



**Report of Production Readiness Review  
of HL-LHC AUP Series Structure  
Fabrication & Magnet Assembly:  
302.2.07 & Review of Series Magnet  
Specifications**

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**US HL-LHC Accelerator Upgrade Project**

**Report of Production Readiness Review of the  
HL-LHC AUP Series Structure Fabrication &  
Magnet Assembly: 302.2.07 & Review of Series  
Magnet Specifications**

*February 24 and 25 2021*

- Peter Wanderer (BNL), chairperson
- Mike Anerella (BNL)
- Rodger Bossert (FNAL)
- Susana Izquierdo Bermudez (CERN)
- Diego Perini (CERN)



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## 1. Goal and scope

The HL-LHC AUP project is starting the fabrication of MQXFA Series Magnets (MQXFA08-23). MQXFA magnets [1] are the low-beta quadrupoles to be used in Q1 and Q3 Inner Triplet elements of the High Luminosity LHC. If these magnets meet MQXFA requirements [2] they will be used in Q1/Q3 cryo-assemblies to be installed in the HL-LHC. MQXFA Series magnets are assembled at LBNL (302.2.07) using coils fabricated at BNL (302.2.06) and FNAL (320.2.05), and magnet structures procured by LBNL (302.2.07). Five MQXFA Pre-Series magnets (MQXFA03/4/5/6/7) are to be assembled at LBNL before starting Series production. The first two series magnets (MQXFA03/4) were tested at BNL vertical test facility and both of them met all key requirements.

A Production Readiness Review (PRR) is a major review step in the HL-LHC Accelerator Upgrade Project (AUP). It is held at start of series production, and is intended to be a largely technical review, but it also includes assessment of the planned cost, schedule, and personnel needs to complete the production. The scope of this review includes also the review of the MQXFA Series Magnet Specification [3].

Scope of this review are the following items for Series Magnets:

- MQXFA Series Magnet Specification
- MQXFA Series Magnet Drawings
- Parts and materials for magnet structures
- Structure assembly, magnet assembly and QC test procedures
- Interfaces.



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## 2. Technical details

### Committee

- Peter Wanderer (BNL), chairperson
- Mike Anerella (BNL)
- Rodger Bossert (FNAL)
- Susana Izquierdo Bermudez (CERN)
- Diego Perini (CERN)

### Date and Time

February 24 and 25 2021; starting at 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/47193/>



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### 3. Review Charge responses

The committee was requested to answer the following questions:

1. Specifications: Are the specifications for MQXFA Series Magnet [3] complete? Do they (including referenced documents) cover all steps of structure assembly, magnet assembly and QC? Are magnets fabricated according to these specifications going to allow MQXFA magnets to meet MQXFA Functional Requirement Specifications [2]?

Finding: A complete set of assembly specifications was developed during the assembly of the first four magnets. Assembly of magnets MQXFA05 and MQXFA06 has allowed the opportunity to check that the specifications are complete. Test results for magnets MQXFA03 and MQXFA04 meet the MQXFA Functional Requirement Specification. This demonstrates that the Series Magnets can also meet the Functional Requirement Specification.

Comment: none

Recommendation: none

2. Scope and interfaces: Is the L3 task scope for 302.2.07 clearly defined? Are interfaces with other tasks sufficiently well-defined for executing the series magnet production?

Finding: The scope is in the WBS Dictionary. There are five ICDs with Fermilab and BNL and one with CERN. The scope and ICDs were reviewed at the CD-3 review and found to be satisfactory.

Comment: none

Recommendation: none

3. Drawings: Are all the series magnet structure and series magnet assembly drawings released? Have they been provided to CERN?

Finding: There are 130 drawings, all under revision control and sent to CERN. All structure drawings were made available to reviewers during the MQXFA Final Design Review, and during all subsequent DOE reviews.

Comment: Drawings are reviewed and approved only by the cognizant engineer. No independent checking, quality assurance or safety reviews were conducted.

Recommendation: none



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4. Manufacturing: Are the manufacturing work-flow documents and travelers — including scheduling, personnel needs, floor space, and facilities requirement — appropriate to execute the series magnet production?

Findings: An Assembly Breakdown Structure has been created. The staff is setting up a parallel magnet assembly line with completion expected in March.

The parallel magnet assembly line is to be supported by existing staff with only one new hire.

The commissioning of the second assembly line provides an opportunity to estimate technician labor needs taking into account vacation and sick usage as well as the frequency of use of facilities such as the overhead crane and the availability of specialized support groups such as survey.

**Recommendation:**

Complete a comprehensive daily workflow study using two magnet assembly lines in parallel. Confirm minimum required technical resources to support both assembly lines. Ensure sufficient resources are available for this minimum requirement plus contingency for illnesses, vacation, and other unexpected loss of resources.

5. QA/QC: Are the QA/QC plans adequate? Is there appropriate documentation for quality control procedures, manufacturing and inspection plan, and data reporting (including part and material traceability)? Is the magnet fabrication MIP complete and approved?

Findings: There are two Hold Points that allow for joint CERN-AUP review of the coil selection results and the magnetic field measurements of the coil packs. The purchase order number is used to assure traceability of parts and materials.

The staff has a tool for configuration management that will encompass parts revision, the bill of materials, and the fabrication procedure. This configuration control system has not yet been utilized. Expected utilization begins with magnet MQXFA07. Data was said to be available for prior magnets.

Comment: Use of data from prior magnet assemblies, such as the circumference of the four coils, to flag anomalies and trends is commendable.

**Recommendation:**



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It may be helpful to input the data from a magnet already assembled to commission the use of the tool. Ensure sufficient resources are available and complete configuration control reports on already assembled magnets prior to assembly of magnet MQXFA08.

6. Cost and Schedule: Are the cost and schedule estimates sufficiently well-defined and of adequate maturity to support the series production?

Finding: The major components have been procured through Master Agreements with vendors. The agreements run from 2019 through 2022. The procurements are going well. the Master Agreement awards for FY21 are expected by April 2021.

Comment: The Master Agreements are providing both stability in pricing and some flexibility in vendor selection and schedule for components.

Recommendation: none

7. ES&H: Have all hazards been identified and addressed? Are ES&H policy and documentation sufficient for the series production?

Finding: A Hazard Analysis Report was prepared as part of the DOE CD process. The magnet assembly task is following the LBNL ES&H manual and the LBNL EMS protocols. Special work rules have been created to minimize COVID-19 transmission.

Comment: The anti-COVID-19 changes include daily work planning meetings and more frequent tours by management staff. Both are good practices.

Recommendation: none

8. Risk: Are risks understood and appropriately managed for the series production?

Finding: The project has identified six risks for the series production; all are medium risks.

Comment: The Project is in the process of making purchases that will allow two of the risks to be retired. The others are understood and appropriately managed.

Recommendation: none

9. Reviews: Are all recommendations for this L3 task from previous reviews [4] addressed?

Finding: The Project received recommendations from reviews that included the whole magnet assembly task as well as reviews that are part of the coil selection



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and the assembly process for individual magnets. It was stated that all recommendations have been implemented.

Comment: Highlighting the establishment of a Structural Design Criteria manual and its use in the redesign of the aluminum shell was a good idea.

Recommendation: none

## 10. Is this L3 task ready for series production?

This L3 task is ready for series production after responding to the two recommendations above.

## 4. References

- 1) MQXFA Final Design Report, US-HiLumi-doc-948.
- 2) MQXFA Functional Requirements Specification, US-HiLumi-doc-36.
- 3) MQXFA Series Magnet Production Specification, US-HiLumi-doc-4009
- 4) Closeout Report on the DOE/SC CD-3 Review of AUP, US-HiLumi-doc-3963.