CERN
CH-1211 Geneva 23
Switzerland

the
Large
Hadron
Collider
project

LHC Project Document No.
LHC-DFBX-HCP-0001 rev 1.0

CERN Div./Group or Supplier/Contractor Document No.
AT/ACR-USLHC

EDMS Document No.
829797

Date: 2007-07-25

Hardware Commissioning Procedure

THE COMMISSIONING OF THE DFBXs

Abstract

The DFBXs are compound elements of the collider with many facets. Their task is to mechanically support and provide the cryogenic environment for the current leads and bus bars feeding the LHC interaction region magnets. As such they consist of major cryogenic components (helium vessel, vacuum vessel, etc.) and include complex electrical elements (current leads feeding the superconducting magnet circuits, , bus-bars and related splices, etc), as well as delicate mechanical components (fixed point, cold warm transitions, vacuum vessel, etc.). At the time of cool down the electrical circuits and current leads are connected to the magnets. This sets very serious constraints to the commissioning of the components in these boxes and the establishment of stable operating conditions. This document describes globally the commissioning of these boxes by defining the sequence of the commissioning steps, listing the active participants during each step, and briefly describing the tests specific to the DFBXs but making reference to other commissioning documents as required.

Prepared by :	*Checked by :*	*Approved by:*
S. Feher	**A. Ballarino**	**P. Ciriani**
R. Rabehl	**F. Bordry**	**L. Evans**
J. Rasson	**D. Bozzini**	**Ph. Lebrun**
L. Serio	**S. Claudet**	**S. Myers**
	J. Casas-Cubillos	**P. Proudlock**
	P. Cruikshank	
	K. Dahlerup-Petersen	
	R. Denz	
	J. Etheridge	
	J. Inigo-Golfin	
	R. Lauckner	
	P. J. Limon	
	K.H. Meβ	
	M. Pojer	
	J.P. Quesnel	
	R.Saban	
	R. Schmidt	
	P.Strubin	
	L.Tavian	
	H. Thiesen	
	M. Zerlauth	
	R. van Weelderen	

History of Changes

Rev. No.	***Date***	***Pages***	***Description of Changes***
0.1	2006-06-13	15	First draft of the document circulated to the authors for comment
0.2	2006-07-06	17	Added Figures 2 & 3, modified Table I-1, minor text edits
0.3	2007-03-20	All	Submission for engineering check
0.4	2007-06-04	All	Submission for approval
1.0	2007-07-20		Minor corrections done. Cryo-OK replaced by Cryo-start and Cryo-maintain. Material safety data sheets added for the chemical components used in lead coating.
	2007-07-25	All	Released version

Table of Contents

1. INTRODUCTION

The DFBXs are compound elements of the collider with many facets. In fact, while being a major cryogenic component (helium vessel, vacuum vessel, etc.) their main purpose is, as the name "electrical feedboxes" indicates, to provide mechanical support and appropriate cooling for the warm-to-cold transitions of the electrical circuits. Hence, they incorporate complex electrical elements (current leads feeding the superconducting magnet circuits, bus-bars and related splices, etc), as well as delicate mechanical components (fixed point, cold warm transitions, vacuum vessel, etc.). The 7.5 kA current lead incorporate the novel HTS material, while the 600 A and 120 A current leads are resistive. All leads are active components.

In addition, the DFBXs are interfaced to the QRL, the interaction region magnets, and a number of ancillary systems such as the instrumentation ports, the warm helium recovery line, the vacuum equipment, etc. The connection to the magnets implies that all tests with current have to be done with a considerable stored magnetic energy.

Although all the HTS current leads integrated in the DFBXs will have been fully tested in nominal operating conditions before being installed into the DFBXs, this is not sufficient to guarantee their correct functioning in the DFBXs. In addition, no DFBX has been tested cryogenically before installation in the LHC tunnel. When the DFBXs are being put into service, many tests will therefore have to be made to ensure that the current leads are working correctly.

It is therefore natural that the commissioning of the DFBXs is studied and planned carefully and carried-out globally. To this effect a coordinated joint effort is required among the various groups who are either supplying the DFBXs and its components (US collaboration), or interfacing to the DFBXs (AT/ACR, AT/CRI, AT/MEL, TS/EL, TS/CV, AB/PO, TS/HDO), or supplying services (AT/MEL, TS/SU).

2. SCOPE

This document concerns the commissioning of all the DFBXs. The detailed list and location of these is given in Appendix I. The DFBXs power the high luminosity interaction region low β quadrupoles and in other interaction regions also the separation/recombination dipoles. There are 8 DFBXs in the LHC with 6 different configurations as shown in Appendix I.

This document should be considered as a supplement to document LHC-DFB-HCP-0001, "The Commissioning of the DFBs." Most commissioning steps for the DFBAs, DFBLs, and DFBMs are fully applicable to the DFBXs. Some commissioning steps, however, require additional considerations for the DFBXs. Therefore, in order to minimize repetition and the possibility of conflicts between the two documents, this document will refer to LHC-DFB-HCP-0001 "The Commissioning of the DFBs" as much as possible. Only those steps that require special attention for the DFBXs will be elaborated upon.

It is also important to note that documents LHC-DFL-ES-0001 "LHC HTS Current Leads" and LHC-DFL-ES-0002 "120 A Current Leads for the DFBs" pertain only to the current leads installed in the DFBA, DFBL, and DFBM electrical distribution boxes. The HTS and conventional current leads installed in the DFBX boxes were specified elsewhere [1, 2].

While briefly making reference to the activity which takes place before the installation of the boxes in the tunnel, this document focuses on the tests which take place in the tunnel and concern the boxes themselves but also the main electrical equipment (current leads and bus-bar feeding the magnets) and ancillary equipment connected to them. The tests described here span from the Individual System Tests of the Cryogenic Instrumentation to the end of the Powering Tests of the superconducting circuits when all the circuits traversing the boxes are powered in unison.

3. LAYOUT

3.1 VACUUM

The insulating vacuums of the DFBXs at all IRs are common with the inner triplet, while at IR2 and IR8 they are also common with the superconducting D1 dipole.

3.2 THE CRYOGENIC FLOW SCHEME

The cryogenic system of the DFBXs provides the cryogenic environment needed by the current leads for their operation as well as cryogenic distribution to the superconducting magnets.

The DFBX electrical distribution feed boxes are low design pressure equipment (0.35 MPa (3.5 bar)) connected to high design pressure (20 bar) equipment and cryogen supplies. This peculiarity has specific consequences for their cryogenic implementation, commissioning and operation. A typical DFBX flow scheme with a cryogenic D1 dipole connection is given in Figure 1 [3], and with a warm dipole connection is given in Figure 2 [4].

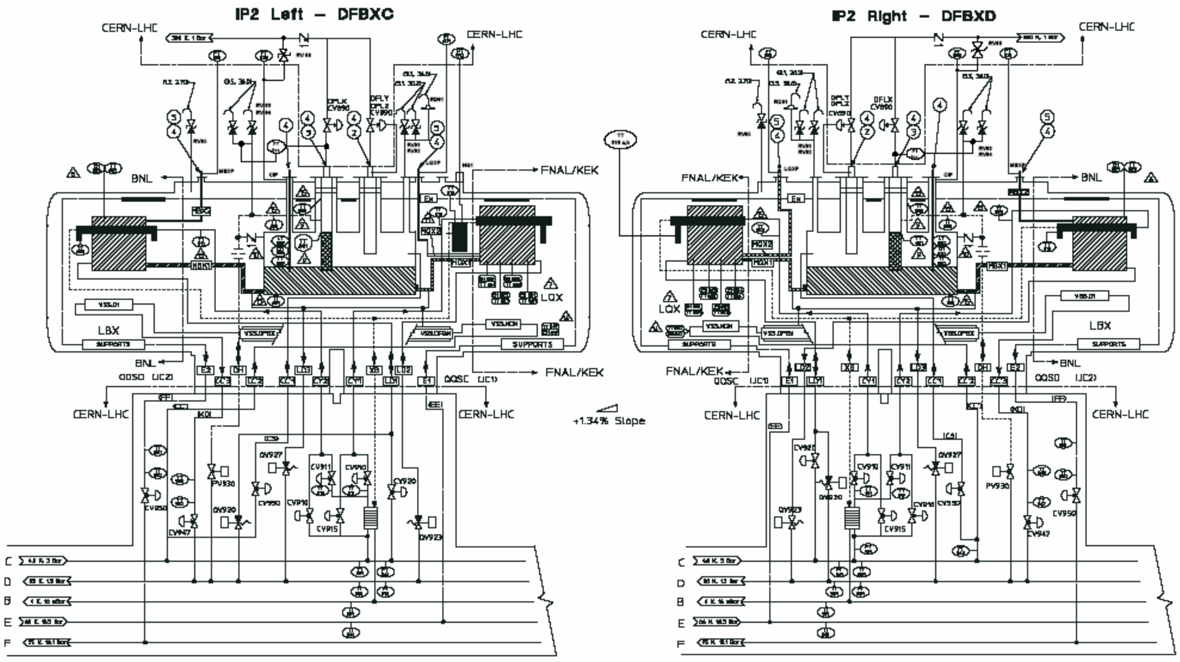

Figure 1 Cryogenic flow-scheme and instrumentation of the DFBX type electrical distribution boxes on either side of IP2 with a cryogenic D1 dipole connection.

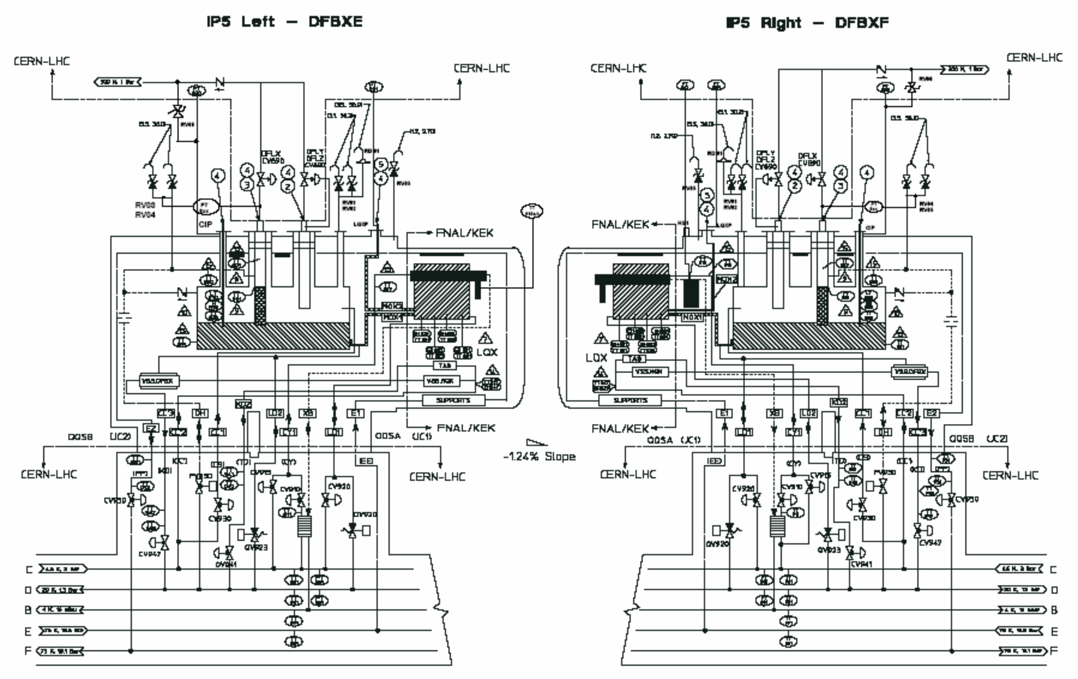

Figure 2 Cryogenic flow-scheme and instrumentation of the DFBX type electrical distribution boxes on either side of IP5 with a warm dipole connection.

All DFBXs have an actively cooled 70 K thermal screen. The lower part of the DFBX current leads and busbar bundles are in a saturated liquid helium bath which has liquid level regulation. The upper, resistive part of the HTS leads is cooled by gaseous helium at a temperature below or equal to 20 K. Liquid for the saturated helium bath is taken from QRL header C, and vapour is returned to a collector which connects QRL header D to the 20 K gaseous helium inlet of the HTS leads. A check valve is placed between this collector and the saturated liquid bath to prevent high temperature gas inadvertently entering the liquid bath space. The 20 K helium supply for the resistive part of the HTS leads consists of the bath evaporation complemented with helium from QRL header D. The helium is returned at ambient temperature to the warm recovery line. These flows are controlled at ambient temperature by lead specific valves. To protect the DFBXs from overpressure from header D, a pressure controlled shut-off valve is placed in the connection to QRL header D. Protection from overpressure in the warm recovery line is provided by a check valve. Protection from pressure differences over the control valve in excess of 50 kPa (500 mbar) is provided by a pressure control valve in the warm recovery line connection. Discharge of any helium contained in enclosed DFBX spaces will be into the LHC tunnel. In the event of a failing header D pressure shut-off valve, the flow rate from header D into the tunnel and the DFBX pressure build up are restricted by design of the connecting piping.

The pressure in the current leads hydraulic circuits (20 K and 4.5 K circuit) should never exceed 0.35 MPa.

3.3 THE CURRENT LEADS

The general descriptions of the current leads, cryogenic cooling circuit verification, and voltage signal verification contained in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

4. QUALITY ASSURANCE

The quality assurance statements contained in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning. All tests, checks, and controls will be recorded, documented, and communicated to all concerned.

5. ASSEMBLY AND INSTALLATION

The groups involved in assembly and installation of the DFBXs are the same as those listed in LHC-DFB-HCP-0001, except for the U.S. collaboration.

6. TESTS AT THE SURFACE

Surface tests consisting of leak checks, pressure tests, system purging, and warm high voltage tests described in LHC-DFB-HCP-0001 are fully applicable to the DFBX.

7. THE PHASES

The phases of DFBX commissioning will coincide with the commissioning phases of the other DFB boxes as described in LHC-DFB-HCP-0001.

8. WARM TESTS

8.1 WARM TESTS ON THE CURRENT LEADS

The following tests and checks shall be made:

- Verify that the G-10 surfaces of the 7.5 kA HTS power leads have been properly coated with silicone and polyurethane to prevent moisture-related problems. See Appendix II [5]. Materials will be procured by the U.S. collaboration. The coatings will be applied by a CERN technician under the direction of the U.S. collaboration.
- Leak test the 20 K (HTS leads) and 4.5 K (conventional leads) hydraulic circuits. This will be completed as part of the sector pressure test carried out by the AT-ACR group.
- Check that temperature sensors to each lead are connected to the appropriate control circuits. This will be completed as part of the instrumentation verification.
- Check that Pt 100 thermometers TT891A (HTS warm terminal) and TT893 (current lead flag) read room temperature. A third, inactive Pt 100 sensor is located at the HTS warm terminal. A fourth Pt sensor, located in the copper section, is also inactive and is not expected to be used. A thermocouple is located at the flag cartridge heater, but a remote readout is not provided. The locations of the Pt sensors and thermocouple are shown in Figure 3. This step will be completed as part of the instrumentation verification.
- Check that voltage taps used for interlocks are connected to the correct circuits. This will be completed as part of the ELQA.
- Tune the lead flag heater circuit with a 315 K setpoint to provide a cross-reference point between the flag Pt sensor and the cartridge heater thermocouple. This will be completed by the AT/MEL group and the U.S. collaboration.
- Check that all local lead head heaters are connected and working with their control signal. Verify continuity of their power and instrumentation

(thermocouples) cables. Fix and verify the set-point of each control system. This will be completed as part of the ELQA.

- When connecting or disconnecting the warm power cables from the HTS power leads, the six nuts on the underside of each HTS lead mounting flange must be hand-tightened. These nuts must then be backed down at least 1 mm prior to cooldown.
- Pump out the insulating vacuum of each HTS power lead. This will be completed by the AT/VAC group.

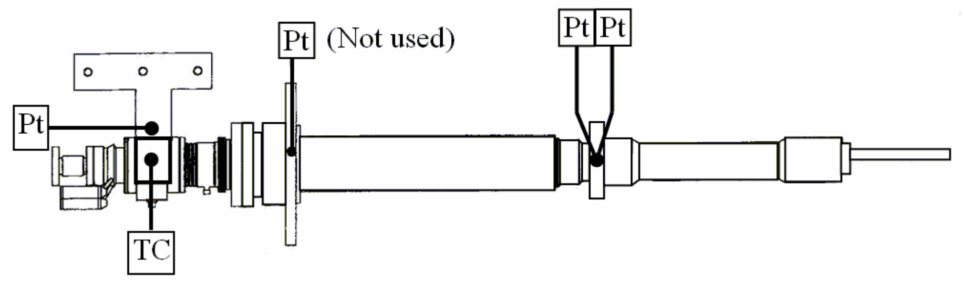

Figure 3 DFBX HTS current lead temperature sensor locations.

8.2 THE CRYOGENIC INSTRUMENTATION

The description of the cryogenic instrumentation system and its required warm tests as described in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

8.3 THE QUENCH PROTECTION SYSTEM AT WARM

The description of the quench protection system and its required warm tests as described in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

8.4 GENERAL, INTERMEDIATE LEAK TESTS, PUMP DOWN, GLOBAL LEAK AND PRESSURE TEST

Intermediate leak test

As stated in LHC-DFB-HCP-0001, intermediate leak tests are performed on DFBX installation in-situ welds.

Pump down & vacuum vessel leak test

Pump down of a DFBX insulating vacuum can begin once installation of the associated inner triplet and D1 dipole (at IR2 and IR8) are completed. The vacuum is pumped out using portable vacuum pump systems. The leak check is performed by attaching a leak detector to the portable vacuum pump system. Helium pockets are then placed around potential leak sites, such as seals. The minimum expected time to complete this operation on a DFBX and the associated magnets is 7 days to pump out the vacuum and 2 days for leak-checking. The pumpdown and leak-checking are the responsibility of the AT/VAC group.

Global leak and pressure test

The global leak and pressure test as described in LHC-DFB-HCP-0001 is fully applicable to the DFBX commissioning. Like the other DFBs, the DFBXs have a relatively low maximum allowable working pressure which will need to be respected during the global pressure test.

Safety valves protecting the power leads and the helium vessel are tested and certified for operation as all other safety devices of the cryogenic system by SC. This is done before the cooldown and after the pressure test. Then every two years all the safety devices are re-tested and re-certified at the premises of SC. No in situ testing is accepted at the moment by SC.

Mechanical and functional verification of the DFBX and components

Requirements for personnel and equipment involvement during the leak and pressure tests as described in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

8.5 ELECTRICAL QUALITY ASSURANCE AT WARM

The description of the electrical quality assurance at warm and its required tests as described in LHC-DFB-HCP-0001 are fully applicable. It should be stressed that this must include the current lead tests specified in *8.1 Warm Tests on the Current Leads*.

8.6 CONDITIONING AND FLUSHING OF ALL PROCESS LINES

All helium process lines shall be purged to prevent contamination issues during cool down and cold operation. This is performed for the whole cryogenic system at once when all process line are closed and is described in the cryogenic system general commissioning document.

8.7 VERIFICATION OF THE SAFETY VALVES PROTECTING THE CURRENT LEADS

On DFBX-G, it shall be verified that the Circle Seal relief valves have been replaced.

8.8 VERIFICATION OF THE SAFETY VALVE PROTECTING THE HELIUM VESSEL

On DFBX-G, it shall be verified that the Kunkle relief valves and associated manifolding have been installed.

9. COOL DOWN

The general cryogenics commissioning documents cited in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

As part of the general procedure for the commissioning of the LHC cryogenic system this section describes the sequence of step and procedures which lead to the commissioning of the DFBX units. The overall cryogenic system is described in detail in [6-7]. The commissioning will be performed together with the whole cryogenic system as the refrigerators and distribution systems are common. Cryogenic commissioning starts once all process lines have been closed, leak and pressure tested.

The commissioning process will consist of several phases during which progressively all the instrumentation and components are tuned to control the required levels of temperature, pressure or flow. Prior to magnets powering some coarse tuning is performed using electrical heaters to simulate the dynamic heat loads on the helium bath. The coarse tuning of the current leads temperature is performed to obtain stability and in response of step changes in the set-point. In stand-by conditions (zero current, transient or stable cryogenic conditions) the temperature at the top of the HTS element of the HTS current leads should be maintained at 70 K and the mass flow through the conventional current leads should be maintained at the recommended values, which will be presented in section 9.1. Final verification and fine tuning is performed in parallel with the powering phase at progressively increasing current levels.

The DFBX commissioning will be performed in parallel with the whole cryogenic system commissioning and will therefore be terminated after 8 weeks (10 weeks for the first sector).

The person responsible for the cryogenic commissioning is the AT-ACR-op operation engineer in charge. He will manage the commissioning of the associated cryogenic system. He will take into account the procedures established on the basis of the documentation given by the equipment responsible.

9.1 CONDITIONS REQUIRED TO START AND DURING THE COOL DOWN

Conditions required during cooldown as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

9.2 COOL DOWN: PART 1 (COOL DOWN FROM 300 K)

Cool down of the helium vessel and the current leads together with the sector cryogenic system (i.e., magnets) once the pressure in line D is below 2 bar.

The cooldown monitoring checks as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning. These checks are:

1. Monitor the DFBX insulating vacuum. Stop, warm up, and repair in case of failure.
2. Monitor pressure. Stop, analyze, and repair in case of anomaly.
3. Check the current lead temperature readings for plausibility.
4. Check that every lead is correctly identified at the level of the cryogenic control system.
5. Verify that the lead flag heater system is functioning properly. Verify correspondence between the setpoint and the measured temperature. In addition, the lead flag Pt sensor and the cartridge heater thermocouple readings should be compared and the control loop retuned as necessary.
6. The temperature at the HTS warm terminal should be brought to its nominal standby value of 70 K.
7. Nominal cooldown flows, as specified in Table 1, should be established in each of the DFBX conventional current lead clusters.
8. Record the mass flows in all current leads. This is especially important for the HTS leads, which have never been tested at 70 K.
9. Check for cold spots on the DFBX vacuum vessel, indicating thermal insulation gaps. Use a thermal sensitive camera.

The commissioning of the current leads requires participation of Fermilab personnel Sandor Feher and Roger Rabehl during *8.1 Warm Tests on the Current Leads* and *9.2 Cool Down:Part 1*. Also, during the cool-down there must be trained AT/MEL technicians or US personnel continuously present in the vicinity of the DFBXs under test, in contact with operators. These technicians should have access to the current leads and current lead ancillary equipment.

During cool-down and in stand-by operation (zero current), the recommended mass flow rates to cool the conventional power leads are given in Table 1. These values are

60% [8] of the recommended full-current values [9]. No flowmeter is available to measure this flow. A mass flow will be inferred by computation of valve opening and pressure drop with an accuracy of no better than 30 %.

Table 1 Recommended cooldown and stand-by flow rates for the DFBX conventional current leads.

Lead Assembly	Cooldown & Stand-by Mass Flow Rate Per Lead [g/s]
120 A – 10 lead assembly, DFLZ	0.009
600 A – 6 lead assembly, DFLY	0.028
600 A – 2 lead assembly, DFLY	0.038

Electrical quality assurance during cool down

The remarks regarding ELQA as written in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

Mechanical and functional verification of the DFBX and components

The remarks regarding mechanical and functional verification of the DFBX and its components as written in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

Calibration of cryogenic instrumentation

The remarks regarding calibration of cryogenic instrumentation as written in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

Filling the DFBX helium vessel with liquid helium with current leads at operating temperature

The remarks regarding filling the helium vessel in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

9.3 COOL DOWN: PART 2 (COLD OPERATION)

Cryogenics

1. The cold operation tasks as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning. These tasks are:
2. Tuning and validation of the cryogenic system
3. Tuning of cryogenic cooling loops
4. Check the operational parameters (levels, flows, temperatures)
5. Verify the process and recovery procedures after non-nominal conditions and transients
6. Monitor liquid helium level using the level gauges. If oscillations occur, retune the control loop
7. Keep the system under steady conditions for at least 2 hours with a 70 K warm terminal temperature on the HTS leads.
8. Verify proper operation of the HTS lead flag heater system. Retune the control loop, if necessary.
9. Monitor current lead chimneys for condensation or ice.

10. Check for cold spots on the DFBX vacuum vessel. Use a thermal sensitive camera.
11. Measure and record the DFBX helium vessel boil-off rate at zero current.
12. Measure and record the mass flow through each HTS current lead at 70 K standby mode.
13. Achieve nominal operation and "CRYO-START" permissive for powering.

Electrical quality assurance at cold

The ELQA tasks at cold as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

Individual system tests of the quench protection system at cold

The quench protection system tasks at cold as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

10. POWERING TESTS

10.1 POWERING TESTS: PART 1 (POWERING CONDITIONS)

Connection of the cables to the current leads

In addition to the tasks specified in LHC-DFB-HCP-0001, it is recommended to use metal foil or conductive grease to ensure a low-resistance joint between the power cable and the current lead. While connecting the warm power cables, the six nuts on the underside of each DFBX HTS current lead mounting flange must be hand-tightened. The nuts can be loosened once this work is complete.

Interlock tests after connection of power cables (HCA:PIC2)

The interlock tests as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

Lower the temperature at the top of the HTS to 50 K

The cold operation tasks as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning. These tasks include:

- After controlling for a few hours to ensure steady operation with the leads in standby condition (i.e., 70 K at the HTS warm terminal), change the HTS warm terminal temperature to 50 K.
- Monitor the DFBX liquid helium level under these changed conditions. If oscillations are present, retune the control loop to prevent LTS quenches.
- Record the calculated cooling flow required by each HTS power lead to maintain a 50 K HTS terminal with zero current.
- Record the calculated boil-off rate of the DFBX at zero current.
- As a reference, recommended full-power flow rates for the DFBX resistive currents leads are listed in Table 2 [10].

Table 2 Recommended full current flow rates for the DFBX conventional current leads.

Lead Assembly	Full Current Mass Flow Rate Per Lead [g/s]
120 A – 10 lead assembly, DFLZ	0.015
600 A – 6 lead assembly, DFLY	0.047
600 A – 2 lead assembly, DFLY	0.064

The commissioning of the current leads requires that during the whole powering exercise of a DFBX there must be trained technicians continuously present in the vicinity of the DFBX, in contact with cryo and power converter operators.

10.2 POWERING TESTS: PART 2 (SUBSYSTEM POWERING)

Powering individually or by groups of the superconducting circuits

The first time a superconducting circuit is powered, special attention must be devoted to the cooling control of the current leads and to the detection of bad splices slowly heating at low currents. This mainly concerns the new interconnections which were carried out during installation and have therefore never been tested (e.g., the one inside the DFBX). This effect is difficult to detect because no dedicated instrumentation is available on each side of the splices.

The temperatures at the HTS lead flags must also be monitored for signs of a high resistance connection between the power cable and the current lead flag. A high resistance will be indicated by a steadily rising lead flag temperature with no input from the heater circuit.

Whenever the current in a circuit is increased beyond a previously tested value:

1. During ramp and a flat top, monitor the liquid helium level for oscillations and proper control at the setpoint.
2. Monitor the mass flows of the current leads. Verify that the mass flows increase with the increased current according to expected values.
3. Verify that the voltage drop of the resistive parts of the current leads increases with the increased current according to expected values.
4. Check the superconducting state of the HTS and LTS parts of the leads.
5. Monitor the HTS lead temperatures and compare with the 50 K setpoint.
6. Monitor the lead flag heating system. Verify that the relative readings between the Pt sensor and the thermocouple are as expected.
7. Monitor current lead chimneys for condensation or ice.
8. During ramp, measure all current lead signals (temperatures, voltages, and helium flows). At flat top, measure all current lead signals for at least one hour.
9. Check for stability.

Tuning of the cryogenic control loops

The cryogenic control loop tuning tasks as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

Tuning of the cryogenic quench recovery procedure

The cryogenic quench recovery procedure tasks as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

Loss of coolant test

Each of the HTS power leads has undergone a loss of coolant test at full power. The leads are now installed in a different thermal environment with a new quench protection system. The loss of coolant test will therefore be repeated for each lead before being operated at full power. With the HTS warm terminal maintained at the nominal operating temperature of 50 K, ramp the current to 3000 A. Shut off the lead flow through one lead, and monitor the lead voltages until a voltage threshold is exceeded and the quench detection system shuts down the power supply. Repeat this for every DFBX HTS lead.

10.3 POWERING TESTS: PART 3 (FULL SYSTEM POWERING)

Powering of all the circuits of a DFBX in unison

The comments regarding the final, full powering of all DFBX circuit as written in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

Tuning of the cryogenic control loops

The cryogenic control loop tuning tasks as specified in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

10.4 CONDITIONS AFTER THE POWERING TESTS

The comments regarding the system conditions after commissioning is concluded as written in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

11. SAFETY

The safety comments related to leak and pressure tests, cryogenics, electricity, personnel safety, safety panels and signs, and tunnel access as written in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning

12. DOCUMENTATION IN MTF

The working groups responsible for hardware commissioning activities and individual system tests (ISTs) as written in LHC-DFB-HCP-0001 are fully applicable to the DFBX commissioning.

13. CONCLUSIONS

This document presents the steps unique to the DFBX electrical distribution boxes to successfully commission these components in parallel with the other components of an LHC sector.

14. REFERENCES

[1] 7500 A Current Leads Using High Temperature Superconductor for the LHC Inner Triplet Magnets, LBL #M923B,

http://www-eng.lbl.gov/~uslhc/RETRIEVE/DFBX/Documents/M923B-1.pdf

[2] 600 A and 120 A Vapor Cooled Current Lead Assemblies for the LHC Interaction Region Feedboxes (DFBX), LBL Specification M981A, http://www-eng.lbl.gov/~uslhc/RETRIEVE/DFBX/Documents/M981A.pdf

[3] DFBX IP2 Flow Schematics, LBL Dwg. 25H4096 Rev. B, CERN CDD LHCDFBX_0044

[4] DFBX IP5 Flow Schematics, LBL Dwg. 25H4116 Rev. B, CERN CDD LHCDFBX_0046

[5] Tevatron H Spool (TSHH) High Temperature Leads Assembly Power Lead Assembly, Fermilab #5520-TR-333695.

[6] The Process of the Cryogenic System for LHC Functional Analysis, LHC-Q-ES-0003, EDMS No. 710797.

[7] The Circuits of the Cryogenic System of the LHC, LHC-Q-ES-0004, EDMS No. 710799.

[8] American Magnetics Incorporated, Oak Ridge, TN, USA. Product literature.

[9] Vendor Test Data; Operational Recommendations, LBL Engineering Note M8211.

Appendix I: Locations of the DFBXs

Table I-1: List of the DFBXs

IR	Equip. Code	Current leads			N chimneys	Notes
		7.5 kA	600 A	120 A		
IR1 Left	DFBXA	4	14	10	8	
IR1 Right	DFBXB	4	14	10	8	
IR2 Left	DFBXC	6	14	10	10	Same configuration as DFBXG
IR2 Right	DFBXD	6	14	10	10	Same configuration as DFBXH
IR5 Left	DFBXE	4	14	10	8	
IR5 Right	DFBXF	4	14	10	8	
IR8 Left	DFBXG	6	14	10	10	Same configuration as DFBXC
IR8 Right	DFBXH	6	14	10	10	Same configuration as DFBXD
TOTAL		40	112	80	72	

Appendix II: DFLX Power Lead Conformal Coatings In-Situ Application Guide

1. Clean and de-grease the surface of the areas to be coated (G-10 and Ceramic) with Alcohol or Acetone. These areas are the upper ceramic insulator, the lower G-10 insulator, and the neighboring stainless steel surfaces.
2. Mix the two components of Conathane CE-1155 as per the chart below. Please refer to the Conathane CE-1155 technical data sheet for further information regarding this product.

Component	Part	Recommended	Lot #	Amount used
Part A	**100 parts**	**40 g**		
Part B	**70 parts**	**28 g**		

3. With an acid brush or heavy artist brush apply CE-1155 to all of the desired surfaces of the Power Lead. A maximum coating at any one given application should not exceed 0.05 mm to 0.06 mm of wet film thickness. If more than one coat is desired, allow 2 hours drying time at room temperature before applying subsequent coats.
4. After A 7 Day cure time of the CE-1155 at room temperature, apply Si-coat 570 to all external surfaces that has been previously coated with CE-1155. An acid brush or heavy artist brush may used for application also. If applied by brush, a 0.25 mm to 0.38 mm coating thickness can achieved and is desirable. Subsequent coats can be

applied when the surface coat has become tacky. The total Si-coat 570 coating thickness should be in the range of 0.38 mm to 0.5 mm, to a maximum of 1.3 mm. Please refer to the Si-coat 570 technical data sheet for further information regarding this product.

5. It is recommended to allow a 7-day cure of the Si-coat 570 before hi-potting.