



Report of the Review of MQXFA03 Structure & Loading

US-HiLumi-doc-2260

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US HL-LHC Accelerator Upgrade Project

Report of the Review of MQXFA03 Structure and loading

Zoom meeting, May 22nd, 2019

Peter Wanderer – BNL, chairperson

Michael Anerella – BNL

Paolo Ferracin – CERN

Friedrich Lackner – CERN



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1. Goal and scope

The HL-LHC AUP project is starting the assembly of MQXFA03 magnet. 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.

MQXFA03 coils and shim plan were reviewed on March 14, 2019 [2].

The goal of this review is to evaluate the MQXFA03 structure and pre-load targets. The reviewers are requested to assess that the MQXF03 structure meets the MQXFA Structural Design Criteria [3], that non-conformities have been adequately processed, and that structure and pre-load targets will allow MQXFA03 to meet MQXFA requirements [1].

2. Technical details

Committee

Peter Wanderer – BNL, chairperson

Michael Anerella – BNL

Paolo Ferracin – CERN

Friedrich Lackner – CERN

Date and Time

May 22, 2019. Start time is 7:00 am (Pacific time)

Location/Connection

LBNL, room B47

Video-link by Zoom, info by email.

Link to agenda with talks and other documents

<https://indico.fnal.gov/event/20781/>



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Review Charges response

The committee was requested to answer the following questions:

1. Do structure design and pre-load targets meet MQXFA Structural Design Criteria?

Yes, for the material presented.

Findings. The structural design follows a graded analysis approach, using a Failure Analysis Diagram (FAD) for the most complex analysis, Grade IV and a safety factor of 1.2. The Grade IV analysis was applied to the two largest cutouts of the aluminum shell and to the cutouts in the weld strip. The loading shown in the FADs has safety factors greater than 1.2.

Comments. The end section of the weld strip has the lowest safety factor.

Recommendation. Extend analysis to include operations with both two and four bladders at full bladder pressure needed to permit load key installation. Apply same analysis for determining fillet radii to 0.5 mm cutout on weld strip groove.

2. Did structure fabrication and QC follow the recommendations of the *Review of the MQXFAP2 Al-Shell Issue and Lessons Learned*?

Yes.

Finding: In a note dated May 28, the LBNL group summarized its response to the key points of the recommendations (FEA analysis, measurements of K1c at 4K, flaw inspection, fatigue) which relate to the decision to reduce the FAD safety margin to 1.2.

Comment: The response of the LBNL group was very thorough.

Recommendation: see recommendation for Charge #1.

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

No.

Comment. CERN reviews non-conformities on a weekly basis. (AUP reviews them on a monthly basis.)

4. Have all Lessons Learned from previous MQXF magnets been implemented in MQXFA03 travelers?

No statement was made in regard to "all Lessons Learned."

Finding: Fourteen travelers are needed to specify the magnet fabrication process. The majority of them have been released. Revisions based on Lessons Learned have been and will continue to be made.

5. Are the proposed pre-load targets adequate for allowing MQXFA03 to meet MQXFA requirements?

Maybe. The proposed pre-load targets should be re-evaluated to include the analysis of available data from MQXFAP01b testing.

Findings.

- LBNL presented a plot of the azimuthal and axial preloads of the short models and the two long prototypes that had training performance consistent with the Acceptance requirement (Requirement: survive 50 quenches to Ultimate current; stable operation at nominal current).
- The pre-load target was stated to be consistent with MQXFAP01b.
- No data on retraining after a thermal cycle were presented. (Requirement: no more than three quenches to Nominal).
- The assembly plan also includes a target range for the strain on the shell.

Comment.

- As compared to MQXFAP01b, two changes result in there being more margin in the aluminum shell strength in MQXFAP03. First, the corner fillet radii have been increased as described. Second, the amount of collar key gap has been increased, resulting in greater coil stress for a given aluminum shell stress. Both of these changes increase the safety margin in the aluminum shells for a given coil stress.

Recommendation.

- Consider using as the pre-load target a higher value than the MQXFAP01 value, or else use the MQXFAP01b value, as it is known to be less than that required for nominal field, as a lower bound of the pre-load.
 - Reevaluate preload goal after test of MQXFAP01b is completed.
6. Do you have any other comment or recommendation to assure MQXFA03 is going to meet requirements?

Recommendation. Document the loading sequence in the Q&A section of the Indico page.



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REFERENCES

- [1] Functional Requirements Specification, US-HiLumi-doc-36 (April 30, 2019)
- [2] Report of the Review of MQXFA03 Coils and Shims, US-HiLumi-doc-2180 (March 22, 2019)
- [3] Structural Design Criteria, US-HiLumi-doc-909 (Sept. 27, 2018)