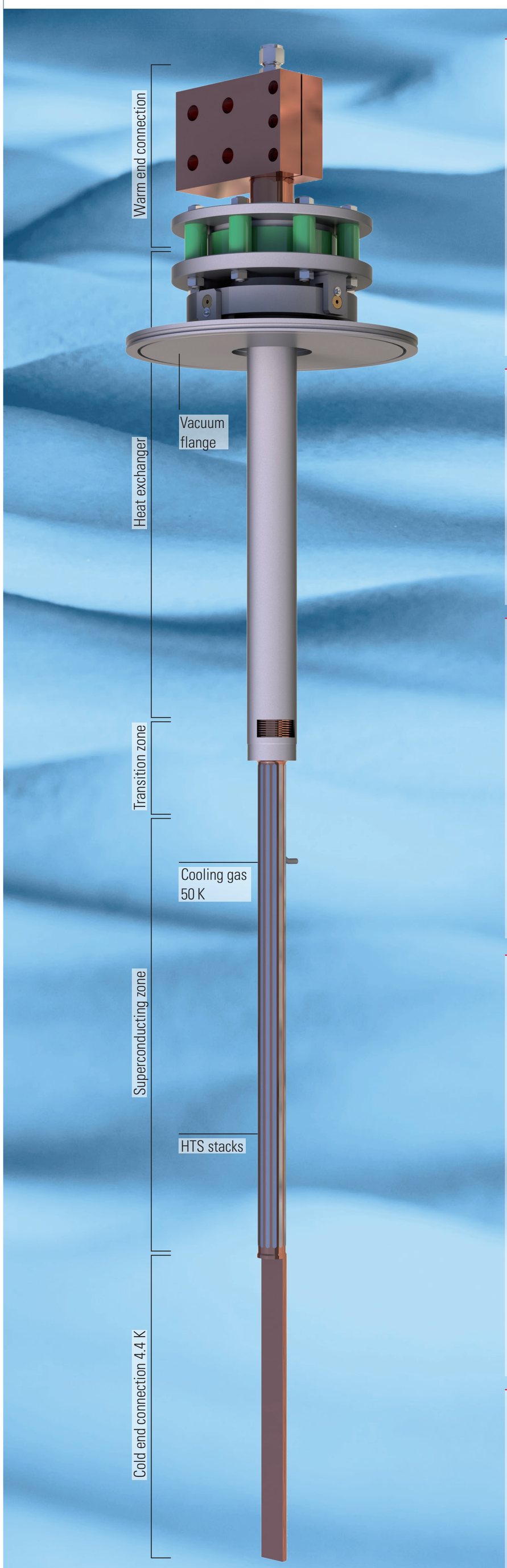
Design, Testing and Commissioning of 25.7 kA HTS Current Leads

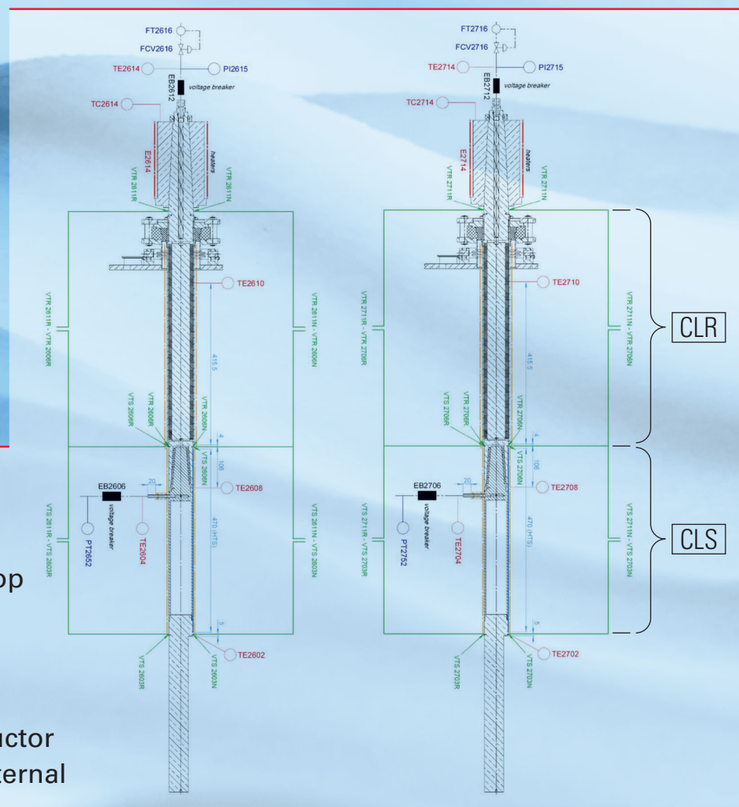


Introduction

- Superconducting magnets require current leads, leading very high currents from ambient to the operating temperature of the magnet
- In metals heat is mainly transported by the conduction electrons. Therefore, good electric conductors are also good heat conductors (Wiedemann-Franz-Law)
- Hybrid current leads reduce the heat load at the 4 K level by the use of a ceramic superconductor in the cold part (4 K to ≈ 60 K)
- CRPP and WEKA have developed current leads for currents in the range of 3 kA to 30 kA which are suitable for industrial fabrication
- A novel design of the heat exchanger and optimization of the transition zone were introduced into development of hybrid current leads
- WEKA manufactured a pair of hybrid current leads for CEA Saclay, 25,7 kA current leads will be used in the JT60-SA test facility, equipped with voltage taps, temperature sensors, as well as Paschen insulation
- The current leads have been successfully commissioned

Technical Characteristics

Current Level	25.7 kA
Superconducting material	BSSCO 2223
Cold end temperature	4 K
Helium feed temperature	50 K
Helium consumption	1,8 g/s @ 25.7 kA
Total length	1.775 m
Length in vacuum insulation	1.340 m



Design of the current lead

Resistive zone with optimized heat exchanger (80–300 K)

- Parallel plate heat exchanger with reduced pressure drop
- Helical cooling directly machined in the resistive part
- Allows application in any gravitational orientation

Transition zone (50–80 K)

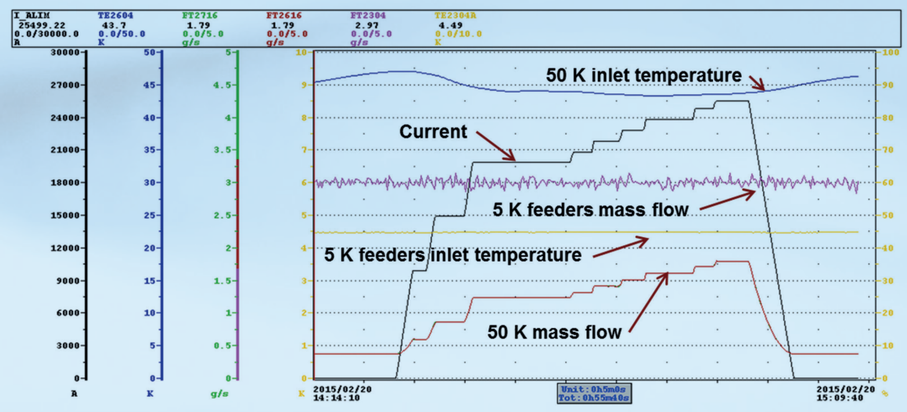
- Extended overlapping between copper and superconductor with continuously reduced copper cross section and internal heat exchanger
- Improved transfer of the current to the HTS with reduced heat losses in the resistive copper

Superconducting zone (4.4–50 K)

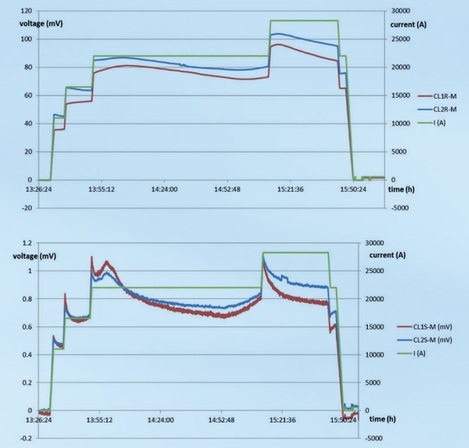
- BSSCO 2223 stacks soldered into longitudinal grooves on a stainless steel support
- Heat transfer by conduction

Setup of testing and commissioning

- Application of current ramp from 0–25.7 kA-0 within 1 hour
- Control of the voltage drop on the superconducting (CLS) and restistive zone (CLR) of the current lead
- Measure of the temperature at cold end (TE2602, TE2702 – 5 K), middle point (TE2608, TE2708 – 50–80 K), top of the current lead (TE2614, TE2714 – 35 °C)
- Measure of the coolant mass flow



Temperature profile during the application of the current ramp



Voltage drop in the resistive and superconductive zones of the current lead, during the application of the current ramp

Conclusions

This first campaign of tests allowed us to successfully commission the current leads of the test facility.
The results show that:

- Operating conditions given by the test facility to energize the current leads respected the specifications
- The middle point temperature, specified between 50 and 80 K has been achieved
- The bottom end temperature does not overpass 6 K, as specified
- The contact resistence between copper and HTS at 50 K as well as between HTS and copper at 5K are particularly low

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