composed of two parts:
  - first – the insert [1]
  - second – the coupling nut [2]

  All the dimensions have to be machined within the tolerances visible on the drawings
- The interconnector (M8, male, A - coded) has to be placed inside the coupling nut. The required working conditions requirements (HV (1.1kV) resistant insulation, and water/dust resistance (IP67)) must be written in its specification.
- The inner side of the coupling nut design may be modified, after the company approval, to fit better the selected interconnector.
- Both brass parts of the heater must be glued together (Loctite 638 or the company-approved replacement) in a position that will leave 6.5mm of the inserts thread uncovered.
  Both brass parts assembled together with the interconnector are presented on Figure 2.



Figure 2. *The LCL heater assembly.*

- Each heater must include a cable with a matching connector, to be attached to the heater. It also needs to have length of 150 to 250 cm. The cable needs to be halogen-free, each of 4 cables needs to have a standard color code for M8 connectors:
  - pin 1 – brown cable
  - pin 2 – white cable
  - pin 3 – blue cable
  - pin 4 – black cable

  The pinout configuration is presented on figure 3.

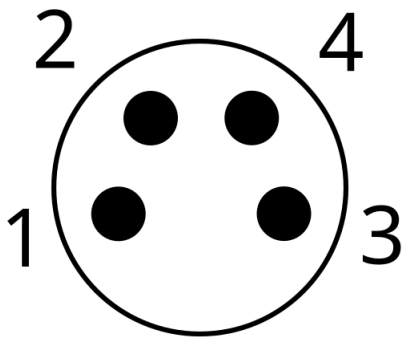


Figure 3. *The M8, male, A coded, 4 pin connector layout.*

- Pins 1-2 of the interconnector must be connected to the heater, while pins 3-4 must be connected to the PT100 sensor.
- The cable specification must state that its insulation can withstand the required HV (1.1 kV).
- Constantan heating wire with resistance of 40 +/- 2 Ω has to be implemented in the cartridge as the heating element, connected to the two copper leads (0,25 mm² each). The leads need to be connected to the interconnector on one side and the heating wire on the other. Leads must be long enough, to not allow any heating wire to pass in the proximity of the PT100 sensor.

- The heating wire needs to be applied in a folded, bifilar way to minimize the inductance. The total heaters inductance must be lower than 3 µH.
- the heating wire must be placed at the bottom of the heater housing (given that interconnector side is the top side)
- PT100 sensor implemented (Class B), with 2 copper leads to the temperature controller (0,25 mm² each). The sensor must be placed on the top, inside of the nonthreaded part of the heater housing, over the resistive wire. Sensor leads must be connected to the interconnector on the top of the heater.
- Insulation resistance between each electrical connection of the heater cartridge and the cylindrical outer shell at 1.1 kV must be better than 1 GΩ at usual air humidity 20-70 % at 25 °C for 120 seconds.
- Insulation resistance between the heater circuit and the sensor circuit at 1.1 kV must be greater than 1 GΩ at usual air humidity 20-70 % at 25 °C for 120 seconds.
- the resistive wire and the temperature sensor must be placed in the brass insert inside a shrink tube filled with epoxy. After mixing the epoxy components, the epoxy must be checked for bubbles before application.
- Epoxy used for all applications within this project must be 286 Blue Loctite Ablestik. Used of another epoxy is possible, but has to be approved by the company.
- Epoxy must be used for filling the inside of the cartridge. It must be properly degassed and applied bubble-free.
- The opening at the bottom of the heater and around the interconnector (if needed) must be sealed with the Epoxy. All surfaces there must be smooth, without any cracks, gaps or cavities. The sickout of the epoxy from the brass at the bottom of the heater must not be greater than 2mm).

4.2. Functional Requirements (Parameter List)

- All geometrical dimensions shall be within tolerances indicated in the technical drawings.
- The heater surface shall be scratch free, smooth and clean (oil free).
- Resistance of the heater must have a value of 40 +/- 2 Ω.
- Inductance of the heater wire circuit must not be greater than 3 µH.

4.3. Interfaces

- Heater will be connected to the controllers via terminal box which does not require any kind of connectors.
- Terminal box will be the point of transition from 2 to 4 wire leads for the PT sensor. That means only 2 sensor leads are needed as part of the heater.

4.4. System Environment and Constraints

- Heater has to be compatible with the heater slot that is presented in the attachments [3][4][5]

4.5. Production Labeling

- A unique, 4-digit long, serial number must be engraved on the hex head of each heater. No CID numbers can be engraved on the heaters, due to the lack of space. Because of the HV

work environment, no plates or any other additional labeling (including CID) can be attached to the heater.

5. Procedure

As the design phase is over and a prototypes with given parameters were tested successfully, the production may start immediately, with no need for a sample delivery of FoS pieces.

5.1. Design Phase

The design phase was completed within the company. The design was tested on a prototype batch of heaters, and the drawing of the modified and version was prepared to pass to the manufacturer [1][2].

5.2. Production Phase

During the production each heater needs to be marked with a serial number. This is only for the purpose of testing and documentation. Single pieces of heaters after production will not present any unique characteristics, therefore no CID number is needed for their identification.

The design was tested on a prototype, for this reason together with the simplicity of the design no “First of series” heater is needed for separate testing. The production must be organized in a way that will emphasize testing of components at the beginning of production (as described in chapter 6).

6. Quality Assurance, Tests and Acceptance

The required quality will be provided by a series of visual inspections and test runs. This will happen both on the production site (FAT), and after the delivery (SAT)

6.1. Factory Acceptance Test (FAT)

Factory Acceptance Test of the LCL heaters consists of the visual inspection, dimensional inspection and insulation test.

- All heaters have to be checked for scratches;
- 100% of leads has to undergo a HV test, and the result has to be greater than 1 GΩ (at 1.1kV, 120 seconds);
- 10% of heaters, including the first 3% of production has to go through a test run, during which:
  - The resistance of the heater will be measured, with the accuracy of ± 0,5 Ω;
  - The resistance of the PT100 sensor will be measured, with the accuracy of ± 0,5 Ω;
  - For 90 minutes each heater has to maintain the temperature of 40±3 °C;
  - After the heating cycle heaters have to go through the HV test (referred to as the “dry test”) between all 4 pins of the connector to the brass heater shell. The insulation resistance must be greater than 1 GΩ at the usual air humidity between 20% and 70% and voltage of 1.1 kV; The measured ambient temperature must be between 20 °C and 25 °C.
  - The resistance of the heater will be measured again. with the accuracy of ± 0,5 Ω;

- The resistance of the PT100 sensor will be measured again, with the accuracy of ± 0,5 Ω;

- First 3% of production must also undergo the insulation test while being submerged in water (referred to as the “wet test”). Water must be covering the whole brass shell and part of the leads. The insulation must be measured between each of the electrical leads and the water. The duration and parameters of the test must be same as above mention parameters for the dry test.
- 4 first heaters of the production have to go through the “cold HV test” during which heaters will be located in a water container, and cooled down until water in the container becomes ice. The parameters and duration of the test must be the same as in case of the dry test.

A protocol from such test has to be delivered to the company together with each tested heater. The protocol must be mapable to the tested heater in a firm way. It must also include all the environmental data, mentioned above (e.g. ambient temperature and humidity).

6.2. Site Acceptance Test (SAT)

Site Acceptance Test of the LCL heaters consists of the visual inspection, dimensional inspection and insulation test.

- 10% of heaters, chosen randomly, have to be checked for scratches and cracks;
- 5% of leads, chosen randomly have to undergo a HV test, of the same parameters as described for FAT;
- 5% of heaters, chosen randomly, have to go through the HV, of the same parameters as described for FAT;

7. Documentation

Contractor is obligated to deliver test protocols (FAT) of delivered heaters at least two weeks ahead of the day of shipment in electronic form. An Electronic Document Management System will be used to store all manufacturing information.

Hard copy also has to be included in the shipment.

8. Related Documents

[1] Drawing MG-1231627-P-000, “Cartridge heater system”
[2] Drawing MG-1373344-P-000, “Coupling nut”
[3] Drawing MG-1011668-A-000, “Current lead flange sextupole”
[4] Drawing MG-1027802-A-000, “Current lead flange multipole”
[5] Drawing MG-1010463-A-000, “Current lead flange steerer”