



**Report of the
MQXFA13
Coils Acceptance Review**

US-HiLumi-doc- 4609
Other:
Date: 11-02-2022
Page 1 of 7



US HL-LHC Accelerator Upgrade Project

Report of the MQXFA13 Coils Acceptance Review

November 2nd 2022

- Steve Gourlay (chairperson), LBNL
- Arup Ghosh, BNL retired
- Susana Izquierdo Bermudez, CERN



Report of the MQXFA13 Coils Acceptance Review

US-HiLumi-doc- 4609
Other:
Date: 11-02-2022
Page 2 of 7

TABLE OF CONTENTS

1. GOAL AND SCOPE	3
2. TECHNICAL DETAILS.....	3
3. COMMENTS.....	4
4. RECOMMENDATION.....	4



Report of the MQXFA13 Coils Acceptance Review

US-HiLumi-doc- 4609
Other:
Date: 11-02-2022
Page 3 of 7

1. Goal and scope

The HL-LHC AUP project is planning to start assembly of MQXFA13. This is the 6th series low-beta quadrupole magnet (MQXFA) for the Inner Triplet of 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.

For MQXFA13 assembly AUP is planning to use QXFA coils: 139, 141, 227 and 229. Coil 218 is planned for future use in MQXFA07b and is a spare coil for MQXFA12. Coil 218 was reviewed during the *Coils Acceptance Review for MQXFA07b and MQXFA11* [2]. Another spare coil is coil 220. Coil 220 was reviewed during the *MQXFA10 Coils Acceptance Review* [3] and during the *MQXFA12 Coils Acceptance Review* [4].

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: 139 (cable P43OL1164), 141 (cable P43OL1167), 227 (cable P43OL1156), and 229 (cable P43OL1161).

Technical details

Committee

Steve Gourlay (chairperson), LBNL
Arup Ghosh, BNL retired
Susana Izquierdo Bermudez, CERN

Date and Time

Nov 02, 2022. 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/56491/>



Report of the MQXFA13 Coils Acceptance Review

US-HiLumi-doc- 4609
Other:
Date: 11-02-2022
Page 4 of 7

2. Review Charges responses

The committee is requested to answer the following questions:

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

In summary: Yes.

Strand and Cable: The non-conformance of the furnace temperature control for strand sample heat-treatment is not significant as the sample RRR measured were well above the requirement. I_c of the strands are well above minimum requirement of 315A. Corrective action for the temperature monitoring and control has been implemented.

The non-conformances observed for the cables were all judged to be minor and unlikely to affect coil dimensions. The serious cable discrepancies were located at the beginning or towards the last 5 m of the cable run. These sections are usually part of the cable drop-off during coil winding. However, specific mention should accompany the cable traveler to indicate the lengths that should be discarded.

FNAL Coils 139 and 141: Discrepancies in coil winding, reaction and impregnation steps were carefully noted and recorded for these coils.

For Coil 139 several DR's were recorded, only one critical – 12497.

Cable roped in 2 locations coming off the reel while prepping for L2 winding. Loss of cable tension caused cable layer turns to slide down during cable back-wind in preparation for L2 winding. Both cable layers roped at cross over.

Both repaired areas located on L2 pole turn straight section. Repairs were made and the region was inspected carefully and judged to be acceptable. Corrective action has been put into practice: a 3rd tech has been added to monitor cable tension and layer position during L2 winding setup.

For Coil 141 no significant DR was observed.

BNL Coils 227 and 229: Here too, all discrepancies were recorded and where required, corrective action was implemented. None of the DR's were critical.

Coil Dimensions: There are no significant deviations in the dimensions measured. None of the coils have any excess arc lengths. In fact, coil 227 is less than the minimum and will require shims during assembly.

Pole inner radial deviations are observed in all coils at certain locations along the length. Coil bumpers will need to be adjusted.



Report of the MQXFA13 Coils Acceptance Review

US-HiLumi-doc- 4609
Other:
Date: 11-02-2022
Page 5 of 7

Cable length seems to be the same for the coils from FNAL and BNL where in the past there was a systematic difference.

	Overall Coil Length (mm)
Pre-Series Requirement	4532 ± 5.0
Series Requirement	4529 ± 5.0
QXFA 139	4528.0
QXFA 141	4531.1
QXFA227	4527.6
QXFA229	4528.5

Regarding the remeasure of coil 136: the second set of measurements did not show any excess arc length as was observed earlier. In fact, further scrutiny of the measurements would lead to the conclusion that reproducibility is rather limited.

This is particularly concerning the outliers in the data. Some data re-produce quite well. It is possible, even likely, that the average value does not change much, but the min and max values and where the outliers are located is changed.

Question: How does LBNL data compare with FNAL data? How reproducible are the data if the coil is not removed, but measured on another day (say the following day)? How reproducible is the measurement set-up?

Coil Ordering: Based on RRR measurements of rolled strands and minor edge RRR of extracted strands, there are many possible assembly options.

There is one selection that seems to be most optimal, where opposing coils are fabricated by the same Lab.

P1	P2	P3	P4	V
227	139	229	220	336
227	139	220	229	336
141	227	220	229	338
141	139	229	220	338
141	139	220	229	338
141	139	220	227	340
227	141	220	229	336
220	141	229	227	341
220	141	229	139	341



Report of the MQXFA13 Coils Acceptance Review

US-HiLumi-doc- 4609
Other:
Date: 11-02-2022
Page 6 of 7

220	139	229	141	340
229	227	220	141	342
227	141	229	220	336
227	139	220	141	338
139	227	220	229	334
220	139	229	227	341
229	227	220	139	342
227	139	229	141	338
139	141	220	229	334
139	141	229	220	334
139	141	227	220	350
139	141	227	229	351
141	139	227	220	352
141	139	227	229	353

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 identified critical Discrepancies/Non-conformities?

Yes

4. Is there any coil that you recommend not to use in MQXFA13?

No, all coils are acceptable.

5. Do you have any other comment or recommendation regarding these coils and their conductor for allowing MQXFA13 to meet MQXFA requirements [1]?

3. Comments

All cables are dimensionally within specification and fairly uniform. Cable insulation at NEEWT shows good consistency in the thickness measurements done at the vendor and that performed at LBNL and is within specification.

Strand I_c and RRR are well above specifications.

Coil fabrication at FNAL and BNL shows only minor discrepancies.

For these coils the incidence of "popped" strands was not observed during coil winding. Overall coil lengths are well within specifications



Report of the MQXFA13 Coils Acceptance Review

US-HiLumi-doc- 4609
Other:
Date: 11-02-2022
Page 7 of 7

There are no major concerns regarding coil dimensions measured for the coils at LBNL. Reproducibility of coil dimension measurements at LBNL is questionable as evidenced by the re-measure of coil 136. Comparison with FNAL measurements needs to be performed. Cross-checking of measurements has been proposed and the Committee encourages the team to continue to pursue this approach.

There are many options available for coil assembly that are within the voltage criterion of < 353 V. One combination would likely be favored for coil assembly where opposing coils are from the same lab.

BNL reports more DR's for chips in the end spacers than FNAL. Is this due to a difference in the inspection protocol or does FNAL just have less of a problem? The Committee believes it would be a good idea to cross-check to determine if the same kind of defects appear at FNAL. If FNAL does not have this problem, perhaps BNL can take some lessons learnt and modify handling of the parts to minimize the damage.

There has been a great improvement on the documentation transfer to CERN, which is greatly appreciated, and we encourage the AUP team to keep working to ensure that the documentation transfer follows production as close as possible.

The Committee would find it helpful if, when discussing the DR's, to add a comment indicating the degree of impact or corrective action that is required.

4. Recommendations

NONE

5. References

- 1) *MQXFA Functional Requirements Specification*, US-HiLumi-doc-36
- 2) *Coils Acceptance Review for MQXFA07b and MQXFA11*, US-HiLumi-doc-4224.
- 3) *MQXFA10 Coils Acceptance Review*, US-HiLumi-doc-4186
- 4) *Specification for Quadrupole Magnet Conductor*, US-HiLumi-doc-40
- 5) *Cable Specification*, US-HiLumi-doc-74
- 6) *Quadrupole Magnet Cable Insulation*, US-HiLumi-doc-75
- 7) *QXFA Series Coil Production Specification*, US-HiLumi-doc-2986
- 8) *QXFA Series Coil Fabrication Electrical QC plan*, US-HiLumi-doc-521