US HL-LHC Accelerator Upgrade Project

Report of the Review of MQXFA03 Coils and Shims

Zoom meeting, March 14th, 2019

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1. Goal and scope

The HL-LHC AUP project is planning to start assembly of MQXFA03 magnet in April 2019. MQXFA03 is the first pre-series of the MQXFA low beta quadrupoles to be used in Q1 and Q3 for the High Luminosity LHC. If MQXFA03 meets MQXFA requirements [1] it will be used in the first Q1/Q3 cryo-assembly to be installed in the HL-LHC.

AUP is planning to use QXFA coils 109, 110, 111 and 202 for MQXFA03 assembly. The reviewers are requested to assess that the proposed coils (including the conductor) meet specifications [2], and to evaluate the impact of non- conformities in strands, cables and coils. The reviewers should also evaluate the proposed coil shim plan.

2. Technical details

Committee

Steve Gourlay – LBNL, chairperson
Najib Cheggour – ASC, NHMFL
Paolo Ferracin – CERN

Date and Time

March 18, 2019

Location/Connection

Video-link by Zoom

Link to agenda with talks and other documents

https://indico.fnal.gov/event/20110/

3. Comments

Strand and cables

Strands appear to have been well characterized and both strands and cables present properties that exceed specifications as documented in the US-HiLumi-doc-948. The committee noted only minor non-conformities which are irrelevant with regard to magnet performance.

Performance of the cables was extrapolated based on measurements of extracted strands. We note that the US-HiLumi-doc-948 design report does not seem to specify what the cable performance should be. Nevertheless, it would have been informative if measurements were conducted on at least one or two sample cables to verify calculations and avoid surprises at the magnet level. This is not necessarily a requirement for this particular magnet assembly, but a suggestion for future efforts if possible.

Coils

Coils 109, 110, 111, and 202 appear to have no major non-conformities. However, as mentioned by the presenters, coils 110 and 111 still need to be hi-pot tested at LBNL to 3.68 kV. The committee suggests recording the resistance between the coil and pole just in case it might be needed at some point in the future.

Coil 202 presents an irregularity at one particular spot. It was not clear to the committee whether this is a potential risk to the magnet performance. We suggest that it would be prudent to identify a spare coil in case the need arises. For future magnets it might be good policy to routinely make prearrangements for a spare coil.

Mechanical Assembly

The committee notes that the coil dimensional measurements are not consistent between the participating laboratories. The CMM measurements from LBNL should be the reference but the committee suggest that the project reconcile the discrepancies. The current shimming plan calls for different shims in the ends and straight section. This has not been done before. In general, there are still some uncertainties in the overall shimming scheme and a concrete plan should be agreed upon well before assembly.

Review Charges response

The committee was requested to answer the following questions:

1. Do coils 109, 110, 111, and 202 meet MQXFA coil specifications [2]?

   Strand is well within specifications for RRR and I_c. There were only minor discrepancies in cable width.

2. Are conductor/coil fabrication and QC data of the proposed coils adequate for a thorough evaluation and for allowing MQXFA03 to meet MQXFA requirements [1]?

   In general, yes. See comments above. In particular, it suggested to resolve the discrepancies between coil measurements at the different laboratories.

3. Are there major non-conformities? If answer is yes, have they been adequately documented and processed?

   No.

4. Is the proposed coil-shim plan properly based on CMM measurements, including measurements of coil ends?

   Yes, assuming the CMM measurements made at LBNL are the correct values.

5. Is the proposed coil-shim plan adequate for allowing MQXFA03 to meet MQXFA requirements [1]?

   Yes, but with the caveat that a closer, more detailed look at the straight versus end shimming choice be made.

6. Do you have any other comment or recommendation regarding conductor, coils or coil-shim plan for allowing MQXFA03 to meet MQXFA requirements [1]?

   See comments section above.

[1] *Acceptance Criteria Part A: MQXFA Magnet*, US-HiLumi-doc-1103.
[2] *MQXFA Final Design Report*, US-HiLumi-doc-948 sections 3 and 5.1.1; and *QXFA Coil Fabrication Electrical QA*, US-HiLumi-doc-521 step 16.

4. Recommendation

1) Conditionally accept coil 202 pending an internal investigation aimed at determining the relevance of the damage and the possible implications on magnet performance.

2) Further study of the shimming plan, particularly with respect to the ends versus the straight section, should be performed.