



Report of the MQXFA09 Coils Acceptance Review

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US HL-LHC Accelerator Upgrade Project

Report of the MQXFA09 Coils Acceptance Review

June 16th 2021

- Steve Gourlay (chairperson), LBNL
- Arup Ghosh, BNL retired
- Juan Carlos Perez, CERN




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1. Goal and scope

The HL-LHC AUP project is planning to start assembly of MQXFA09 magnet in June 2021. MQXFA09 is the second series low-beta quadrupole magnet (MQXFA) for the Inner Triplet of the High Luminosity LHC. If MQXFA09 meets MQXFA requirements [1] it will be used in a Q1/Q3 cryo-assembly to be installed in the HL-LHC.

For MQXFA09 assembly (including a spare coil) AUP is planning to use QXFA coils: 129, 130, 216, 217 and 117. Coil 117 was approved for use in MQXFA05 [2] and is assumed approved for use in MQXFA09.

Conductor and series coil specifications are presented in [3-7]. 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: 129 (cable P43OL1132), 130 (cable P43OL1136), 216 (cable P43OL1128), and 217 (cable P43OL1129).

2. Technical details

Committee

Steve Gourlay (chairperson), LBNL

Arup Ghosh, BNL retired

Juan Carlos Perez, CERN

Date and Time

June 16, 2021. 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/49436/>



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3. Review Charges responses

The committee is requested to answer the following questions:

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

Yes. The non-conformances observed for cables were all judged to be minor and unlikely to affect coil dimensions.

FNAL Coils 129 and 130: Discrepancies in coil winding, reaction and impregnation steps were carefully noted for these coils.

For Coil 129 a DR was upgraded to CDR for the presence of grooves in the midplane after impregnation. The cause was identified (seen also in Coil 128) and corrective action implemented in controlling the width of the mid plane shim. The DR was resolved by repairing the groove by filling with Stycast® which is deemed acceptable.

For Coil 130 several DR's were recorded none were critical. It is noted that the reaction control was still inadequate (DR 12273). However, it is noted that the furnace improvement campaign has progressed sufficiently such that the reaction of coils 133 and 134 were within specifications. DR's related to furnace control should be absent in future coils. That is commendable. It is noted that the non-conformance in reaction temperature control for coil 130 was verified by witness sample measurements.

For Coil 216 one CDR recorded; coil to pole short. Repair effected before impregnation.

For Coil 217 two DR's recorded. One involved cable collapse during winding. Cable reworked and winding completed successfully.

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

Yes

The critical discrepancies and non-conformance to specification were adequately recorded and processed.

3. Did the L3s properly identify critical Discrepancies/Non-conformities? Yes

4. Is there any coil that you recommend not to use in MQXFA09?



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No, all coils are acceptable. AUP has to decide on its choice of whether to use 117 instead of one of the FNAL coils 129 or 130 or the BNL coils 216 or 217. Inner radius coil deviations are observed for the earlier measured 117. It would be prudent to remeasure 117 to confirm the earlier findings.

5. Do you have any other comment or recommendation regarding these coils and their conductor for allowing MQXFA09 to meet MQXFA requirements [1]?

See below.

4. Comments

Strand and Cable

All cables are dimensionally within specification and fairly uniform. Although no Coil-reaction witness sample tests were presented, we find that, based on past history of the pre-series coils, the expected cable performance should have significant margin at operating current and temperature to ensure easily reaching the required operating current. This has been demonstrated for the pre-series coils.

Cable insulation shows good consistency in the thickness measurements done at the vendor and that performed at LBNL and is within specification.

Coil Ordering

Although using the minor edge RRR is not quite representative of the cable RRR for a coil, the analysis presented for coil ordering using the minor edge RRR of the extracted strands measured at LBNL is deemed acceptable. It seems that there are many options available for coil assembly for a voltage criterion of < 353 V and other considerations pertaining to mechanical compatibility could be applied in the selection.

The committee also noted that there are cases where considerable modification to the pion geometry is necessary to compensate deviation of the inner radius. Given this and the comment above, the committee suggests giving priority to coil mechanical shape when ordering the coils for assembly instead of RRR for low voltage peak.

The incidence of popped strands observed during coil winding at both FNAL and BNL is worrisome. Based on a study performed by one of the committee members (AG), it is noticed that popped strands are a constant problem that varies from coil to coil. The committee suggests that both labs



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rigorously track incidents, try to determine possible causes and evaluate detection efficiency.

5. Recommendations

Redo mechanical measurements of coil #117 to take advantage of experience gained from measurements of subsequent coils.

6. References

- 1) MQXFA Functional Requirements Specification, US-HiLumi-doc-36
- 2) MQXFA05 Coils Acceptance Review Report, US-HiLumi-doc-2742
- 3) Specification for Quadrupole Magnet Conductor, US-HiLumi-doc-40
- 4) Cable Specification, US-HiLumi-doc-74
- 5) Quadrupole Magnet Cable Insulation, US-HiLumi-doc-75
- 6) QXFA Series Coil Production Specification, US-HiLumi-doc-2986
- 7) QXFA Series Coil Fabrication Electrical QC plan, US-HiLumi-doc-521