



## **US HL-LHC Accelerator Upgrade Project**

### **Report of the MQXFA10 structure and shim review**

*October 08, 2021*

- Peter Wanderer, BNL chairperson
- Mike Anerella, BNL
- Susana Izquierdo Bermudez, CERN



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US-HiLumi-doc-4202

Other:

Date: 10/8/2021

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## 1. Goal and scope

The HL-LHC AUP project is starting the assembly of MQXFA10 magnet. This is the third series magnet of the MQXFA low beta quadrupoles to be used in Q1 and Q3 for the High Luminosity LHC. If MQXFA10 meets MQXFA requirements [1] it will be used in a Q1/Q3 cryo-assembly to be installed in the HL-LHC.

MQXFA10 coils were reviewed on September 8, 2021 [2].

MQXFA Series magnet specifications are presented in [3].

Discrepancy or Non-Conformity Reports are generated whenever a component does not meet specifications. The goal of this review is to evaluate the MQXFA10 structure and shim plan. The reviewers are requested to assess that discrepancies and non-conformities of the magnet structure have been adequately processed, and that the shims will allow MQXFA10 to meet MQXFA requirements [1].

## Technical details

### Committee

- Peter Wanderer, BNL chairperson
- Mike Anerella, BNL
- Susana Izquierdo Bermudez, CERN

### Date and Time

October 08, 2021. Start time is 7/9/10/16 (LBNL/FNAL/BNL/CERN)

### Location/Connection

Video-link by Zoom, info by email.

### Link to agenda with talks and other documents

<https://indico.fnal.gov/event/51311/>



## 2. Review Charges response

The committee is requested to answer the following questions:

*1. Have discrepancies and non-conformities been adequately documented and processed?* No.

**Finding:** The MQXFA08 coil preloading stopped below the lower limit in the assembly procedure because the load on the conductor was at the upper limit of 110 MPa resulting in a non-conformance.

**Comment:** It would be useful to bring additional information to bear on the measurements related to this non-conformance. The total force exerted by the bladders can be compared to the total of the forces seen by the coils. Alternatively, the ratio of the coil azimuthal stress to the shell azimuthal stress could be plotted against bladder pressure to check that they track one another. Data from previous assemblies could be used to determine typical values. With these measures it could be possible to identify anomalous high strain gauges as inaccurate, to support increasing coil stress to within acceptable target limits.

**Recommendation 1:** Determine whether the comparison of total bladder force to coil force or plotting the ratio of the coil stress to the shell stress are useful parameters for monitoring the assembly of MQXFA10.

**Finding:** DR (AM-204) for coil 221 reports that one of the stainless steel pins used to align the inner and outer coils protruded into the coil keyway (MQXFA-NCR-0275). To compensate for this non-conformance, a procedure to relieve the G-10 collar alignment key in the region of the pin was proposed and approved by BNL and LBNL staff and by AUP QA and L2 management. However, the LBNL non-conformance disposition simply says, "Trim the pins."

**Comment:** A procedure to modify the G-10 key was chosen because it was easier and safer to do so off-line than grinding a stainless steel pin inside the superconducting coil.

**Recommendation 2:** Consult with affected colleagues before changing approved procedures.

**Recommendation 3:** In the future, supply more detail in repair procedures. For example, "trim the pin" should include details such as: carefully mask and tape coil except for repair window, vacuum while grinding, carefully clean with tack rag after vacuuming. This level of detail will be particularly important for helping new tech staff come up to speed on the repair of non-conformances.

**Finding:** LBNL MQXFA-NCR-0275 (rust on yokes): The disposition says, "File off the rust" followed by reinspection.

**Comment:** A more detailed procedure would include specifics about removing the filings during and after the filing process.

**Recommendation 4:** Reinspection should determine whether or not the yoke o.d. was reduced by the rust removal.



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2. If there are major non-conformities, have they been adequately documented and processed? Yes.

3. Are the proposed shims adequate for allowing MQXFA10 to meet MQXFA requirements [1]? Yes.

**Comment:** It would be useful to include in the preload information a calculation of the current corresponding to local unloading of the coils during excitation, at the axial position where the coils have the smallest azimuthal size (in this instance 0.1mm smaller than at the strain gauge location).

4. Have all recommendations from previous reviews [4, 5] been adequately addressed?

**Finding.** The LBNL team prepared a detailed resource loaded schedule that included detailed study of the availability of the staff and tooling needed for two assembly lines.

**Comment:** Technician staffing. There is concern because a lead assembly tech is expected to retire next spring and one of the other assembly techs may be lost due to the vaccination requirement. The staffing situation is improved compared to what it was at the time of the MQXFA09 structure review in July but the vaccination requirement jeopardizes this improvement. The risk of being short-staffed would be somewhat mitigated if two additional techs begin training in the immediate future. One would be the new hire (J. Wan). The other could be either the "support" tech (who is already on staff) or a tech from the pool supported by EG overhead. The new hire, expected in the next few weeks, could join the EG pool.

5. Do you have any other comment or recommendation to assure MQXFA10 is going to meet requirements? Yes.

**Comment:** The number of items that need to be discussed in the structure and shim review is decreasing, a good sign.

**Comment:** the upload of magnet data to the CERN MTF database is running very late.

### 3. Comments are above

### 4. Recommendations -summary

**Recommendation 1:** Determine whether the comparison of total bladder force to coil force or plotting the ratio of the coil stress to the shell stress are useful parameters for monitoring the assembly of MQXFA10.

**Recommendation 2:** Consult with affected colleagues before changing approved procedures.

**Recommendation 3:** In the future, supply more detail in repair procedures. For example, "trim the pin" should include details such as: carefully mask and tape coil except for repair window, vacuum while grinding, carefully clean with tack rag after vacuuming. This level of detail will be particularly important for helping new tech staff come up to speed on the repair of non-conformances.



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**Recommendation 4:** Reinspection should determine whether or not the yoke o.d. was reduced by the rust removal.

**Recommendation 5:** Proceed with assembly of Magnet MQXFA10 after completing recommendations #1 and #4.

### 5. References

- 1) MQXFA Functional Requirements Specification, US-HiLumi-doc-36.
- 2) MQXFA10 Coils Acceptance Review, US-HiLumi-doc-4186.
- 3) MQXFA Series Magnet Production Specification, US-HiLumi-doc-4009.
- 4) MQXFA09 Structure & Shims Review, US-HiLumi-doc-4183.
- 5) Production Readiness Review of the HL-LHC AUP Series Structure Fabrication & Magnet Assembly: 302.2.07 & Review of Series Magnet Specifications, US-HiLumi-doc-4005.

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