



**Report of the
MQXFA13
Structure & Shim Review**

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US HL-LHC Accelerator Upgrade Project

**Report of the MQXFA13 Structure & Shim
Review**

November 18th 2022

- Rodger Bossert (chairperson), FNAL
- Susana Izquierdo Bermudez (CERN)
- Mike Anerella, (BNL)



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1. Goal and scope

The HL-LHC AUP project is starting the assembly of MQXFA13 magnet. This is the 6th series magnet of the MQXFA low beta quadrupoles to be used in Q1 and Q3 for the High Luminosity LHC. If MQXFA13 meets MQXFA requirements [1] it will be used in a Q1/Q3 cryo-assembly to be installed in the HL-LHC.

MQXFA13 coils were reviewed on November 2, 2022 [2].

MQXFA Series magnet specifications are presented in [3]. Discrepancy or Non-Conformity Reports are generated whenever a component does not meet specifications [4]. The goal of this review is to evaluate MQXFA13 structure and shim plan. Reviewers should also assess that discrepancies and non-conformities of the magnet structure have been adequately processed, and that the shims will allow MQXFA13 to meet MQXFA requirements [1].

Technical details

Committee

- Rodger Bossert (chairperson), FNAL
- Susana Izquierdo Bermudez (CERN)
- Mike Anerella, (BNL)

Date and Time

November 18, 2022. Start time is 7:30/9:30/10:30/16:30 (LBNL/FNAL/BNL/CERN)

Location/Connection

Video-link by Zoom, info by email.

Link to agenda with talks and other documents

<https://indico.fnal.gov/event/57183/>



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2. Review Charges responses

The committee is requested to answer the following questions:

1. Have all recommendations from previous reviews [5] been adequately addressed?

Finding: Yes

Comment: The status of the recommendations is:

- Study Pole gap size vs torque.
 - Data was compiled which showed that the RMS difference between 125 ft-lb and 75 ft-lb of torque is about 0.001 inches.
- Protection heater wire issue: LBNL shall carefully check the coil production procedures in this region. Provide a list of which wires needed repair.
 - Study shows that insulation in this area is prone to abrasions. LBNL finds areas that need dressing or even total replacement of wires.
 - Compilation of list of specific coils and heaters which required repair is in progress, but not yet completed.

2. Have discrepancies and non-conformities been adequately documented and processed?

Finding: Yes.

Comment: So far Magnet MQXFA13 has 15 NCRs.

3. If there are major non-conformities [4], have they been adequately documented and processed?

Finding: No major non-conformities.

4. Are the proposed shims adequate for allowing MQXFA13 to meet MQXFA requirements [1]?

Finding: Yes

Comment: The shims have been chosen to achieve preload targets which are the same as for magnets 03-06 and 10-12. These magnets met performance requirements.

5. Do you have any other comments or recommendations to assure MQXFA13 is going to meet requirements?

Finding: Yes



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3. Comments

PH wires on coils are nicked and sometimes scratched on inside surface of coils, at or near where the wire exits the end of the coil. Depending on the severity of the problem, the issue has been corrected by either adding insulation or cleaning out the green putty and completely reinstalling the PH wire. Coils are routinely inspected for this issue and repaired as necessary.

Glass beads from laser cutting of glass cloth poked holes or created defects in ground plane insulation and were repaired on 3 different occasions. Glass cloth adjacent to ground wrap will be cut by hand in the future to eliminate this issue.

Hipot failure – Hipot of Magnet MQXFA12 revealed potential weakness of strain gauges to pole as well as strain gauges to shell, resulting in coil-to-ground failure. Solution is under consideration.

On slide 4 of “Coil Pack and Shimming Proposal”, the coil sizes at the strain gauge location are noted. One point of this is intended be able to estimate the lowest coil preload in areas away from the gauges based on relative coil sizes. By inspection, the 1500mm location is, for the four coils, on average approximately 100 μ m smaller than at the strain gauge location. Although this value is within the specification, consider using this data to estimate the resulting lower preload, and then to project the excitation current at which the coils will unload locally.

Slide 11 of “Coil Pack and Shimming Proposal”, shows that the midplane corrections were made but not radial corrections. It was stated that this was also the case in previous magnets, but was not corrected in those either. A look at previous magnet data confirms this. However, it also appears from coil LEICA plots that the data used was done “with respect to the outer radial surface”, in other words, normalizing the outer surface deviations to an average of zero, and applying the azimuthal shims based on the resulting plot. If this is the case, then the midplane adjustments include the effect of undersized outer radius, and adjustment of this radius would be unnecessary anyway.

Slide 6 of “Preload Targets” shows that the -80 \pm 8 MPa target has not been met on the last 4 magnets. MQXFA13 is also expected to be below average because of coils radially undersized. (Note that coils in magnet A10, one of the recent magnets below the target lower limit, are shown in slide 7 to have unloaded at ~ 14.7kA.)



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4. Recommendations

1. Finish compiling a list of the coils which had PH wires that needed repair, and what repair was done on each coil.
2. Resolve issue of strain gauge to coil short and document solution before completing strain gauges on MQXFA13.

5. References

- 1) *MQXFA Functional Requirements Specification*, US-HiLumi-doc-36.
- 2) *MQXFA13 Coils Acceptance Review*, US-HiLumi-doc-4609.
- 3) *MQXFA Series Magnet Production Specification*, US-HiLumi-doc-4009.
- 4) *Handling of Discrepancies and Nonconformances*, US-HiLumi-doc-2484.
- 5) *MQXFA12 Structure & Shims Review*, US-HiLumi-doc-4329.