HiLumi HL-LHC PROJECT

Subcooling HEX Contract Kick Off Meeting

Specification review / feedback on the production of the 1st HEX batch

V. Gahier

CERN, 06/10/2023

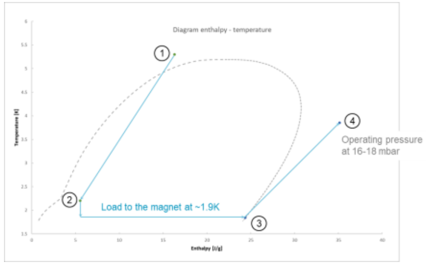
Outline

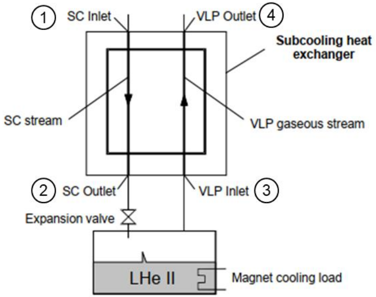
- CERN requirements
- Documentation and planning delivery
- Feedback related to the first order

Function of the sub-cooling heat exchangers

- Helium sub-cooling heat exchangers are used to minimize the helium vapour fraction produced in the final expansion of the 1.9 K loop :

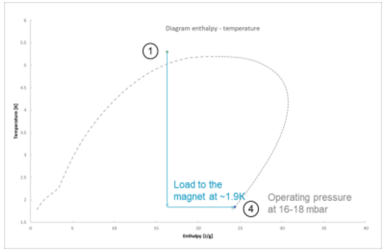
With sub-cooling heat exchanger

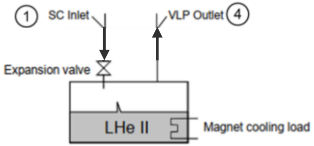




~80% of useful liquid produced

Without sub-cooling heat exchanger





~50% of useful liquid produced

- For a given heat load at the magnet level at 1.9 K, the circulating helium flow is decreased thanks to the sub-cooling heat exchanger and increasing the global efficiency of the system.

HL-LHC P1/P5 Cryogenic architecture

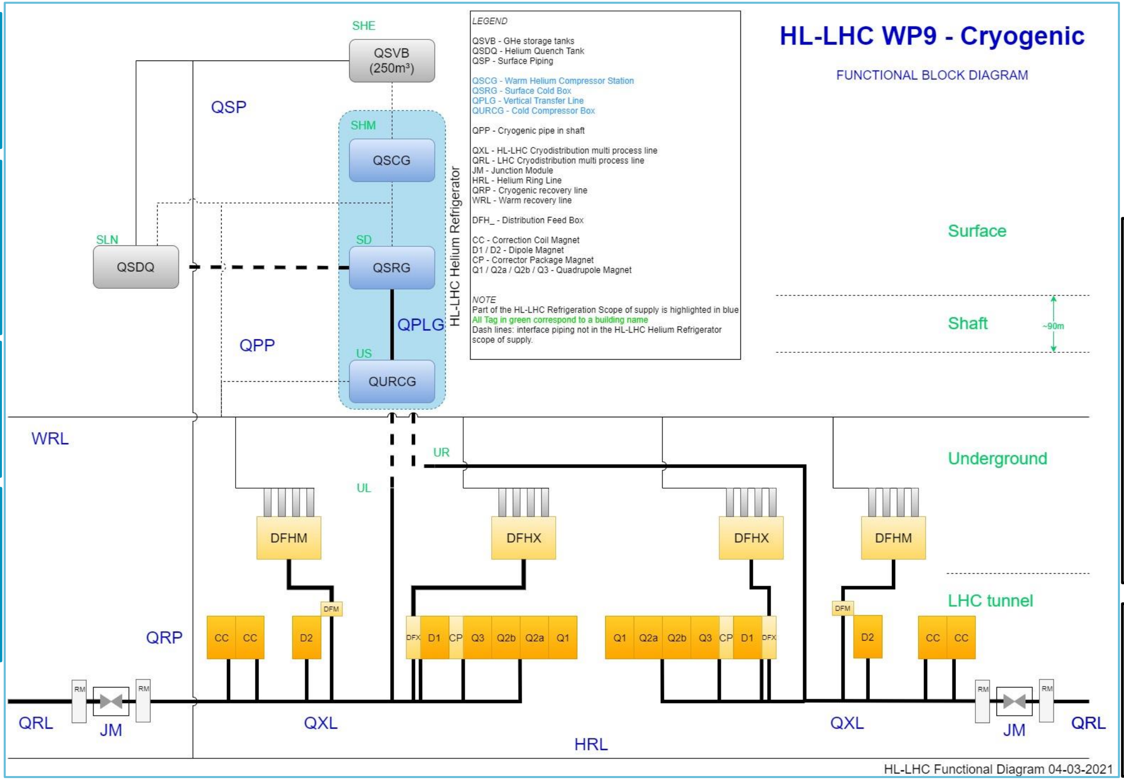
QSRG : Compressor station providing gaseous helium **20 B**

QSRG : 4.5K refrigerator providing supercritical helium at **3 bara and 4.6 K**

QPLG : Vertical transfer line (~100 m height)

QURCG : Cold compressor box providing cooling capacity at **1.8 K**

Users at tunnel level

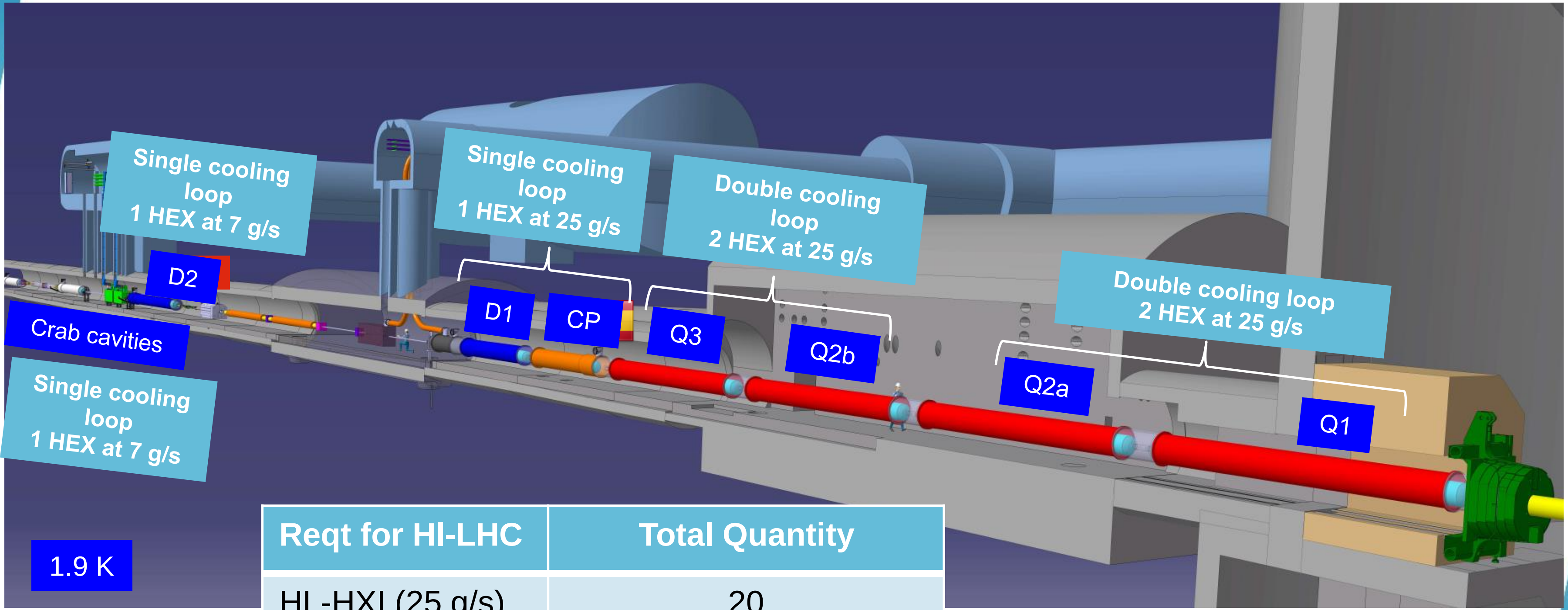


QXL : Distribution line distributing C,E and returning B,D,F

- 70 m for the common branch
- 270 m for the long branch
- 60 m for the short branch

RM/JM : Return module and junction module at extremities for transient handling and back-up

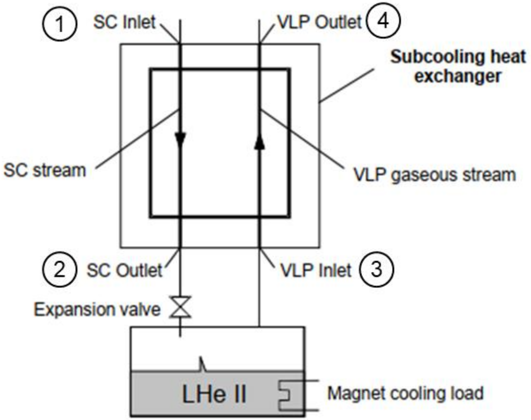
Reminder : What needs to be cooled at 1.9 K



Reqt for HI-LHC	Total Quantity
HL-HXI (25 g/s)	20
HXD (7 g/s)	12

Objectives of the Requirement/Project

- **Quality**
  - Counter flow helium heat exchanger operating in superfluid helium conditions integrated in an insulated vacuum.
  - Shall be compact due to integration constraints.
  - Pressure drop on the VLP circuit at 1 mbar is crucial in order to operate the magnet heat exchanger at a temperature lower than 1.9 K.
  - Material Special Reqt: the cobalt content for the Stainless Steel shall be as low as reasonably possible and in any case below 0.3% of mass.
- **Cost and Time**
  - Shall be available in due time for integration in the service modules of the Cryogenic distribution line (QXL).



7 g/s capacity heat exchanger

	circuit A (SC stream)	circuit B (VLP stream)
Type of fluid	Helium	Helium
Inlet temperature	4.6-5.3 K	Vapour saturated (1.8-1.9 K)
Outlet temperature	<2.2 K	3.2-3.9 K
Nominal flow	7 g/s	7 g/s
Reduced flow	1.3-7 g/s	1.3-7 g/s
Nominal pressure	2.3 – 4.2 bar a	0.0164- 0.023 bar a
Design pressure	20 bar a	4 bar a
Max Pressure drop	20 kPa	100 Pa

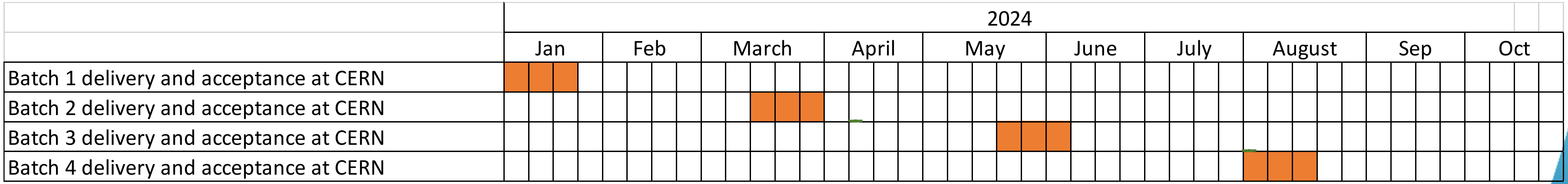
25 g/s capacity heat exchanger

	circuit A (SC stream)	circuit B (VLP stream)
Type of fluid	Helium	Helium
Inlet temperature	4.6-5.3 K	Vapour saturated (1.8-1.9 K)
Outlet temperature	<2.2 K	3.2-3.9 K
Nominal flow	25 g/s	25 g/s
Reduced flow	1.8-25 g/s	1.8-25 g/s
Nominal pressure	2.3 – 4.2 bar a	0.0164- 0.023 bar a
Design pressure	20 bar a	4 bar a
Max Pressure drop	20 kPa	100 Pa

Documentation / Delivery planning

- Required Documentation :
  - Timing plan for design, manufacturing testing;
  - Detailed design file;
  - Manufacturing and Inspection Plan;
  - Testing plan;
  - Templates used for reporting the results of the tests;
  - Material certificates and tests report at reception

- Delivery planning for the tendering contract



First batch order - CERN feedback

- ✓ First batch ordered in Dec 2022
  - ✓ 3 HXD;
  - ✓ 5 HL-HXI.
- ✓ Documentation received:
  - ✓ Detailed drawing and 3D model;
  - ✓ Welding book;
  - ✓ Thermal and mechanical CN;
  - ✓ Reception reports and material certificate.
- ✓ All the pieces received as per the defined planning.
- ✓ CERN visit during the production for intermediate inspection.

First batch order - CERN feedback Inspection report HXD

- Improved quality compared to the HXI batch received for the SQXL.

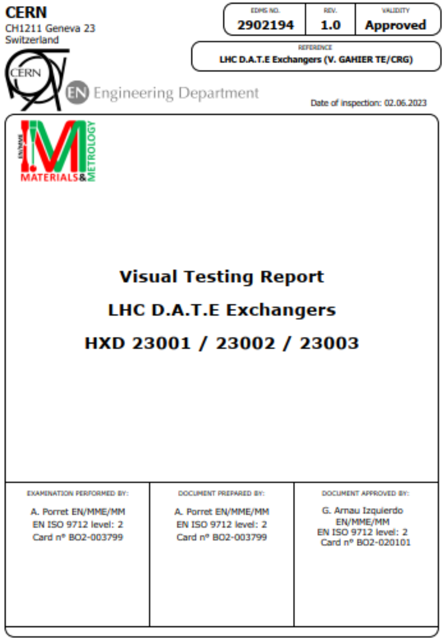
- HXD production lesson learnt:
  - Fiber present on the VLP circular weld
  - Lack of penetration on the SC inlet and outlet pipe not acceptable according to ISO 5817 level C.

- CERN shared recommendation on welding procedure of the SC inlet and outlet pipe.

- DATE took into consideration feedback and trained to improve quality.

→ Problem solved for HL-HXI !

- Repairs in progress in CERN central workshop.



CERN
CH1211 Geneva 23
Switzerland

EDMS NO.	REV.	VALIDITY
2902194	1.0	Approved

REFERENCE: LHC D.A.T.E Exchangers (V. GAHIER TE/CRG)

EN Engineering Department

Date of inspection: 02.06.2023

MATERIALS & METROLOGY

Visual Testing Report

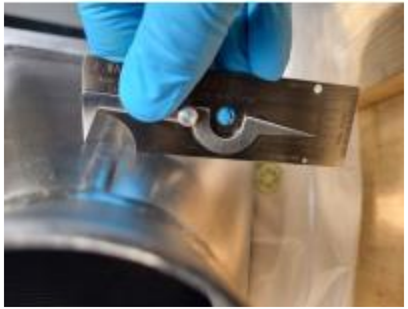
LHC D.A.T.E Exchangers

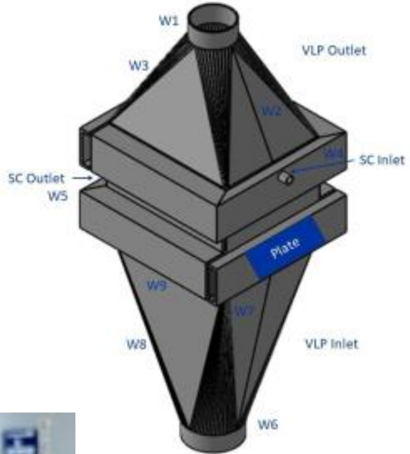
HXD 23001 / 23002 / 23003

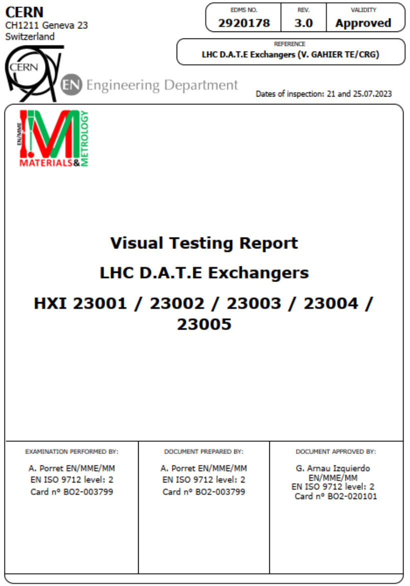
EXAMINATION PERFORMED BY:	DOCUMENT PREPARED BY:	DOCUMENT APPROVED BY:
A. Porret EN/MME/MM EN ISO 9712 level: 2 Card n° BO2-003799	A. Porret EN/MME/MM EN ISO 9712 level: 2 Card n° BO2-003799	G. Arnau Izquierdo EN/MME/MM EN ISO 9712 level: 2 Card n° BO2-020101

First batch order - CERN feedback Inspection report HXI

- High level of welding quality.
- Particularity of the HL-HXI : VLP diffusers of 5 mm thick
  - On 2 HXIs, Linear Misalignment (up to 3 mm) on the longitudinal weld.
  - Maximum limit allowed according to ISO 5817 level C is 0.75 mm.
- Two end crater pipe defaults found → Repair will be performed at CERN






CERN
CH1211 Geneva 23
Switzerland

EDMS NO.	REV.	VALIDITY
2920178	3.0	Approved

REFERENCE
LHC D.A.T.E Exchangers (V. GAHIER TE/CRG)

Engineering Department

Dates of inspection: 21 and 25.07.2023

MATERIALS & METROLOGY

Visual Testing Report

LHC D.A.T.E Exchangers

HXI 23001 / 23002 / 23003 / 23004 / 23005

EXAMINATION PERFORMED BY:	DOCUMENT PREPARED BY:	DOCUMENT APPROVED BY:
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HiLumi HL-LHC PROJECT

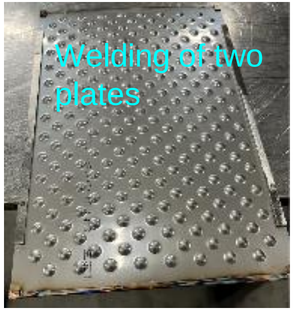
Conclusion

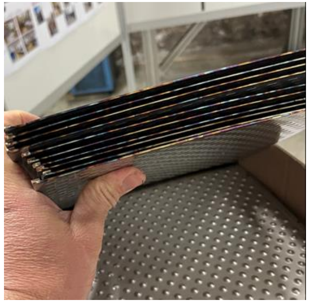
- Collaboration with DATE since LHC construction.

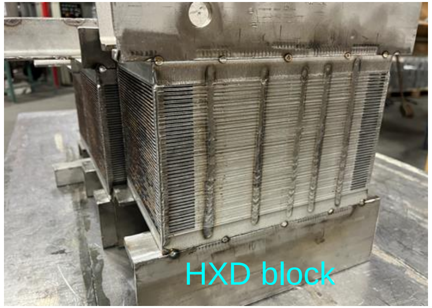
- First batch order allowed :
  - Matching CERN / DATE expectations in term of quality.
  - Establishing efficient communication between the teams.
  - Sharing the lesson learnt to improve the quality and processes for the series batch.

- CERN inspection visit to be planned before batch expedition.

Production steps of one HXD of the single order

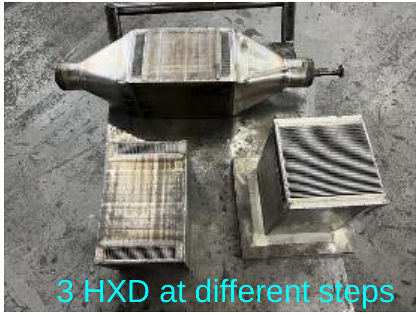

Welding of two plates




HXD block


“spread weld”


HXD collector


3 HXD at different steps


Weld inspection


HXD with VLP collector welded


HXD with collector welded

Thank you for your attention