US HL-LHC Accelerator Upgrade Project

Report of the MQXFA18 Coils Acceptance Review

May 21, 2024

– 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 MQXFA18. This is the 15th series low-beta quadrupole magnet (MQXFA) for the Inner Triplet of the High Luminosity LHC. If MQXFA18 meets MQXFA requirements [1] it will be used in a Q1/Q3 cryo-assembly to be installed in the HL-LHC.

For MQXFA18 assembly AUP is considering the following QXFA coils: 160, 161, 243, 244, 154 and 246.

Conductor and series coil specifications are presented in [2-6]. Discrepancy or Non-conformity Reports are generated whenever a component does not meet specifications. Magnet MQXFA18 is planned for use in a Cold Mass without previous vertical test. Therefore, the coils presented at this review were selected because they do not have critical Discrepancies/Non-conformities.

The reviewers are requested to review discrepancies and non-conformities in strands, cables, and coils for the following coils: 154 (P43OL1196), 160 (1203), 161 (1209), 243 (1191), 244 (1195), 246 (1199).

2. Technical information

Committee
Arup Ghosh (chairperson), BNL retired
Susana Izquierdo Bermudez, CERN
GianLuca Sabbi, LBNL

Date and Time
May 21, 2024. Start time is 7/9/10/16 (LBNL/FNAL/BNL-FSU/CEA-CERN)
Location/Connection

Video-link by Zoom, info by email.

Link to agenda with talks and other documents
https://indico.fnal.gov/event/64536/

3. Review Charges responses

The committee is requested to answer the following questions:

1. Have all recommendations from previous reviews [7] been adequately addressed?

Recommendations from previous reviews were adequately addressed and additional CMM measurements have been implemented at the coil ends. These are being used to access coils based on the additional specification which states:

- at 260 and 300 mm (for the lead end) and at 4340 and 4380 mm (for the return end), the absolute value of the coil Delta arc-length must not exceed **210 μm.**

When the specification is not met the following disposition plan is implemented:

- If Delta arc-length is slightly above 210 μm, disposition may be to **set minimum magnet preload > 80+ MPa.**
- If Delta arc-length is significantly above 210 μm, disposition may be to **use tapered shims for loading keys in the ends.** However, use of tapered keys is not yet planned for MQXFA18, pending demonstration in MQXFA12b.

The committee endorses this course of action for the magnet assembly.

It is noted that the difference in the repeat measurements of the impulse test that were seen for coils 224 and 225 may have been due to differing environmental conditions for the two sets of tests.

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

Strand and Cable: There were no critical DRs recorded for the cables in the six coils. As seen in previous cables, DRs related to out-of-specification mid-thickness were all at startup of the cable runs (which is typical) and were properly recorded. It is noted in the acceptance that these out-of-specification sections of the cable are part of the drop-off during coil fabrication.

FNAL Coils 154, 160 and 161: Some minor DR's were noted for all these coils. The DR's were all well documented and addressed.

Coil 154 has one critical DR since its length is 1 mm above the allowed range. However, this can be absorbed during assembly.

BNL Coils 243, 244 and 246: only coil 243 had one non-critical DR for the reaction process and appropriately addressed. All DR's were recorded and properly addressed.

We note that the delta arc-length at the ends for coils 246 and 161 were slightly greater than 220 μm, and that for coil 244 is greater than 300 μm. Therefore coil 244 is not considered to be suitable for MQXFA18.

The NCR's recorded for coil shipment were investigated and the accelerometer data showed no evidence of shock above requirements.

3. Is there any critical Discrepancy/Non-conformity?

The only critical DR was for the coil length for coil 154 which measured 4335 mm which exceeded the maximum specification of length by 1mm (specs: 4329+/- 5 mm). This has been noted in the traveler interface and will be handled by LBNL during assembly.

4. Is there any coil that you recommend not to use in MQXFA18?

We find that all the coils being considered are adequate for use in future MQXFA magnets but coil 244 will require tapered keys and therefore is not recommended for assembling MQXFA18.

5. Do you have any other comment or recommendation regarding these coils and their conductor for allowing MQXFA18 to meet MQXFA requirements [1]?

See below.

4. Comments

Based on the coil end measurements and coil ordering studies, the stated plan is to use coils 243, 246, 154 and 160. This allows using two coils from BNL and two from FNAL. Using one coil (246) with Delta arc-length slightly above 210 μm is acceptable since the other three coils are well within specs. It was also noted that if 3 coils are in spec, we have more margin for accepting a coil slightly out of spec because the midplanes will be shared with coils in spec.

Coils 161 will be held as spare for MQXFA18 and coil 244 will be held for use in a future magnet.

We endorse the choice of coils stated.

5. Recommendations

As coil production is nearing completion, there is a good pool of coils at FNAL and BNL waiting to be shipped to LBNL. If logistically feasible, (space and resource permitting for storage at LBNL), we suggest that these coils be shipped to LBNL and measured. This will allow for flexibility when selecting coils for the upcoming magnets.

6. References

1) *MQXFA Functional Requirements Specification*, US-HiLumi-doc-36
2) *Specification for Quadrupole Magnet Conductor*, US-HiLumi-doc-40
3) *Cable Specification*, US-HiLumi-doc-74
4) *Quadrupole Magnet Cable Insulation*, US-HiLumi-doc-75
5) *QXFA Series Coil Production Specification*, US-HiLumi-doc-2986
6) *QXFA Series Coil Fabrication Electrical QC plan*, US-HiLumi-doc-521
7) *MQXFA12b Coils Acceptance Review*, US-HiLumi-doc-4937