DFX Functional Specification

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31 Jan. 2019

Conceptual design review of the DFX

DFX in Cold Powering System

Each IP1 and IP5 sides equipped with a cold powering chains of cryostats

- Triplet insertion : DFHx – SC Link (DSH) – **DFX**

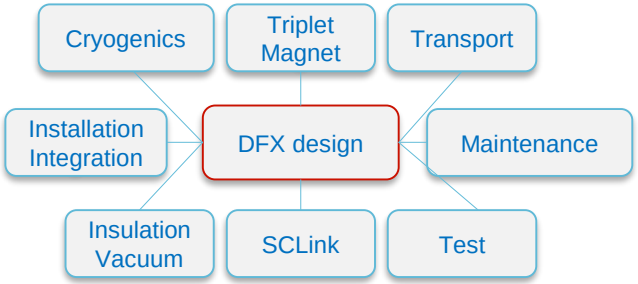
DFX basic functions:

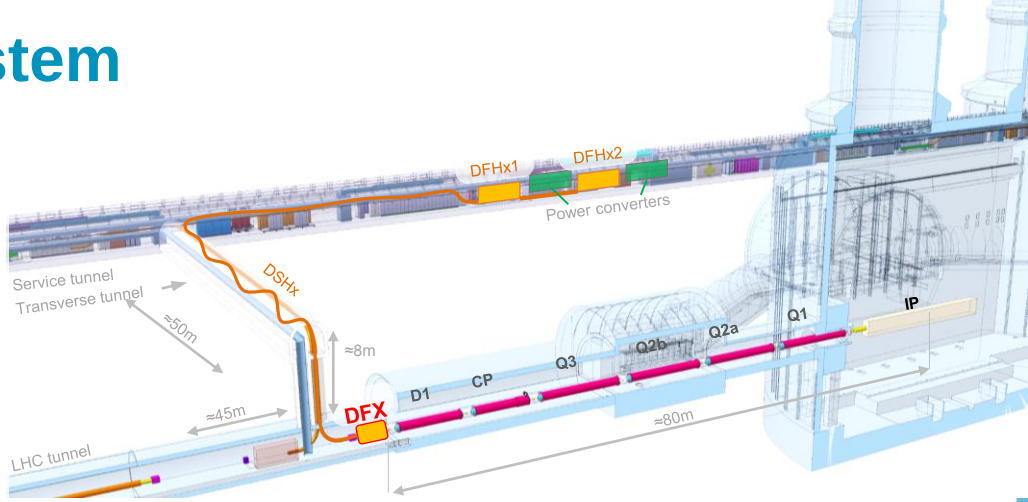
- Electrical interface between SC Link and superconducting magnets
- Supply cryogenics to the SCLink

System Interfaces

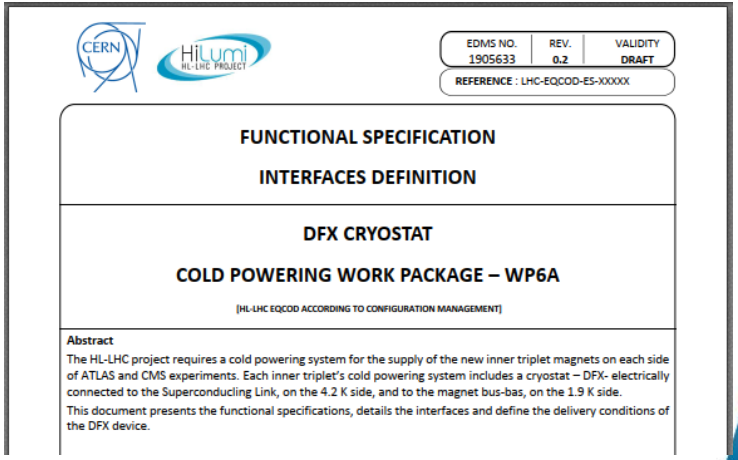
DFX functional specification and interface definition EDMS1905633

DF system interfaces





DFX functional specification EDMS 1905633



EDMS NO. 1905633 | REV. 0.2 | VALIDITY DRAFT

REFERENCE : LHC-EQCOD-ES-XXXXX

FUNCTIONAL SPECIFICATION

INTERFACES DEFINITION

DFX CRYOSTAT

COLD POWERING WORK PACKAGE – WP6A

[HL-LHC EQCOD ACCORDING TO CONFIGURATION MANAGEMENT]

Abstract

The HL-LHC project requires a cold powering system for the supply of the new inner triplet magnets on each side of ATLAS and CMS experiments. Each inner triplet's cold powering system includes a cryostat – DFX- electrically connected to the Superconducting Link, on the 4.2 K side, and to the magnet bus-bas, on the 1.9 K side.

This document presents the functional specifications, details the interfaces and define the delivery conditions of the DFX device.

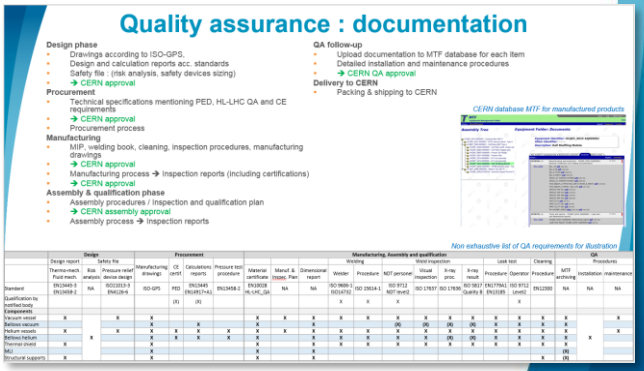
General requirements

- DFX installed in LHC machine
  - ➔ Comply with CERN rules
    - CERN Safety Rules
    - GSI-M-4 - Cryogenic equipment :

GSI-M4: “The manufacture […] by collaborating institutions, of all new cryogenic equipment shall comply with the applicable CERN Safety Rules, European directives and harmonised standards”.

  - ➔ European directives
    - Pressure Equipment Directive 2014-68-EU
  - ➔ HL-LHC QA requirements
    - ALARA principle
    - Material requirements
    - Documentation & MTF

HL-LHC documentation requirements
Details in spare slide

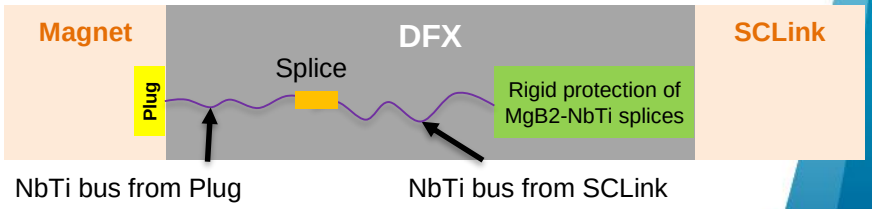


Electrical main specifications

- DFX shall ensure the electrical connectivity between the SCLink and triplet cables
- SCLink cables layout:
  - MgB2 bus bars of the SCLink are pre-soldered to NbTi extentions
  - MgB2-NbTi splices are protected
  - Only NbTi extensions are accessible
- Magnet cables layout:
  - NbTi bus bars
- Details on bus bars and layouts are presented in the “Bus bars” and “Plug” talks

- The NbTi extensions shall be routed and connected to the NbTi bus coming out of from the plug (see dedicated talk for details)

- Instrumentation shall be routed to feedthroughs on the vacuum vessel interface

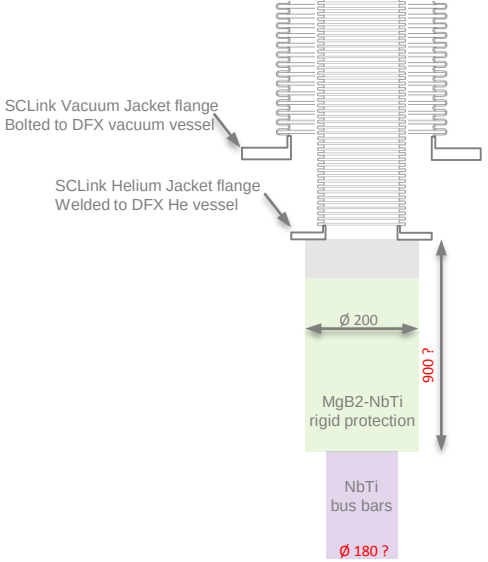


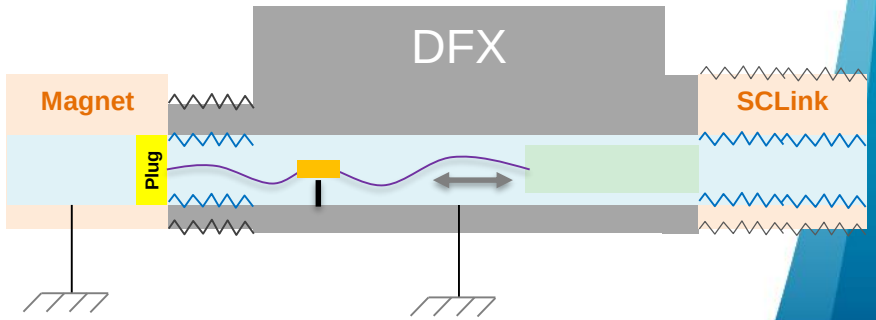
Mechanical interfaces

- SCLink mechanical interface
  - Vacuum & helium jacket flanges fixed to DFX
  - MgB2-NbTi splices contained in rigid protection
  - Only NbTi extensions access the DFX He volume

- Magnet mechanical interface
  - Plug fixed to ground
  - DFX fixed to He/vacuum interfaces with bellows
  - Access to NbTi-NbTi splices granted during installation and maintenance

- Cables thermal contractions
  - NbTi-NbTi splices fixed to DFX He vessel
  - DFX covers internal contractions
  - DFX shall allow NbTi bus bars displacement





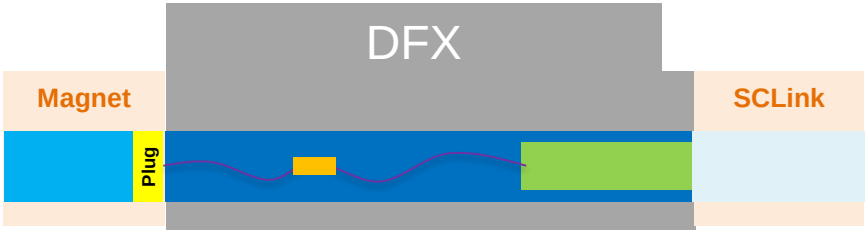
Cryogenics requirements

- Dedicated presentations on:
  - Cryogenic flow scheme
  - Interface with Cryogenic equipment
  - Operation boundaries
  - Hardware & instrumentation
  - Safety

- DFX cryogenic principles
  - NbTi cables & MgB2-NbTi splices shall be immersed in liquid helium
  - The DFX shall produce up to 10 $g.s^{-1}$ gaseous helium mass flow to the SCLink helium volume

- Cryogenic instrumentation shall be routed to the vacuum vessel interface

- Access to valves and instrumentation shall be granted for inspection and maintenance



DFX functional specification

Table 2: Cryogenic parameters and equipment design pressures [9]

Description	Ref:	Inlet outlet	DN [mm]	Fluid	Nominal pressure [bara]	Design pressure [bara]	Temperature range [K]
Inlet Liquid helium	CS	From line C	DN12 TBC	Mix liquid-gas helium	1.3	3.5	[4.5;300]
Return gas helium for transient phases	SD	To line D	DN40 TBC	Gaseous helium	1.3	3.5	[4.5;300]
DFX helium volume	S	From line CS To DSHx	TBD	Saturated liquid helium bath	1.3	3.5	[4.5;300]
Outlet thermal shield	E'_HF_{H2}	From D1 side To DFX jumper	TBD	Gaseous helium	24	25	[60;300]
Inlet coil warm up	TBD	From E'_HF_H	DN4	Gaseous helium	24	25	[40;300]
Outlet coil warm up	TBD	To jumper	DN4	Gaseous helium	24	25	[40;300]

Insulation vacuum

- The DFX insulation vacuum shall be compatible with the General WP6a insulation vacuum layout EDMS 2048016
- The DFX insulation vacuum is independent to:
  - Allow local maintenance & leak detection
  - Minimise inter-dependence between helium volumes
- DFX presents vacuum barriers with:
  - The cryolines
  - The SCLink
  - The triplet cryostat
- Interfaces:
  - Standard type flanges with elastomer seal
  - Ports for pumps and instrumentation
  - Pressure relief plate

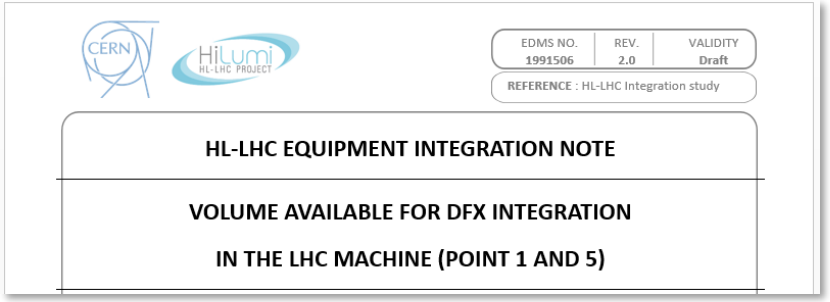
Table1 : Insulation vacuum requirements for WP6a components

Unit	Value
Insulation vacuum pressure level at ambient temperature	$< 1.10^{-4}$ mbar
Insulation vacuum pressure level in nominal operation	$< 1.10^{-5}$ mbar
Maximum allowed overall leak rate in nominal operation	$< 2.10^{-8}$ mbar.l.s^{-1}

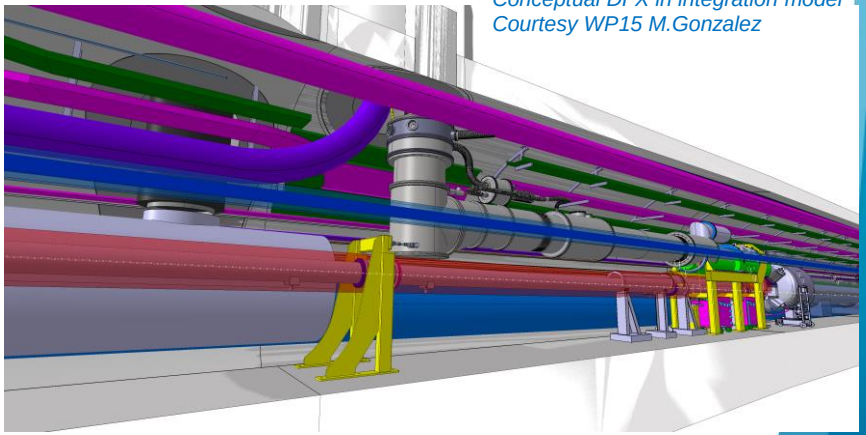
Integration specification

- Dedicated talk from HL-LHC WP15
  - Definition of volumes
  - Environment
  - Accessibility

EDMS 1991506



Conceptual DFX in integration model
Courtesy WP15 M.Gonzalez

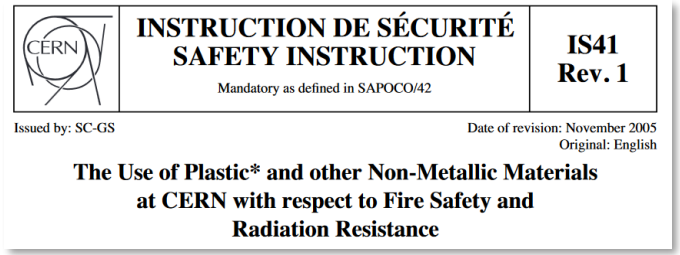


Maintainability

- Operations of maintenance shall be considered in the design from the ALARA point of view:
  - Inspections of the instrumentation interfaces;
  - Preventive maintenance of safety relief devices and vacuum equipment;
  - Replacement of the plug, heater, instrumentation devices;
  - Repair of Nb-Ti-Nb-Ti splices on the DFX side of the plug;
  - Repair of the MgB2-Nb-Ti splices in situ.

Manufacturing & Inspections

- Manufacturing & Inspections according to
  - Pressure Equipment Directive (PED)
  - HL-LHC QA requirements (see spec)
- Materials specific requirements:
  - Compatible with Dose level over HL-LHC project period:
  - Cobalt content for stainless steel < 0.1%
  - Polymers according to IS41 EDMS335806
- Inspections and certifications as for HL-LHC cryostat supplies
  - Welding and welders
  - Leak tightness level, procedure and operators
  - Pressure testing according to PED
  - COLD TEST ?
- Documentation
  - Manufacturing procedures & qualifications
  - Inspection reports
  - CE certification
  - Upload into CERN database MTF


INSTRUCTION DE SÉCURITÉ
SAFETY INSTRUCTION
Mandatory as defined in SAPOCO/42
IS41
Rev. 1
Issued by: SC-GS
Date of revision: November 2005
Original: English
The Use of Plastic* and other Non-Metallic Materials at CERN with respect to Fire Safety and Radiation Resistance

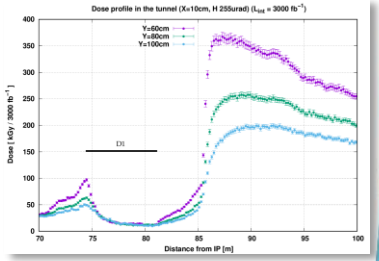
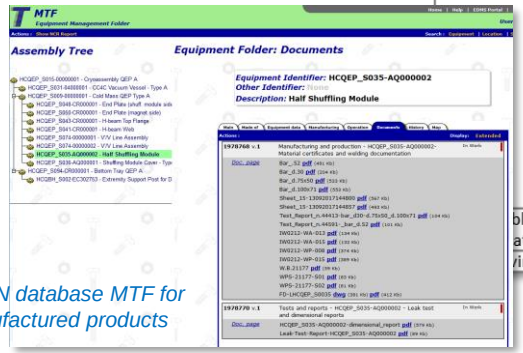


Table 4: Documentation

Phase	Requirements
Design	- Specification drawings according to ISO-GPS; - Design and calculation reports according to applicable standards; - Safety file as defined in [2];
Procurement	- Technical specifications with certification requirements;
Manufacturing	- Manufacturing drawings to ISO-GPS standards; - Manufacturing and Inspection plan; - Welding book - Welder certifications (ISO9606-1) - Weld qualification (ISO 15614-1) - Welds visual and radiographic inspection reports (ISO 17637, ISO 17636-1) - NDT operator certification (ISO 9712 NDT level2) - Cleaning procedure and reports - Pressure test procedure and reports - Leak test procedure, report, personnel certification (ISO 9712); - Dimensional control reports;
bly & ation	- Assembly and maintenance procedures; - CE certification;
ing	- Archiving of all documentation in MTF, CERN database;



CERN database MTF for manufactured products

Spare slides

Quality assurance : documentation

Design phase
- Drawings according to ISO-GPS,
- Design and calculation reports acc. standards
- Safety file : (risk analysis, safety devices sizing)
- ➔ CERN approval

Procurement
- Technical specifications mentioning PED, HL-LHC QA and CE requirements
- ➔ CERN approval
- Procurement process

Manufacturing
- MIP, welding book, cleaning, inspection procedures, manufacturing drawings
- ➔ CERN approval
- Manufacturing process ➔ Inspection reports (including certifications)
- ➔ CERN approval

Assembly & qualification phase
- Assembly procedures / Inspection and qualification plan
- ➔ CERN assembly approval
- Assembly process ➔ Inspection reports

QA follow-up
- Upload documentation to MTF database for each item
- Detailed installation and maintenance procedures
- ➔ CERN QA approval

Delivery to CERN
- Packing & shipping to CERN

CERN database MTF for manufactured products

Non exhaustive list of QA requirements for illustration

	Design			Procurement				Manufacturing, Assembly and qualification												QA		
	Design report	Safety file									Welding		Weld inspection				Leak test		Cleaning		Procedures	
	Thermo-mech. Fluid mech.	Risk analysis	Pressure relief device design	Manufacturing drawings	CE certif.	Calculations reports	Pressure test procedure	Material certificate	Manuf. & Inspec. Plan	Dimensional report	Welder	Procedure	NDT personel	Visual inspection	X-ray proc.	X-ray result	Procedure	Operator	Procedure	MTF archiving	Installation	maintenance
Standard	EN13445-3 EN13458-2	NA	ISO21013-3 EN4126-6	ISO-GPS	PED	EN13445 EN14917+A1	EN13458-2	EN10028 HL-LHC_QA	NA	NA	ISO 9606-1 ISO14732	ISO 15614-1	ISO 9712 NDT level2	ISO 17637	ISO 17636	ISO 5817 Quality B	EN1779A1 EN13185	ISO 9712 Level2	EN12300	NA	NA	NA
Qualification by notified body					(X)	(X)					X	X	X					X				
Components																						
Vacuum vessel	X		X	X				X	X	X	X	X	X	X	X	X	X	X	X	X		X
Bellows vacuum				X		X		X		X			(X)	(X)	(X)	(X)	X	X	X	X		
Helium vessels	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Bellows helium		X		X	X	X	X	X		X	X	X	X	X	(X)	(X)	X	X	X	X	X	
Thermal shield	X			X				X		X	X	X	X	X	X	X	X	X	X	X		
MLI				X				X		X										(X)		
Structural supports	X			X				X		X									X	(X)		

Cold powering system basic principle