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Cryo Meeting

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Cryo Meeting
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Agenda

1. Cryostat Assembly Functional Requirements Specifications — Sandor
2. AOB

LQXFA/B Cryostat Assembly FRS

Purpose

- DOE requirement
  - Any **Requirement** changes need to be documented since the cost is based on the requirements of the work to be performed
  - Direct cost dependence on FRS
- Cryostat Assembly Acceptance is based on this document
- It covers essential elements that are important for the US team to be able to execute
  - The assembly work
  - Cryostat assembly testing and
  - Shipping

Keeping in mind the above purpose we have put together the Cryo-Assembly FRS. The actual details can change within the realm of not introducing for the US team any unnecessary cost or schedule increase.

LQXFA/B Cryostat Assembly FRS

Physical Envelop Requirements

R-T-01: Those dimensional values (listed in drawing LHCLSXH_0010) that have direct impact on two different equipment owners must be respected as envelope dimensions that could not be violated even if the fabrication tolerances or other constraints are taken into consideration. Any changes of LHCLSXH_0010 drawing must be approved by the Q1/Q3 equipment owners as well.

R-T-02: The LQXFA/LQXFB vacuum vessel physical length (end flange to end flange) must be ≤ 9,500 mm (the actual length shell be specified to make sure that the length plus the tolerance value is less than 9,500 mm). This dimension is at room temperature (296 K).

CERN supplies the vacuum vessel. In my opinion this should not be a requirement in this document

R-T-03: Any support structure attached to the vacuum vessel must be within 1,055 mm outer diameter. This dimension is at room temperature (296 K).

1055 mm is the max width. The overall height will be higher. (by CERN)

Note:

Components attached to the vacuum vessel required for cryostat installation may exceed the 1,055 mm diameter envelope if it does not interfere with transportation in the LHC tunnel

We need to make sure that the dimensional envelop is defined. Infrastructure should be able to handle it.

LQXFA/B Cryostat Assembly FRS

Weight Requirements

R-T-04: The total weight of the whole cryostat assembly must be ≤ 25 000 kg.

Crane availability is affected. We need a number well below the crane limit.

I guess the weight is more of a result from a design made to meet other requirements. We should not compromise on operational requirements to stay below a max weight… >25000 kg seems doable though. (by CERN)

Alignment Requirements

R-T-06: LMQXFA cold mass is centered in Z within ± 5 mm with respect to the Z-center of the QQXFA/QQXFC vacuum vessel using the Z-center of the magnetic lengths.

R-O-01: The common magnetic axis of cold mass must be positioned within ±1 mm accuracy with respect to the vacuum vessel end flange center points. The deviation of the common magnetic field angle of the cold mass (in the vacuum vessel coordinate system) must be within ±5 mrad.

Ultimately the magnetic measurements based alignment will matter for the tunnel alignment. Manufacturing tolerances can be tighter and they will be set in the interface documents.

LQXFA/B Cryostat Assembly FRS

Alignment Requirements

Note:

- The vacuum vessel dimensions are referenced to the vacuum vessel coordinate system. The Z direction is the centerline of the vacuum vessel. The gravity line pointing upward is the Y direction. The origin of the coordinate system is at the center of the vacuum vessel.
- The vacuum vessel centerline is established by finding the center of the vacuum vessel end flanges at both ends of the vessel and placing a line through the center points of the two ends. Half way relative to the two center points (on the centerline) is the center of the vacuum vessel.
- The Cold Mass fix point is at the center of the cold mass.

It's better to place the origin at the intersection between Z and the axis of the central support post. (by CERN)

LQXFA/B Cryostat Assembly FRS

Vacuum Vessel Requirements

R-T-07: The QQXFA and QQXFC are a pressure vessels that must be designed and documented in accordance with CERN and U.S. HL-LHC Accelerator Upgrade Project safety agreements [5].

Literally, this is not true under European regulations because vacuum vessels are not covered by the pressure directive (inner pressure < 0.5 barg). CERN will design and implement quality control as if it were a pressure vessel but there will be not official declaration of conformity of the cryostat with the pressure European directive. (by CERN)

R-T-08: The QQXFA and QQXFC vacuum vessel must be designed for a Maximum Allowable Working Pressure (MAWP) of 1 bar differential either direction.

1 bar outside pressure. 0.5 bar inside pressure. (by CERN)

LQXFA/B Cryostat Assembly FRS

Forces Requirements

R-T-09: The LQXFA/LQXFB cryostat assembly must be capable of sustaining loads resulting from up to 25 bar (125% of MAWP) of pressure differential in the LHe containment vessel (cold mass and associated pipes) and 1 bar pressure differential in the vacuum vessel without physical damage or performance degradation.

We will perform pressure tests so we need to know the test requirements and that the cryostat is capable of handling these pressures.

The reality is more complex than this. See https://edms.cern.ch/document/1856323/0.5 and https://edms.cern.ch/document/1868420/0.1 (by CERN)

LQXFA/B Cryostat Assembly FRS

Leak Rate

R-T-10: The LHe containment vessel (Cold Mass and associated pipes) and all other pressurized pipes need to be leak tight under their operating pressure. The leak check must measure that the leak reate is lower than 10^{-9} torr-liter/sec.

Heat Loads

R-T-11: The LQXFA/LQXFB cryostat assembly must be designed and manufactured to be able to intercept most of the heat flow from room temperature to 1.9 K. The maximum static heat flow to 1.9 K must be less than equal to 0.85 W/m for LQXFA and 0.84 W/m for LQXFB

We have limited cooling capacity at the test stand. We need to set a limit early to know what additional upgrade needed if the heat loads are higher than our current capability.

Where is this value coming from? Before announcing an heat load we need a design of the instrumentation, CLIQ and 35A trim feedthrougs. There are also heat loads through BPM and CWT that are to be defined together with BE-BI and TE-VSC.
Again, this should not be a requirement for the US… (by CERN)

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Radiation Hardness Requirements

R-O-02: All LQXFA/LQXFB components can withstand a maximum radiation dose of 30 MGy.

In a case we need to procure some parts by ourselves we need to know what rad-hard specs to follow.

Not for the cryostat. The critical component in the cryostat is the cold support post and it is expected to see no more that 100 kGy (c.f. Francesco Cerrutti). As such we do not plan radiation hardness tests on the support posts material. (by CERN)

Interface Requirements

R-T-15: The LQXFA/LQXFB cryostat assembly must meet the detailed interface specifications with the following systems: (1) LMQXFA cold masses; (2) the CERN supplied Cryogenic System; (3) the CERN supplied power system; (4) the CERN supplied quench protection system, and (5) the CERN supplied instrumentation system. These interfaces are specified in Interface Control Document [4].

LQXFA/B Cryostat Assembly FRS

CERN Provided parts

R-T-17: CERN provides all the parts for LQXFA/LQXFB cryostat assemblies except the LMQXFA cold mass itself. The cryostat kit for the prototype and 10 production units will be supplied and shipped to Fermilab by CERN at no cost to US HL-LHC AUP. The list of the components of the kit can be found in [6].

Tooling

R-T-18: Cryostat assembly tooling will be designed, procured and shipped to Fermilab by CERN or a vendor selected by CERN at no cost to US HL-LHC AUP. The tooling that will be used for cryostat assemblies at CERN and Fermilab will be identical with minor differences that are site and cryostat specific (if any).

Cryostat Assembly Procedures

R-T-19: Cryostat assembly procedures including every QC and QA steps will be developed by CERN. The first prototype cryostat assembly work will be directed by CERN personnel to assure proper transfer of the procedures to Fermilab. At Fermilab an engineer will be assigned to be in charge for the cryostat assembly work.

LQXFA/B Cryostat Assembly FRS

Shipping to CERN

R-T-20: Fermilab is responsible for shipping the Cryo-asemblies to CERN. Fermilab will procure special shipping frames (two) that will assure 80% shock reduction.

Note:

The cryostat and cold mass design need to withstand 2g acceleration in every directions, based on accidental shipping malfunction that creates up 10 g acceleration.

This is especially important to agree. This may require additional shipping fixtures to be introduced in a case the cryostat design will not support these shipping loads.

The 80% shock reduction may not be enough. The US should assume responsibility for the safe transport to CERN.
We should not overdesign the cryostat to resist transport loads otherwise the heat loads would be prohibitive. It should be up to the US to ensure that transport loads acting on the support posts are within the limits of the load cases listed in document https://edms.cern.ch/document/1868420/0.1 (by CERN)