ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Ref.: AT-MEL-CF
EDMS No.: 44036
LHC Project document No.: LHC-DFL-CI-0005

The Large Hadron Collider Project ***IT-3303/AT/LHC***

Technical Specification for the Cryogenic Testing of HTS Current Leads

Abstract

This specification concerns the testing of High Temperature Superconducting (HTS) current leads at cryogenic temperatures. In total 1049 HTS current leads operating at currents of 600 A, 6000 A and 13000 A shall be tested.

The date foreseen for delivery is from September 2004 to mid 2006 with a delivery rate of about 100 leads tested per month.

March 2004

Table of Contents

List of Tables

Terms and Definitions

Term	Definition
CDD	CERN Drawing Directory
EDMS	Engineering Data Management System
QAP	Quality Assurance Plan
HTS	High Temperature Superconducting

1. INTRODUCTION

1.1 Introduction to CERN

The European Laboratory for Particle Physics (CERN) is a European intergovernmental organisation with 20 Member States*. It has its seat in Geneva but straddles the Swiss-French border. Its objective is to provide for collaboration among European States in the field of high energy particle physics research and to this end it designs, constructs and runs the necessary particle accelerators and the associated experimental areas.

At present more than 5000 physicists from research institutes world-wide use the CERN installations for their experiments.

1.2 Introduction to the LHC project

The Large Hadron Collider (LHC) is the next accelerator being constructed on the CERN site. The LHC machine will mainly accelerate and collide 7 TeV proton beams but also heavier ions up to lead. It will be installed in the existing 27 km circumference tunnel, about 100 m underground, formerly housing the Large Electron Positron Collider (LEP). The LHC design is based on superconducting twin-aperture magnets which operate in a superfluid helium bath at 1.9 K. This machine is scheduled to come into operation in the year 2007.

1.3 Subject of the specification

This Technical Specification concerns the testing of High Temperature Superconducting (HTS) current leads of various current ratings at cryogenic temperatures. The functionality and the design of the mechanical interfaces are the subjects of separate documents [LHC Project Document, EDMS CERN Database, Document No. 350602: LHC HTS Current Leads, Drawings in Annex A].

2. SCOPE OF THE TENDER

2.1 Scope of the supply

This Technical Specification concerns the complete testing of HTS leads for powering the LHC superconducting magnets. These leads will operate in a temperature range between room temperature and liquid helium temperature.

The scope of the supply comprises:

- testing of the HTS leads at cryogenic temperatures,
- provision of the test equipment and consumables for the testing,
- documentation and protocols of all test results,
- packing, transport, and delivery to CERN.

The responsibility for the test equipment and the test results rests with the Contractor.

---

* CERN Member States are: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, The Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Bulgaria and the United Kingdom.

The requirements stated in this specification are based on the testing experience gained at CERN on numerous prototype and pre-series HTS current leads.

2.2 Items supplied by CERN

The HTS current leads to be tested will be supplied by CERN. They will be delivered at a rate consistent with the testing schedule and agreed with the Contractor.

3. GENERAL CONDITIONS FOR CONTRACTING

Please refer to the Tender Form for more complete information.

3.1 Contract Procedure

3.1.1 Pre-contract Discussions

The Contractor is strongly encouraged to contact CERN and discuss details of the specification before the Contract is placed. In particular, CERN wishes to ensure that no doubt exists as to the interpretation of this specification.

3.1.2 Preliminary Programme

The Contractor shall propose a preliminary testing schedule, based on the specified CERN delivery schedule.

3.2 Contract execution

3.2.1 Responsibility for Design, Components and Performance

The Contractor shall be responsible for the correct performance of all test equipment, irrespective of whether it has been chosen by the Contractor or suggested by CERN. CERN's approval of the test equipment and procedure does not release the Contractor from his responsibilities in this respect.

CERN assumes responsibility for the performance parameters of items and sub-systems supplied by CERN.

3.2.2 Contract Follow-up

3.2.2.1 Contract Engineer

The Contractor shall assign an engineer to be responsible for the Contract and its follow-up including all contacts with CERN throughout the duration of the Contract.

3.2.2.2 Progress Report

The Contractor shall supply, within one month of adjudication of the order, a written programme detailing the test schedule. The programme shall include preliminary dates for inspections and tests.

A written progress report shall be sent to CERN every month until the completion of the full test programme.

3.2.2.3 Test equipment and procedure Approval

The detailed concept for the testing of the HTS leads shall be submitted to CERN for approval within one month of adjudication of the order. CERN will give its approval or refusal, in writing, within 4 weeks. The ordering of test equipment and materials shall not start without CERN’s written approval.

3.2.2.4 Pre-series Testing

Before starting the series testing of the HTS leads at cryogenic temperatures, at least two leads of each type shall be tested in the presence of CERN representatives to qualify the test benches and other test equipment for the series testing. These pre-series leads shall be shipped to CERN for re-testing and comparison. Series testing at cryogenic temperatures of the HTS leads shall not start before CERN has given its formal approval in writing.

3.2.3 Deviations from the Specification

If, after the Contract is placed, the Contractor discovers that he has misinterpreted the specification, this will not be accepted as an excuse and CERN will expect that the Contractor delivers equipment according to the specification at no extra cost.

During execution of the Contract, all proposed deviations from this Technical Specification, or any other subsequent contractual agreement, shall be submitted to CERN in writing. CERN will give its approval or refusal in writing

3.3 Laboratory Access

CERN shall have free access during normal working hours to the test sites, including any subcontractor’s premises, during the contract period. The place of testing may only be changed after written approval by CERN.

CERN will give 5 working days' notice of any visit.

4. TECHNICAL RESCRIPTION

4.1 General Description

The LHC involves the operation of about 8000 superconducting magnets of various current ratings. Essential elements for the powering of these magnets are HTS leads mounted inside the liquid helium vessel and operating at cryogenic temperatures. The operation of the LHC will require more than 1000 HTS leads.

The use of HTS material incorporated in the lower part of the lead allows a reduction of heat load into the liquid helium by a factor of about 10 if compared to conventional self-cooled leads. The corresponding reduction in total cooling power is about a factor of 3.

The HTS current leads provide the electrical link between the warm cables from/to the power converter and the low temperature superconducting bus bar bringing the current from/to the cryo-magnets (see Fig. 1).

4.2 Number of leads and current ratings

The HTS leads to be tested have three different nominal current ratings. They were designed and validated at CERN. Prototypes of each lead have been successfully tested under nominal operating conditions.

Table 1 summarises the total number (N_{TOT}) of HTS leads to be tested and their corresponding nominal current (I_{nom}).

I_{nom} (A)	N_{TOT}
600	716
6000	269
13000	64

Table 1: Number of HTS leads to be tested

4.3 Arrangement of the leads

The 6000 A and the 13000 A current leads are supplied as single units. The 600 A current leads are supplied mounted on a common flange in a group of 4, see technical drawings in the Annex A.

4.4 Labelling and equipment code

Each HTS lead is labelled individually by a number, which shall be entered in the corresponding testing data sheet.

The following equipment code is adopted:

13000 A	600 A	6000 A
DFLAS	DFLBS	DFLCS

Table 2: Equipment code

4.5 Mass of HTS leads and overall dimensions

The 600 A HTS current lead assembly has a mass of about 40 kg, while for a single 6000 A and 13000 A current lead the mass amounts to about 50 kg and 70 kg respectively.

Each HTS lead has a maximum overall length of 1.5 m. The outer diameter of the insulating mounting flange is 218 mm for the 13000 A and for the 6000 A lead and 255 mm for the assembly of four 600 A leads. The external diameter of the envelope is about 128 mm for the 13000 A lead and 50 mm for each 600 A lead. Detailed information on the size of the components is given in the technical drawings in the Annex A.

4.6 Cryogenics

4.6.1 Cooling Scheme

The HTS current lead consists of a resistive heat exchanger and a HTS part (see Fig.1). The resistive heat exchanger is cooled using 20 K helium gas at 0.13 MPa. It operates between room temperature and the operating temperature of the HTS (T_{HTS}) and its cryogenic envelope is thermally insulated from the cryostat environment via a vacuum jacket.

The HTS part operates between T_{HTS} and 4.5 K. The HTS cold end dips into liquid helium (4.5 K) and is self-cooled by the vapour created by the heat conducted into the bath. The 20 K circuit and the 4.5 K circuit are hydraulically separated at the warm end of the HTS. A warm cryogenic valve controls the nominally 20 K helium flow of each lead to maintain a fixed temperature at the top of the HTS section.

The resistive part of the lead is designed to work stably (stable temperature profile with the maximum temperature of the resistive heat exchanger never exceeding room temperature) at all currents up to I_{nom}. The gas escaping at the warm end of the HTS stays in the helium vessel and is recovered with the cryostat boil-off.

4.6.2 Cryogen requirements

The HTS lead operation requires:

- helium gas, at a temperature in the range 10 K to 25 K (0.13 MPa), for the cooling of the resistive part,
- liquid helium at 4.5 K covering the cold end of the HTS (see section 5.2).

4.6.3 Gas flow and control

A room temperature helium control valve is required for each HTS lead on test. The valve shall be controlled using the signal from one of the platinum sensors incorporated at the top end of the HTS part (TT821 or TT822 in Fig.1). The helium flow shall be adjusted to maintain the temperature at the top end of the HTS at a fixed value of 70 K ± 2 K in stand-by operations and at a fixed value of 48 K ± 2 K when the lead is powered.

The 20 K helium mass flow (m_{20K}) necessary to operate the leads at zero and nominal current and the corresponding heat load into the liquid helium bath ($Q_{4.5K}$) are given in Table 3.

The maximum pressure drop of the 20 K helium gas inside the resistive heat exchanger is 3 kPa.

LEAD CURRENT RATING (A)	**I=0 A**		**I=I_{nom}**	
	TT821=TT822=70 K		**TT821=TT822=50 K**	
	m_{20K} (g/s)	**$Q_{4.5K}$ (W)**	**m_{20K} (g/s)**	**$Q_{4.5K}$ (W)**
600	0.02 ± 0.01	0.090	0.05 ± 0.01	0.090
6000	0.2 ± 0.1	0.7	0.45 ± 0.1	0.7
13000	0.3 ± 0.1	1.5	0.9 ± 0.1	1.5

Table 3: Cooling requirements and expected thermal performance of HTS current leads

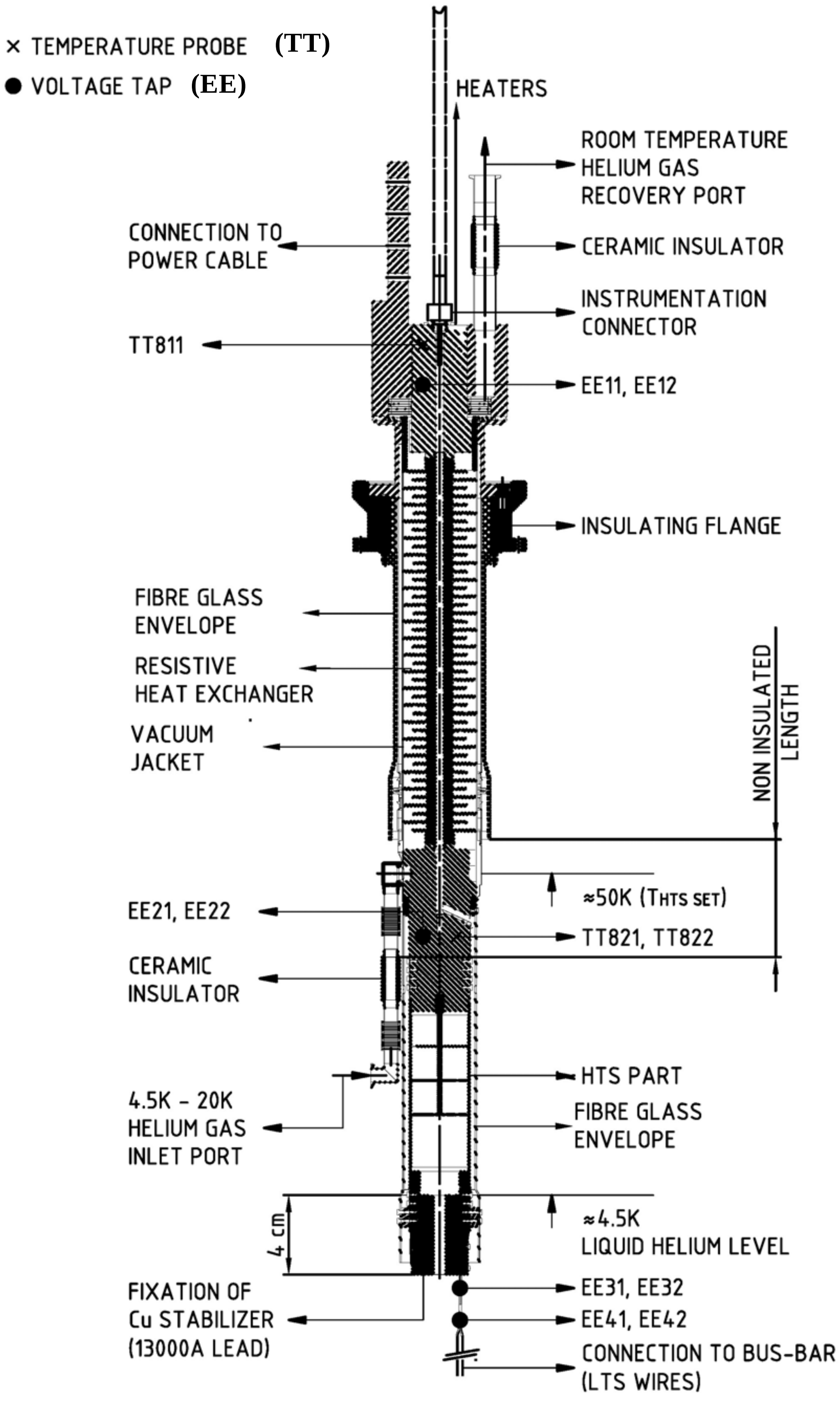

Fig.1: LHC HTS lead schematic

4.6.4 Temperature control

4.6.4.1 Operation with current

Nominal set points of T_{HTS} in the range 30 K-60 K shall be foreseen. The tolerance on the set point temperature is ± 2 K.

4.6.4.2 Operation in stand-by conditions (without current)

A nominal set point of T_{HTS} of 70 K shall be foreseen. The tolerance on the set point temperature is ± 2 K. Lower set point temperatures shall be avoided to prevent icing at the top of the leads.

4.6.5 Nominal Pressure of hydraulic circuits

The inlet pressure of the 20 K helium gas is 0.13 MPa ± 0.01 MPa.

The nominal pressure of the saturated helium bath is 0.12 MPa ± 0.01 MPa.

4.6.6 Design pressure of hydraulic circuits of the lead

The design pressure of the 20 K and 4.5 K helium circuits is 0.35 MPa.

4.6.7 Leak rate

The integral of leak detected at operating conditions is specified to be:

$\leq 1 \cdot 10^{-6}$ mbar·l·s^{-1} for the 20 K circuit,

$\leq 1 \cdot 10^{-8}$ mbar·l·s^{-1} for the lead vacuum insulation.

4.7 Electrical performance and design parameters

4.7.1 Electrical insulation tests

The insulation test and the maximum leakage current ($I_{LEAKAGE}$) admitted per each type of lead are given in Table 4. The insulation test of the lead shall be performed with warm helium gas (295 K ± 5 K, 0.13 MPa) in the resistive heat exchanger and in the cryostat environment.

Lead Current Rating (A)	U (V)	$I_{LEAKAGE}$ (μA)	Voltage Test duration (s)
600	1500	|3|	30
6000	1300	|10|	30
13000	3100	|20|	120

Table 4: Insulation test voltage of current leads (helium @ 295 K ± 5 K, 0.13 MPa)

4.7.2 Steady state operation

The total voltage drop across the lead operating at nominal current and nominal cooling conditions is ≤ 70 mV for each type of lead.

4.7.3 Transient operation and protection of the leads

The resistive section and the HTS section of the leads shall be protected independently.

In case of thermal run-away of the resistive heat exchanger, the total voltage drop across the lead shall never exceed 100 mV. Within 5 seconds from the detection of this threshold, the leads shall be discharged at its nominal current decay rate with a time constant of 120 s for the 13 kA leads, with a time constant of 30 s for the 6 kA leads, and with a time constant of 20 s for the 600 A leads.

In case of resistive transition of the HTS element, the total voltage drop across the HTS shall never exceed 3 mV. Within 5 seconds from the detection of this threshold, the leads shall be discharged at the nominal current decay rate as stated above.

4.7.4 Instrumentation inside the current leads

Instrumentation (voltage taps and temperature probes) is incorporated in the lead for:

- control of the 20 K helium flow,
- independent protection of both the resistive heat exchanger and the HTS part.

Two additional voltage taps are made available for the protection of the LHC magnets circuit.

Each current lead of any current rating is equipped with the same type and number of instrumentation signals. These signals consist of (see Fig.1):

1. Eight voltage taps located at:

- warm end of resistive heat exchanger (EE11, EE12),
- warm end of HTS (EE21, EE22),
- cold end of HTS (EE31, EE32),
- low temperature superconducting wires (EE41, EE42);

2. Three platinum resistance thermometers (Pt100 IEC) located at:

- warm end of resistive heat exchanger (TT811),
- warm end of HTS (TT821, TT822).

The voltage taps in any position on the lead and the temperature sensors at the warm end of the HTS are doubled to allow redundancy.

The purpose of the voltage signals is as follows:

- the voltage EE11-EE21 (or EE12-EE22) is for the protection of the resistive heat exchanger,
- the voltage EE21-EE31 (or EE22-EE32) is for the protection of the HTS part,

- the voltage tap EE41 (or EE42) is provided for the protection of the magnet circuit.

The purpose of the temperature sensors is as follows:

- TT821 (or TT822) is for the control of the 20 K helium flow,
- TT811 is for monitoring the temperature at the top of the lead and verifying the integrity of the lead heating system.

A 16-pin instrumentation helium-tight connector is incorporated in the top terminal of each lead. It is at the lead potential and it provides the leak tight separation between the 4.5 K helium circuit and the room temperature outside environment. All the wires of the lead instrumentation terminate in this connector with the exception of the temperature sensor TT811, located at the top of the resistive heat exchanger and accessible from outside. The wires of the TT811 temperature sensor are connected in a 4-pin connector incorporated in the top terminal of the lead.

The body of the two instrumentation connectors is at the lead potential.

The temperature sensors are electrically insulated (100 V) from the lead body.

During the high voltage insulation tests, the lead instrumentation shall be left floating.

4.7.5 Instrumentation wires and connectors

The 16-pin connector at the top of the resistive heat exchanger is a leak tight Fischer connector DEE 104 A086. The pin designation of the connector is indicated in Table 6.1. The four wires of each temperature sensor are twisted.

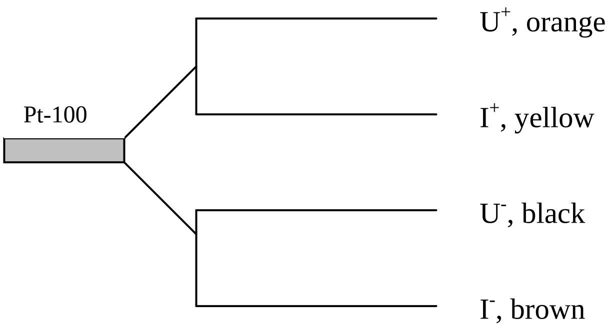

Fig.2: Schematic of Pt-100 probe and instrumentation wires in the lead

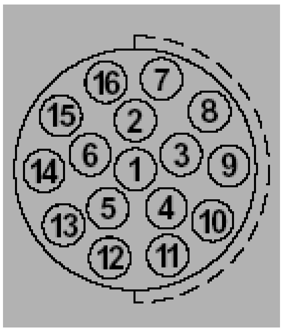

Fig.3: Schematic of DBEE 104 A086 instrumentation connector (<u>seen underside</u>)

Pin	**Sensor**	**Signal**
1	EE11	Voltage
2	EE12	Voltage
3	EE21	Voltage
4	EE22	Voltage
5	EE31	Voltage
6	EE32	Voltage
7	EE41	Voltage
8	EE42	Voltage
9	TT821	U^+
10	TT821	U^-
11	TT821	I^+
12	TT821	I^-
13	TT822	U^+
14	TT822	U^-
15	TT822	I^+
16	TT822	I^-

Table 5: Pin designation of the Fischer DBEE104 A086 connector

The wires of the temperature sensor TT811 terminate in a 4-pin connector. The pin designation of this connector is given in Table 6.

Pin	**Sensor**	**Signal**
1	TT811	U^+
2	TT811	U^-
3	TT811	I^+
4	TT811	I^-

Table 6: Pin designation of the connector relative to TT811

4.7.6 Heating system

Cartridge heaters are incorporated inside the top part of each lead to avoid heavy condensation or ice formation when the leads are operating at zero current or at a current lower than the nominal one. These heaters guarantee that the temperature at the top of the lead stays above the dew point on condition that the helium flow in the resistive part of the lead does not exceed the values specified both for stand-by conditions and operation with current. The heater electrical circuit operates at 24 V-a.c.. The insulation transformers (220 V-a.c./24 V-a.c., one per lead) and the heaters control system will be supplied by CERN. The maximum power supplied by the heating system is about 1000 W for each 13000 A lead, 500 W for each 6000 A lead and 100 W for each 600 A lead.

4.7.7 Tests to be carried out in the presence of CERN representatives

CERN reserves the right to be present, or to be represented by an organisation of its choice, to witness any tests.

4.7.8 Tests to be carried out at CERN

The pre-series HTS leads of each lead will be re-tested at CERN for comparison.

The tests specified in chapter 5 will be repeated at CERN in a sampling mode on some leads. If, on such a test the lead does not meet the acceptance criteria, it will be rejected.

5. TESTS TO BE CARRIED OUT

5.1 Preparation of tests

The leads shall be electrically connected at their cold end by clamping the free end of the LTS wires. These wires are soldered together in a rectangular shape. The procedure for this electrical connection shall be proposed by the Contractor and approved by CERN.

Prior to integration of the lead in the test cryostat, the Contractor shall verify:

- the electrical insulation (see section 4.7.1),
- the leak tightness of the vacuum jacket and of the 20 K circuit (see section 4.6.7),
- the integrity and continuity of the instrumentation signals inside the lead body.

In case of non-conformities, the Contractor shall report to CERN who will assure the repair or replacement of the faulty components.

During cool-down of the test cryostat, all the temperature signals inside the current lead, the inlet temperature and the mass flow rate of the helium cooling the resistive heat exchanger shall be recorded. In this phase, the 20 K helium mass flow rate in the resistive heat exchanger shall never exceed the values specified in Table 3 for stand-by operation. When the temperature of the lead has reached the nominal values for stand-by operation (T_{HTS}=70±2 K, TT811=295±2 K), the lead shall undergo an electrical insulation test as specified in section 4.6.8. The helium flow rate necessary to cool the resistive heat exchanger with T_{HTS}=70±2 K and the corresponding pressure drop shall be recorded.

5.2 Powering of the leads

The leads shall not be powered unless protected by an interlock on T_{HTS} set to 60 K.

The HTS leads can only be powered once:

- the temperature T_{HTS} is adjusted to 48 K ± 2 K,
- the liquid helium level covers the last 5 cm ± 1 cm measured from the bottom end of the lead,
- the protection system is connected and operational (see section 4.7.3).

When the power converter is switched on and prior to powering, the voltage drops across the lead (see section 4.7.2) shall be recorded.

5.2.1 13000 A - Leads

The temperature T_{HTS} shall be fixed to 48 K ± 2 K. The leads shall be powered up to 13000 A with a ramp rate of 40 A/s. A constant current of 13000 A shall be carried by the leads during 2 hours. Finally, the helium flow rate inside the resistive heat exchanger shall be stopped and the current shall be made to decay exponentially with a time constant of 120s.

The following signals shall be recorded versus time with a sampling rate of 1 s:

- Current.
- Helium flow rate inside the resistive heat exchanger.
- Inlet temperature of the helium inside the resistive heat exchanger.
- Pressure drop of the helium inside the resistive heat exchanger.
- Voltage drops inside the lead via EE11 – EE21, EE22 - EE31, EE32 of 1. lead – EE32 2. lead.
- Temperature signals inside the lead TT811, TT821, TT822.
- Liquid helium level.

The pressure drop in the resistive heat exchanger shall be recorded as a function of helium mass flow.

5.2.2 6000 A - Leads

The temperature T_{HTS} shall be fixed to 48 K ± 2 K. The HTS leads shall be powered up to 6000 A with a ramp rate of 40 A/s. A constant current of 6000 A shall be carried by the leads during 1 hour. T_{HTS} shall be lowered to 40±2 K and a constant current of 7500 A shall be carried by the leads during 1 hour. Finally, the helium flow rate inside the resistive heat exchanger shall be stopped and the current shall be made to decay exponentially with a time constant of 10 s.

The following signals shall be recorded versus time with a sampling rate of 1 s:

- Current.
- Helium flow rate inside the resistive heat exchanger.
- Inlet temperature of the helium inside the resistive heat exchanger.
- Pressure drop of the helium inside the resistive heat exchanger.
- Voltage drops inside the lead via EE11 – EE21, EE22 - EE31, EE32 of 1. lead – EE32 2. lead .
- Temperature signals inside the lead TT811, TT821, TT822.
- Liquid helium level.

The pressure drop in the resistive heat exchanger shall be recorded as a function of helium mass flow.

5.2.3 600 A - Leads

The temperature T_{HTS} shall be fixed to 48 K ± 2 K. The HTS leads shall be powered up to 600 A with a ramp rate of 40 A/s. A constant current of 600 A shall be carried by the leads during 2 hours. Finally, the helium flow rate inside the resistive heat exchanger shall be stopped and the current shall be made to decay exponentially with a time constant of 10 s.

The following signals shall be recorded versus time with a sampling rate of 1 s:

- Current.
- Helium flow rate inside the resistive heat exchanger.
- Inlet temperature of the helium inside the resistive heat exchanger.
- Pressure drop of the helium inside the resistive heat exchanger.
- Voltage drops inside the lead via EE11 – EE21, EE22 - EE31, EE32 of 1. lead – EE32 2. lead.
- Temperature signals inside the lead TT811, TT821, TT822.
- Liquid helium level.

The pressure drop in the resistive heat exchanger shall be recorded as a function of helium mass flow.

5.3 Warm-up

Warm up to ambient can be accelerated by using heaters inside the cryostat and simultaneously monitoring the temperature T_{HTS} (TT821). No heaters shall be attached to the leads.

The removing of the insert from the cryostat shall not be carried out before T_{HTS} (TT821) has reached room temperature.

After the cold tests, instrumentation, electrical insulation and leak tightness shall be checked at room temperature. These tests include integrity, continuity, and the HV-test as specified in section 4.7.1.

6. POWER CONVERTER AND CURRENT MONITORING

A power converter of sufficient output voltage and about 13 kA DC output current is required for testing. The maximum current ripple and noise of the power converter has to be small enough for the precise measurement (± 0.5 µV) of the voltage drop across the HTS-part, which is in the order of 10 µV at 13 kA. In order to meet this demand, adequate filtering may be needed.

The power converter should be capable of supplying a nominal current of I_{max}=13 kA within a maximum rise time of 5 minutes up to a peak current of 13 kA ± 50 A. The ramp up to 13 kA has not to be strictly linear and a short overshoot up to about 13.2 kA is acceptable. The maximum acceptable length of the current overshoot shall not exceed 5 s.

The accuracy for the current measurement shall be better than ± 0.1 % relative and ± 0.5 % absolute of the maximum value.

7. ACCEPTANCE CRITERIA

7.1 13000 A - Leads

- The temperature T_{HTS} shall not exceed 60 K at any current level.
- The voltage drop across the resistive part shall not exceed 70 mV under nominal conditions.
- The voltage drop across the HTS part shall not exceed 300 µV.
- The helium mass flow through the resistive part shall not exceed the values shown in Table 3 under nominal conditions.

7.2 6000 A - Leads

- The temperature T_{HTS} shall not exceed 60 K at any current level.
- The voltage drop across the resistive part shall not exceed 70 mV under nominal conditions.
- The voltage drop across the HTS part shall not exceed 300 µV.
- The helium mass flow through the resistive part shall not exceed the values shown in Table 3 under nominal conditions.

7.3 600 A - Leads

- The temperature T_{HTS} shall not exceed 60 K at any current level.
- The voltage drop across the resistive part shall not exceed 70 mV under nominal conditions.
- The voltage drop across the HTS part shall not exceed 60 µV.
- The helium mass flow through the resistive part shall not exceed the values shown in Table 3 under nominal conditions.

7.4 Failure of leads

If a HTS current lead fails during testing or does not fully meet the acceptance criteria stated in Chapter 7, CERN shall be informed. CERN will decide weather the lead shall be returned to the lead manufacturer or the lead shall be shipped to CERN.

For the conditions governing the re-testing of the HTS leads see the Addendum No.1 to the Collaboration Agreement K828/SL

8. INFORMATION AND DOCUMENT MANAGEMENT

8.1 Engineering Drawings

Engineering drawings prepared by the Contractor for the execution of the contract must comply with the procedure defined in chapter 8 of the QAP document No LHC-PM-QA-306.00, Drawing Process External Drawings.

8.2 Planning and Scheduling

Planning and scheduling activities must be performed according to the procedure defined in the QAP document No LHC-PM-QA-301.01, Planning and Scheduling Requirements.

8.3 Quality Control Records

All specified tests and measurements results shall be recorded in a specific file for each HTS lead, called the "traveller".

8.4 Data Recording and Protocols

A data sheet shall be filled for each HTS lead recording all measurement results for all the tests (see section 5.2). The measurement results shall also be stored on disks in a PC readable format. In addition, both measurements and protocol information have to be stored on CD-ROMs in a PC readable format together with the series numbers of the HTS lead.

Written and signed protocols, in English or French, shall be prepared by the Contractor for all tests performed.

Examples for protocols – established at CERN during the testing of prototype and pre-series leads – are available from CERN on request.

9. QUALITY

9.1 Quality assurance provisions

The Contractor shall plan, establish, implement and maintain a documented quality assurance program that fulfils all the requirements described in the technical specification and drawn up according to the Quality Assurance Plan for the LHC Project.

The list of relevant topics covered by the LHC Quality Assurance Plan, together with the corresponding documents, is given in the table below.

Copies of these documents can be sent on request.

˜ Topic	˜ Document Title	˜ Doc. Number
LHC Configuration Management	Configuration Management - Change Process And Control	LHC-PM-QA-304.00
Design	Quality Assurance Categories	LHC-PM-QA-201.00
	Drawing Process-External Drawings	LHC-PM-QA-306.00
Planning and Scheduling	Planning and Scheduling Requirements for Institutes, Contractors and Suppliers	LHC-PM-QA-301.01
Document & Data Management	Document Standards	LHC-PM-QA-204.00

Table 7: LHC QAP topics and documents

10. PROVISIONAL DELIVERY SCHEDULE

Delivery / Date	13kA leads	6kA leads	0.6 kA lead assemblies
1thSeptember 2004	6	21	26
1thNovember 2004	6	26	15
1stFebruary 2005	8	20	12
1stApril 2005	-	24	18
1thJune 2005	8	17	12
1thAugust 2005	8	18	14
1stOctober 2005	-	18	14
1stDecember 2005	8	19	14
1thFebruary 2006	8	20	14
1thApril 2006	8	20	14
1stJune 2006	4	20	14
1stAugust 2006	-	20	12
1stOctober 2006	-	26	-

Table 8: Provisional delivery schedule

11. HANDLING, TRANSPORT AND INSTALLATION

The leads will be delivered to the Contractor by CERN in purpose-built crates, which assure damage-free delivery. Lifting shall be done via lugs screwed in the lead flanges.

It is the responsibility of the Contractor to deliver the tested HTS current leads to CERN well protected and without damage.

Top (warm electrical connection) and bottom (free end of LTS wires) connections of the lead can withstand a maximum force (F_{MAX}) applied in any direction and a maximum torque (C_{MAX}) as specified in Table 9.

The maximum horizontal and vertical acceleration that the HTS leads are able to withstand during transport when supported vertically by fastening the lead insulating flange to the cryostat flange at the specified torque - as after installation in the cryostat chimney – corresponds respectively to 0.5 g and 1.5 g.

	TOP CONNECTION		**BOTTOM CONNECTION**
	F_{MAX} (N)	**C_{MAX}(N·m)**	**F_{MAX} (N)**
13000 A	800	80	200
6000 A	500	40	150
600 A	200	10	20

Table 9: Permissible forces and torques at the top and bottom connections

12. CERN SUPPLIED ITEMS AND SERVICES

All HTS leads to be tested will be supplied by CERN. The heating system (see section 4.7.3) will be supplied by CERN.

13. ACCEPTANCE AND GUARANTEE

Provisional acceptance will be given by CERN only after all documentation referred to in clause 4 of the Technical Specification has been delivered, all tests specified in clause 4 have been successfully completed and all tests or other certificates have been supplied to CERN.

14. CONTACT PERSONS FOR TECHNICAL MATTERS

Amalia Ballarino
Phone: 0041-22-7673296
Fax: 0041-22-7676180
E-Mail: Amalia.Ballarino@cern.ch

Or in case of absence

Karl Hubert Mess
Phone: 0041-22-767-6642
Fax: 0041-22-7676180
E-Mail: Karl.Hubert.Mess@cern.ch

Annex A: List of Drawings

13 kA HTS leads

Drawing No.	**Version**	**Title**
LHCDFLAS0001	AF	General assembly
LHCDFLAS0002	AC	Interface drawing
LHCDFLAS00011	AD	Insulating flange
LHCDFLAS00025	AB	Helium gas inlet connection-Modified DN 16
LHCDFLAS00031	-	Vacuum jacket sub-assembly-Union small flange DN 16
LHCDFLAS00039	AD	Top copper block sub-assembly-Outer block
LHCDFLAS00042	AA	Top copper block sub-assembly-Insert for helium outlet

6 kA HTS leads

Drawing No.	**Version**	**Title**
LHCDFLCS0001	AF	General assembly
LHCDFLCS0002	AD	Interface drawing
LHCDFLCS00011	AD	Insulating flange
LHCDFLCS00025	AC	Helium gas inlet connection-Modified DN 16
LHCDFLCS00031	AD	Vacuum envelope sub-assembly-Union small flange DN 16
LHCDFLCS00039	AE	Top copper block sub-assembly-Outer block
LHCDFLCS00042	AB	Top copper block sub-assembly-Insert for helium outlet

0.6 kA HTS leads

Drawing No.	**Version**	**Title**
LHCDFLBS0001	AB	General assembly
LHCDFLBS0002	-	Interface drawing
LHCDFLBS00011	-	Insulating flange
LHCDFLBS00033	AB	Top part sub-assembly-Electrical connection
LHCDFLBS00052	AA	20 K Helium inlet-Modified DN 16
LHCDFLBS00057	-	Vacuum jacket sub-assembly-Union small flange DN 16