

Experience on NCRs and future expectations

Julien DEBEUX (CERN) on behalf of HL-LHC WP4

14th HL-LHC Collaboration Meeting – Genoa (Italy) – 08/10/2024

Introduction

Outline

- Brief reminder on NCRs for HL-LHC WP4
- NCRs spotted during RFD-SPS CM fabrication, assembly and reception
- Conclusions + few words about LHC Series

Not part of this presentation

- Manufacturing of CRAB cavities
- NCRs linked to FPCs

Talk of E. Jordan: "RFD NCRs & future mitigation"

Talk of J. Swieszek and S. Barriere: "RFD-CM Repair overview and highlight"



NCRs for HL-LHC WP4

■ Nonconformity → Non fulfilment of a requirement

 Requirements are specified in Engineering specifications, drawings, procedures, standards, etc.

Courtesy of H. Garcia Gavela: EDMS 2894857

Y	HILUM HILL	CONSTRUCT 2093032 REFERENCE : LHC	ACFQC-ES-0001
		ENGINEERING SPECIFICATION	
		HL-LHC LHC CRAB CAVITIES	
	с	RYOMODULE CRYOGENIC LINES	
The present Cavities cryc DQW and RI	document concerr omodules intended ED) installed in the	is the engineering specifications of the cryogenic lines to to how the superconducting noblem nadio-frequency of LHC ring for the HC-HC project.	be installed in the Crab rab cavities (two types:
		TRACEABILITY	
Prepared by	r: L. Dassa (EN-MM	TRACEABILITY E), H. Garcia Gavela (ATS-DO)	Date: 13-05-2020
Prepared by Verified by: T. Demazier T. Jones (STI	r: L. Dassa (EN-MM I. Aviles Santillana e (EN-MME), C. Gai C), R. Lavdal (Triur	TRACEABILITY E), H. Garcia Gavela (ATS-DO) (EM-MME), K. Grozinski (TE-CRG), T. Capelli (EN-MME), ignant (HL DPSO), M. Garlasché (EN-MME), h), Th. Ctto (HL PSO)	Date: 13-05-2020 Date: 27-11-2020
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NCRs for HL-LHC WP4

- Useful links and documents:
 - HL QA training for WP4 (H. Garcia Gavela): <u>EDMS 2894857</u>
 - NCR Process: <u>EDMS 1499015</u>
 - NCR Process for Collaborations: <u>EDMS 2149457</u>
 - NCR Template: EDMS 1501109
 - Launching NCR using EDMS: <u>EDMS 1908145</u>

Main contacts:

- HL-Quality contact for WP4: G. Prica, H. Garcia Gavela
- Standards and specifications: L. Dassa
- Manufacturing quality / Welding activities: J. Debeux, M. Benahmed



NCRs for HL-LHC WP4

 Persons to be contacted in case of Nonconformity on the HL-LHC WP4 Cryomodule

EDMS 3014549

Who (from CERN) should sign the NC will depend on the component/system/domain and the level

	Non-critical	Non-critical		
	1 or 2	3	4 or 5	
Standards and specifications	L. Dassa	O. Capatina		
Transport engineering and Tuner K. Artoos		O. Capatina		
General Design - Test - RF compliance	N. Valverde		R. Calaga	
General Design - Design & calculations	T. Capelli		O. Capatina	
Manufacturing & assembly & Welding & Logistics	J. Debeux / S. Barriere	M. Garlasche		
Materials	C. Santos Maldonado	I. Aviles	S. Sgobba	
Survey	V. Rude	M. Sosin	H. Mainaud	
Vacuum compliance	G.	Bregliozzi		
Cryogenic compliance	L. Delpra			
Cleanroom & RF cavity compliance	N. Valverde		R. Calaga	
RF Tests	K. Turaj		R. Calaga	
Low level RF	G. Hagmann		R. Calaga	
RF Controls	A. Butterworth		R. Calaga	
RF Power compliance	E. Montesinos			
Beam dynamics compliance	N. Mounet R. 1		Готаs	
HL Quality	G. Prica H. Garo		cia Gavela	
Integration, installation	G. Cipolla P. Fessia/		/M. Modena	
HL safety	C. Gaignant		T. Otto	
Transport and handling on site	M. Perez Ornedo	С. В	ertone	
Safety conformity	D. Tshilumba/L. D	Jassa	S. Marsh	
Configuration	M. Zerlauth			



Overview of NCRs for RFD SPS

Not Not</td

Between 30 to 35 NCRs reported on EDMS

12 main steps of assembly, ~1300 items (~900 drawings), etc.



Julien DEBEUX – 14th HL-LHC Collaboration Meeting – Genoa (Italy) – 08/10/2024

NCRs during RFD-SPS CM fabrication, assembly and reception

Bellows and base materials



Bellows ~10 NCRs in total

The NCRs are linked to:

- 2-ply bellows
- Design and Test Pressure
- Dents
- Base material
- Dimensional aspect

Biphase boxes – Level Port Bellows

- Bellows proposal from subcontractor
- Approval focused on dimensions and base material
- Essentially discussed / approved by mail
- Info on «2-ply» missed during discussions





Bellows ~10 NCRs in total

The NCRs are linked to:

- 2-ply bellows
- Design and Test Pressure
- Dents
- Base material
- Dimensional aspect

Bellows for cryogenic lines

- Design pressure is **2.1 barg** and test pressure is **2.7 barg**.
- The supplier used a design pressure of **1.8 barg** based on test pressure **2.7 barg + coefficient of 1.5**; while the actual coefficient in **CERN Specification is 1.25**.





Bellows ~10 NCRs in total

- The NCRs are linked to:
 - 2-ply bellows
 - Design and Test Pressure
 - Dents
 - Base material
 - Dimensional aspect







Parallel with LHC Series (RFD Biphase & DQW PIMs)



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Bellows ~10 NCRs in total

- The NCRs are linked to:
 - 2-ply bellows
 - Design and Test Pressure
 - Dents
 - Base material
 - Dimensional aspect

- Cryogenic lines bellows, blade support and tuner bellows
 - Collars in EN 1.4429 2D Forged instead of 3D Forged
 - Convolutions in EN 1.4404 (EN 10088-2) instead of EN 1.4435 (EN 10028-7)
 - Missing Cobalt assessment or Cobalt content >0.3%
 - No magnetic permeability values given
 - No inclusion content reported



Bellows ~10 NCRs in total

The NCRs are linked to:

- 2-ply bellows
- Design and Test Pressure
- Dents
- Base material
- Dimensional aspect

Cryogenic line bellows (extremity bellows)

- The total length of the bellows is shorter than required (118.6mm instead of 131.5mm)
- The number of convolutions is lower than mentioned on drawing
- Holes of blank extremity collar not perpendicular







Bellows ~10 NCRs in total

- The NCRs are linked to:
 - 2-ply bellows
 - Design and Test Pressure
 - Dents
 - Base material
 - Dimensional aspect

LHC SERIES

- Update of Engineering specifications
- Single sourcing for each type of bellows, then dispatched to the collaborations:
 - Cryogenic bellows: KOMPAFLEX AG
 - Tuner and blade support bellows: MEWASA AG







Base material ~8 NCRs in total

- The NCRs are linked to:
 - Material standard
 - ASME / ASTM vs EN standards
 - EN standards for pressure applications (PED harmonized)
 - Material grades or properties
 - Grade of austenitic stainless steels (EN 1.4429)
 - Welding filler material (WZ 18 16 5 NL)
 - Magnetic permeability
 - Cobalt content
 - Cobalt content not mentioned in the certificates
 - Values are above the limit



Evaluation thanks to PMA



Evaluation by experts Evaluation with destructive testing Non-destructive measurements



Measurements at CERN Tracking in <u>EDMS 2798791</u>

→ For LHC Series: Update of specs and drawings, procurement strategy, improvement of QA/QC



Welding



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Orbital welds on beam screen lines













Orbital welds on beam screen lines



- Potential root causes:
 - Tolerances of the parts
 - Limited access
 - Difficulty of execution
 - Backing gas set-up







- Actions:
 - STFC and CERN performed together the repair
 - Knowledge transfer between the teams
 - Modifications of the design drawing
 - Qualification of the welder for repair operation













Other NCRs

- Dimensional control (Blade support assy, OVV, WMS, biphase line, etc.)
- Clash / Matching during assembly (HOM Cooling line, RF Coax line, etc.)
- Blow-off valve (insulation vacuum)





➔ Evolution of assembly procedure, Engineering Specs, safety components, etc.



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NCRs during RFD-SPS CM Reception

Other NCRs

• Tightening checks:

- Lateral doors: 1 door not OK (1/4 of a turn missing)
- Cavity support system:
 - 1 FPC connection partially OK
 - Top blade connection: locking screws not OK
- Cryogenic transport lock: Loose
- Tuner Thermal Intercept: Connexion to double pipes or braids partially OK







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Courtesy of T. CAPELLI

NCRs during RFD-SPS CM Reception

Other NCRs

- FSI checks:
 - 4 lower FSI were obstructed by MLI
- Cryo instrumentation:
 - Labels removed / replaced
 - Heaters not installed / checked



Courtesy of T. CAPELLI



Conclusions and perspectives

- RFD-SPS Prototype:
 - This prototype phase was highly instructive, also for QA-QC activities.
 - Some difficulties to deliver and review quality and manufacturing documents in time, with a rigorous respect of approval process.
- Concerning requirements:
 - To prepare LHC Series, the Eng. Spec and drawings were updated.
 - → Few Deviation Permit Requests have been already prepared.
- Concerning NCRs:
 - Important step during drafting NCRs: Root causes, preventive and corrective actions and implications

→ For LHC Series:

All the requirements shall be respected, any deviation must be **traced** and **approved before continuing the production**.



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Conclusions and perspectives

- CERN:
 - A new welding and quality engineer hired in April 2024 (Myriam Benahmed)
- Collaborations with STFC / TRIUMF:
 - Good use of HL QA tools
 - Efficient raw material procurement strategy
 - Transparency, respect of reviewing processes (from the procurement specification drafting)
 - Some QA tools have been implemented

EDMS link:	https://edms.com.ch/document/3161383/				
	UPPER CRYOLIN	IE (LHCACFQC0357)			
The documents shall be attached to the rights M	TF asset				
EDMS Link	Document title	Status	sponsible of on-going actio	Actions	Priori
	Traceability and material certificates				
https://edms.cern.ch/document/3124587/	MIP	In work	STFC	Revisions requested from Hyde following CERN comments sent 16/3	0
https://edms.cern.ch/document/3124604/	Weld books (weld traceability reports)	In work	STFC	Revisions requested from Hyde following Julien's comments on 6/8	0
https://edms.cern.ch/document/3140832/	Weld production schedules	HL Engineering Check	STFC	Andy to clarify with Hyde where some of JDb's comments not taken into account	0
https://edms.cern.ch/document/3124603/	WPSa	In work	STFC	Andy to upload updates with CERN feedback sent by email 6/9 after weld tests	0
	WPQs	In work	STFC		0
https://edms.cern.ch/document/3161558/	WPQRs	In work	STFC	Andy to upload after weld tests	0
https://edms.cern.ch/document/3134585/	Welding filler	Released	STEC	Hyde to procure approved welding filler	0
https://edma.com.ch/document/3126097/	NDT qualifications	HL Engineering Check	STFC	Prepare deviation request with Hyde to demonstrate the equivalence / the differences between their certifications and our requirement EN ISO 3712. Ref JDb comments 16/3 (cmail and EDMS)	s 1
https://edms.cern.ch/document/3136659/	Biphase box production drawings	Draft for Discussion	STFC	To be updated following test welds	1
https://edms.cem.ch/document/3140687/	Biphase line cleaning procedures	in work	STFC	Flow chart to be added	0
https://edms.cern.ch/document/3156346/	Biphase line cleaning procedures at Hyde	Under Approval	CERN	To be approved (accepted by JDb 10-Sept)	1
https://edms.cern.ch/document/3156778/	Biphase line cleaning procedures at STFC	In work	STFC	To be provided by vac lab	0
https://edms.cern.ch/document/3160201/	Biphase line leak test procedure	In work	STFC	To be provided by Hyde	1
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Thank you !

Any questions ?



Julien DEBEUX – 14th HL-LHC Collaboration Meeting – Genoa (Italy) – 08/10/2024

Back-up slides



Back-up slides



