



Report of the MQXFA15

Coils Acceptance Review

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US HL-LHC Accelerator Upgrade Project

Report of the MQXFA15 Coils Acceptance Review

February 15 2023

- Arup Ghosh (Chairperson), BNL retired
- Susana Izquierdo Bermudez, CERN
- Gianluca Sabbi, LBNL



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1. Goal and scope

The HL-LHC AUP project is planning to start assembly of MQXFA15. This is the 8th series low-beta quadrupole magnet (MQXFA) for the Inner Triplet of the High Luminosity LHC. If MQXFA15 meets MQXFA requirements [1] it will be used in a Q1/Q3 cryo-assembly to be installed in the HL-LHC.

For MQXFA15 assembly AUP is planning to use these QXFA coils (including a spare one): 109, 127, 220, 226, and 233. Some coils were previously on-hold and were repaired. At this time AUP needs to decide the disposition of some coils on-hold in order to reduce uncertainty. The dispositions were decided taking into account that these coils will be accepted for use in a cold mass only if MQXFA15 meets requirements during vertical test.

Coil 109 was reviewed during the *Review of MQXFA03 Coils and Shims* [2]. It was approved for use and developed an electrical issue during magnet assembly.

Coil 220 was reviewed during the *MQXFA10 Coils Acceptance Review* [3] and it was put on-hold. It was accepted for use during the *MQXFA12 Coils Acceptance Review* [4], and it is assumed accepted for use in MQXFA15.

Conductor and series coil specifications are presented in [5-9]. Discrepancy or Non-conformity Reports are generated whenever a component does not meet specifications.

The reviewers are requested to review discrepancies and non-conformities in strands, cables, and coils for the following coils: 127 (cable P43OL1138), 226 (P43OL1150), and 233 (P43OL1169).

For coil 109 the reviewers are requested to evaluate repair and disposition of the non-conformity that developed during MQXFA03 assembly.

Technical details

Committee

- Arup Ghosh (Chairperson), BNL retired
- Susana Izquierdo Bermudez, CERN
- Gianluca Sabbi, LBNL

Date and Time

Feb 15, 2023. Start time is 7/9/10/16 (LBNL/FNAL/BNL-FSU/CERN)

Location/Connection

Video-link by Zoom, info by email.

Link to agenda with talks and other documents

<https://indico.fnal.gov/event/58154/>



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2. Review Charges responses

For the record, some of the coils being reviewed here, namely 109, 127 and 226 were “on-hold” owing to issues in coil fabrication that needed to be addressed. Below is listed the reason the coils were put on hold and the Coil Configuration at the time of fabrication:

Coil ID	Coil Configuration	Comments
109	Pre-Series 1	Short discovered at LBNL during Hi-Pot test at coil pack assembly.
127	Series 1	An electrical short of a Quench Heater to the Coil
226	Series 6	An electrical short of a Quench Heater to the Coil
233	Series 9	Coil inadvertently HT twice during the Coil cure cycle. Coil Length below minimum specs.
220	Series 3	Coil reviewed earlier. Designated as Spare

It is also noted that Coil 109 has some differences with the other coils: As a Pre-Series Coil it has solid saddles (as opposed to Flexible saddles), shorter NbTi leads than other coils and does not have the *b6* correction implemented in the Series Coils.

The committee is requested to answer the following questions:

1. Have all recommendations from previous reviews [10] been adequately addressed?

There were no outstanding Recommendations from prior reviews. There were no recommendations from the review of Magnets MQXFA13 and MQXFA14.

2. Have Discrepancies and Non-conformities been adequately documented and processed?



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Strand and Cable: there were no critical DR's that were recorded for the cables in these four coils. Cable 1138 had no DR's. Cable 1150 and 1169 had similar DR's stemming from the HT of the extracted strands. The temperature range of the TC's used in the furnace were above specifications at the various plateaus of 210C, 400C and 665C. However, measurements of RRR are within the historical norms. The TC calibration issues have been resolved as evidenced by the HT of samples from later cables.

Coil 109: This coil was fabricated in 2018 as part of the Pre-Series coils. Initially this coil developed a short during Hi-Pot test at LBNL during coil assembly. After being returned to FNAL, the short was traced to the inner RE saddle tip on coil ID. This attributed to the rigid coil saddle being replaced. Subsequent coils were fabricated using a flexible saddle. A repair was affected at the failure site and the coil was checked and is ready for use. This is the only Pre-Series being considered for MQXFA15. It is noted that Pre-series coils have not been used to make magnets since MQXFA07.

Coil 127: This coil was initially rejected as it developed a Quench-Heater (QH) short to coil. This critical DR was recorded and subsequently found to be due to the presence of glass beads underneath the heater insulation which punctured the insulation causing a short to the coil. The beads were traced to its formation during the laser cutting of the glass cloth. Beads may dislocate from cloth edges during cloth installation post heat-treatment. After this coil, laser cutting of the fiberglass cloth was discontinued.

Repairs were made to the QH insulation and is now deemed ready for use. There was also another non-critical DR recorded during the initial HT of the coil. At the 400 C plateau the TC record is not normal. It is stated that witness samples during the coil reaction would be checked to validate the HT. That information was provided and the data show that the reaction cycle is normal.

Coil 233: The significant DR recorded for this coil at BNL was like that observed for 127 at FNAL, namely glass beads puncturing the insulation shorting out the QH and the coil. Insulation repair like that used at FNAL for



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Coil 127 were made and subsequently electrically checked and has been certified for use.

This coil also had a non-critical DR recorded during the coil curing step when the furnace re-activated during the cool-down phase and the coil was above 150C for about 3 hours prior to the furnace shut-off. This should not affect the quality of the coil.

Also noted was the coil length which was below minimum specification. The cause is unknown. BNL coils have tended to be at the low end of specification with occasional coils being below specs. This should not affect magnet performance.

3. If there are critical Discrepancies/Non-conformities, have they been properly identified, adequately documented and processed?

YES, all critical DR's were properly recorded.

On the issue of Processing the NCR's, we received the following clarification:

“Travelers are uploaded on MTF after they are complete in Vector. For FNAL coils all travelers are filled electronically in Vector. For BNL coils all BNL travelers (on paper) are scanned and attached to the Coil Interface Traveler in Vector. The Coil Interface traveler includes the data collected at LBNL (mechanical and electrical inspection reports). Since coil storage space at LBNL is limited, coils are shipped to LBNL a few weeks before the Coil Acceptance Review of the magnet they are assigned to. Therefore, it is almost impossible to have their Coil Interface Traveler complete and uploaded on MTF by the time of the Coil Acceptance Review. AUP aims at having the coil travelers on MTF by the time we do the Structure and Shims Review. This goal is quite challenging because it takes time to complete the travelers, review them and upload them on MTF.”

For this Report we note that the NCR's are being processed with some already completed (coil 127) and uploaded on EDMS.

4. Was the issue in coil 109 adequately repaired?



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YES, the repair should be robust.

5. Is there any coil that you recommend not to use in MQXFA15?

We would rather see coil 220 being used instead of 109. See further comments below.

6. Do you have any other comment or recommendation regarding these coils and their conductor for allowing MQXFA15 to meet MQXFA requirements [1]?

Some additional comments regarding Coil 109:

1. Due to its short NbTi leads, this coil can be in used in any quadrant except P3. However, Coil Ordering Study shows that there are several options where coil 109 appears in a quadrant other than P3. Additionally, there are 10 options where coils other than 109 are used, namely 127, 220, 223 and 226.
2. This is the only coil to have solid end saddles. All other coils have flexible end saddles. If this coil is used, we will be mixing coils with solid and flexible end saddles. Can this have an impact on the axial mechanical behavior? Do we have examples in the past missing coils with and without slits in the end saddles in the same magnet assembly. We were informed that MQXFAP1b used 3 coils with solid saddles and 1 with flexible saddle.
3. Since Coil 109 does not have the b_6 correction implemented for the Series coils, some non-allowed harmonics (b_5 , b_7 , a_4 , a_5 , a_7) are generated at a level comparable to the allowed range from the field quality table. However, there are options to make corrections based on coil pack magnetic measurements, and previous mixing of coils with/without the b_6 correction in MQXFA04 resulted in acceptable field quality.

Comments



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Although we do not Reject Coil 109, based on some of the issues described above we do not recommend using Coil 109 for this magnet. We recommend that the spare Coil 220 be used.

3. Recommendations

Recommend that coil 220 be used instead of coil 109.

4. References

- 1) *MQXFA Functional Requirements Specification*, US-HiLumi-doc-36
- 2) *Review of MQXFA03 Coils and Shims*, US-HiLumi-doc-2180
- 3) *MQXFA10 Coils Acceptance Review*, US-HiLumi-doc-4186
- 4) *MQXFA12 Coils Acceptance Review*, US-HiLumi-doc-4321
- 5) *Specification for Quadrupole Magnet Conductor*, US-HiLumi-doc-40
- 6) *Cable Specification*, US-HiLumi-doc-74
- 7) *Quadrupole Magnet Cable Insulation*, US-HiLumi-doc-75
- 8) *QXFA Series Coil Production Specification*, US-HiLumi-doc-2986
- 9) *QXFA Series Coil Fabrication Electrical QC plan*, US-HiLumi-doc-521
- 10) *MQXFA14 Coils Acceptance Review*, US-HiLumi-doc-4769