Engineering Specifications for HL-LHC WP4: status and open discussion

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Outline

- Why the specifications?
- Strategy for HL-LHC WP4
- Status of the specifications
- Some feedbacks and remarks
- NCRs
- Documentation / Quality FU
- Open discussion

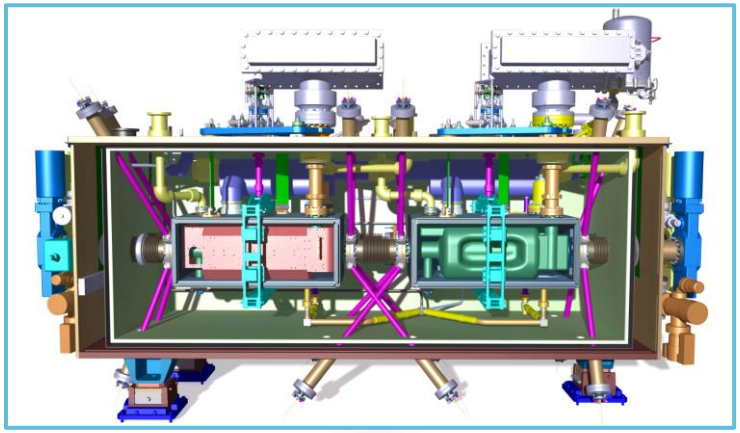
Why specifications?

Functional requirements

CERN rules

Technical requirements

ESRs (Safety requirements)



LHC compatibility

Safety file (technical documentation for compliance)

CERN Procedures

Different actors

Acceptance criteria

Quality

Manufacturer is the responsible for safety

Traceability

…

See my talk at the “International Review of the Crab Cavity system design and production plan for the HL-LHC” on June, 19th -21st 2019 (CERN)

Strategy for HL-LHC WP4

- CERN WP4 is manufacturer of the cryomodule
- The cryomodule shall be designed and manufactured in accordance with the Essential Safety Requirements of PED 2014/68/EU.
- CERN establishes the technical documentation

CONTENT:
- Refers to the corresponding Engineering Specification
- Demonstrate the compliance with CERN Safety Rules, ESR by ESR

Intended for CERN internal use and for HSE, available for consultation

2 **main** documents for the cryomodule
- engineering specification
- guideline for compliance with CERN safety rule

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2 **main** documents per relevant component:
- engineering specification
- guideline for compliance with CERN safety rule

CONTENT
- translates the HL-LHC needs into functional and technical requirements
- lists the required documentation
- complies with ESRs

Respect of engineering specification
=
compliance with CERN requirements (safety included)

Ad-hoc agreements with Collaborating Entities based on described strategy

Cryomodule & Components Specifications

Scope	ID code	*Eng. Spec. [EDMS nr]*	*Guideline for compl. with CERN Saf. Req. [EDMS nr]*
Full Cryomodule, including beam screens and references to requirements for vacuum components (Sector valves, Plug-in modules)	ACFGA	2043014 v.2.0	2043016 v1..0
Safety Request WP4 - Co CONTENT FOR THE DQW & RFD CRYOMODULE FOR LHC	ACFGA	2514225 v.2.0	
HL-LHC LHC CRAB CAVITIES: welded joints for cryomodule assembly	ACFGA	2706475 v.1.3	
Minimum Material Requirements for Austenitic Stainless Steel and Aluminium Alloys to be employed in non-critical applications	ACFGA	2632333 v.1.0	

CRYOMODULE

Dressed cavities, HOMs couplers, Pick-up antennas, Cold magnetic shield	**ACFDC,ACFHC, ACFPU, ACFCM**	1389669 v.2.6	2058183 v.1.0
Cryogenic circuits	**ACFQC**	2093032 v.1.4	2101920 v.1.1
Thermal shield	ACFTS	2101922 v.1.2	2101923 v.1.0
He guard	-	2806004 v.1.4	
MLI	ACFTS	2144140 v.1.3	-
Vacuum vessel	ACFVT	2101924 v.1.6	2101925 v.1.1
Warm Magnetic shield	ACFWM	2101926 v.1.4	-
Alignment monitoring system	ACFAM	-	-
Support and alignment system	ACFAH	-	-
Instrumentation (ONLY FOR RFD SPS)	ACFIS	2450567 v.4 + CRNLSQLj0070 v.AA (PID)	-
Fundamental Power Coupler	ACFMC	2101934 v.1.0	
RF internal lines	ACFRL	2605345 v.1.0	-
Tuning system	ACFTU	2101938 v.0.1	-
Safety protecting devices	ACFGA	2101940 v.1.0	2101943 v.1.0
Sector Valves (beam line)	VVG (TBC)	§ 7.7 of 2043014 v.1.0	-
Plug-in modules for Cold-Warm transition + Intercavity bellow	ACFVW + ACFVC (TBC)	§ 7.7 of 2043014 v.1.0	-
Beam screen	VSSC_	§ 7.7 of 2043014 v.1.0	-

COMPONENTS

STATUS

- Released
- In Work

Relevant for Safety

No further versions are expected!

Some remarks on specifications

Actual version of specifications:

- Implemented feedbacks from prototypes
- Structured approach improved for cryomodule specification
- Homogeneity improved for component specifications: materials; filler metals; leak test inspectors; NDT inspectors; non-standard welded joints…

Links between drawings and specifications updated

Drawings + specifications:
exigent, however defined and proved framework for procurement and manufacturing

Some general remarks

- Cavities, some HOMs and cryogenic lines are **pressure equipment**
- Rules **independent from the WP4** shall be respected (defined at CERN and within HL-LHC)
- CERN remains the **manufacturer,** the responsible entity in term of safety

- **Do not underestimate welded/brazed joints** and related qualifications, for the components and for the cryomodule assembly. Qualifications, tests, documentations are requiring a not negligeable effort.

- Some **additional measurements/tests (i.e. for NCRs) may be needed** to confirm acceptability of an equipment: see thickness distribution on cavities => we expect comprehension and flexibility

NCRs

NCRs are meant to learn from the issue and determine corrective and preventive actions

- NCRs for RFD proto: about 50 (2x WMS, 4xOVC, 3xTS, 15xCryoL, 12xDrCav, 13x CryomAsm…)

- NCRs cavities production: 86
- NCRs for series CMs:
  - STFC: 1 (1xWMS)
  - TRIUMF: 8 (7xCryoL by CERN; 1xOVC)
  - CERN: 11 (1xOVC; 6xCryoL; 1xWMS; 3xTS)

Privilege the Deviation Request tool

Documentation / Quality FU

- **Quantity of documentation**: manpower shall be allocated to it
- **Quality of documentation** is important (date, author, status…)
- MTF shall be correctly prepared and regularly filled
- Documentation shall be reviewed and approved at the correct time
- Approval shall be tracked in EDMS (even after an email exchange)
- Hold points shall be respected. Some hold-points require the presence of CERN members: inform us in advance.

STFC and AUP colleagues have already gained experience gained
TRIUMF colleagues are at the beginning of the experience.

LS2 performed according to the principle of prioritising ***safety first, then quality and then the schedule****, and all of these criteria were met.* (Fabiola Giannotti, Annual Report 2019)

Time for open discussion

- Anything missed in the specs? What about a spec for the instrumentation?
- Drawing & specifications? Any incoherence spotted?
- What about the feedback you receive day-by-day from CERN on spec use?
- Any question on applicable safety policy?
- Any difficulties on outsourcing? Which are the feedbacks from suppliers?
- What about documentations? Is this preventing you from respecting deadlines? What about quality and quantity?
- Is the Deviation Request tool helping you?
- Any comments on NCRs (use, approval…)?

Thank you…

Updates with respect to the previous versions (1)

Name	ID code	Engineering Specification	STATUS	Modifications
Cryomodule	ACFGA	EDMS 2043014 v.2.0	New version released on 16/02/2024 after circulation and update	• 4.2: Table 3: simplified and clarified • 4.3.4 and 4.3.5: Clarification on cryogenic cycles • Section 8 of the old version removed (sections renumbered) • Section 13.4.8: clarifications on pressure tests • Section 14.3: clarification on the cool-down tests at 77K • Minor modification on section 18 (incoterm removed) • Minor modification to the requirements for the High power RF conditioning in SM18 • Section related to the Installation in the HL-LHC machine removed
Cryogenic circuits	ACFQC	EDMS 2093032 v.1.4	Minor modifications; new version released on 13/02/2024.	• Clarification added to Section 3.3.5 on pressure test. • Section 3.2.3: reference [14] replaced with correct EDMS number.
He guard	ACFQC	EDMS 2806004 v.1.4	Minor modifications; new version released on 13/02/2024.	• Clarification added to Section 3.5.3 on pressure test.
Thermal shield	ACFTS	EDMS 2101922 v.1.2	Minor modifications; new version released on 13/02/2024.	• Section 3.2.8: material list for braids uploaded • Section 3.2.10: bolt minimum strength reduced. • Section 3.3.4: clarification for pressure test procedure
Vacuum vessel	ACFVT	EDMS 2101924 v.1.6	Minor modifications; new version released on 13/02/2024.	• Section 2.4.8: bolt minimum strength reduced.
Warm Magnetic shield	ACFWM	EDMS 2101926 v.1.4	Minor modifications; new version released on 13/02/202.	• Section 2.6 (cleaning) modified to be in agreement with specifications of other cryomodule components.
Fundamental Power Coupler	ACFMC	EDMS 2101934 v.1.1	Minor modifications; new version released on 13/02/2024.	• Pressure test removed

Updates with respect to the previous versions (2)

Name	ID code	Guideline for compl. with CERN Safety Req.	STATUS	Modifications
Cryomodule	ACFGA	EDMS 2043016 v.1.0	New document, released on 10/04/2024	
Cryogenic circuits	ACFQC	EDMS 2101920 v.1.1	Minor modifications: new version released on 14/02/2024.	• Minor modifications to Section 3.3 (relaxation of requirements for VT personnel) • Section 3.4: references for the unconventional welded joints updated • Flexible hoses requirements removed.
Thermal shield	ACFTS	EDMS 2101923 v.1.0	New document, released on 10/04/2024	
Vacuum vessel	ACFVT	EDMS 2101925 v.1.1	Minor modifications: new version released on 14/02/2024.	• Minor modifications to Section 3.1 (adapted to new material requirements) • Minor modifications to Section 3.2 (relaxation of requirements for VT personnel)
Safety protecting devices	ACFGA	EDMS 2101943		