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Title
SUPERCONDUCTING MAGNET PROGRAM / LARP QXF
LQXF - MAGNET
MQXFA MAGNETIC MEASUREMENTS WI

Warm Magnet Measurement Work Instructions (WI)

Windchill Unique ID: SU-1010-2018

Rev: A

Issued:

Prepared by

Checked by

Work Instructions Originator

Approved by

Contents

Revision History

Revision	Issued	Changes
A	12-13-2019	Original Issue.

Purpose

The purpose of this Working Instruction is to describe the process of completing the warm magnetic measurements on the MQXFA quadrupole magnets at LBNL.

Scope

The warm magnetic measurements are performed twice. Once after the coil pack has been assembled and once after the splice box has been attached to the nearly finished magnet. This procedure covers both of those measurements.

Definitions

Reference Documents

- SU-1008-8074 – Coil Pack Subassembly WI
- SU-1008-8067 – Splice Box WI
- SU-1011-0518 - MQXFA Test Assembly
- SU-1009-5803 Magnet measurement assembly drawing
- SU-1011-7026 – MQXFA Fiducial Assembly
- SU-1006-1719 – MQXFA Fiducial Block
- Fiducial block measurements, SU-1010-4045
- L. Bottura, “Standard analysis procedures for field quality measurement of the LHC magnets – part I: harmonics” LHC/MTA, Tech. Rep. LHCMTA-IN-97-007, 2001.

Tools Required

Calibrated Tools:

- Laser Tracker
- Magnet Measurement Equipment

Non Calibrated Tools:

- Aluminum pipe (5.270" OD, 5" ID, 216" long)
- Clamps
- Insulation
- Alligator clips
- Fiducial blocks

Tools Recommended:

- Multimeter

Hardware Required

Fabricated Parts & Hardware:

Part #	Description	Req'd
SU-1011-0518	MQXFA Pre-Series Magnet Assy	1
SU-1010-8225	Coil Pack Subassy	1

Work Instructions

1 Overview

1. Enter the following information on the Verification Signoff Sheet:
    a. Serial number
    b. Start date

2 Introduction to Measurement Equipment

2. The warm magnetic measurement equipment

NOTE: Always turn off the control units for the stepper motors before disconnecting the motor cables.

Always disconnect the power cable from the motors before manually rotating the motor shaft.

3. Linear drive control procedure and note
    a. Turn on the power supply box, green light will be on.
    b. Once the power supply is on, the motor freezes. We cannot manually move it.
    c. Turn on the Poll Labview program. Update the COM port number and file path. Stop and start the Poll Labview program.

Figure 1: Top Box: power supply & communication to linear motor, Middle Box: speed of rotation control & power supply for rotating motor, Bottom Box: current to voltage converter

Figure 2: Power supply for the magnet and current monitor for the power supply to the magnet

Figure 3: Encoder to provide Z-axis position reading, 2 proximity sensors to ensure height is okay.

3 Preparation for Coil Pack Measurements

4. Insert aluminum pipe into the coil pack aperture. Take care with any instrumentation wiring in and around the bore.
5. Insulate voltage tap wires at both lead and return ends. (Cover in tape).

VERIFICATION POINT 1

6. Clamp leads together according to the splice box diagram

7. Wrap the leads in pipe insulation to isolate them from each other. Use plastic sheets to keep the leads separate in the area where they are close together.

Figure 4: One set of leads wrapped in pipe insulation

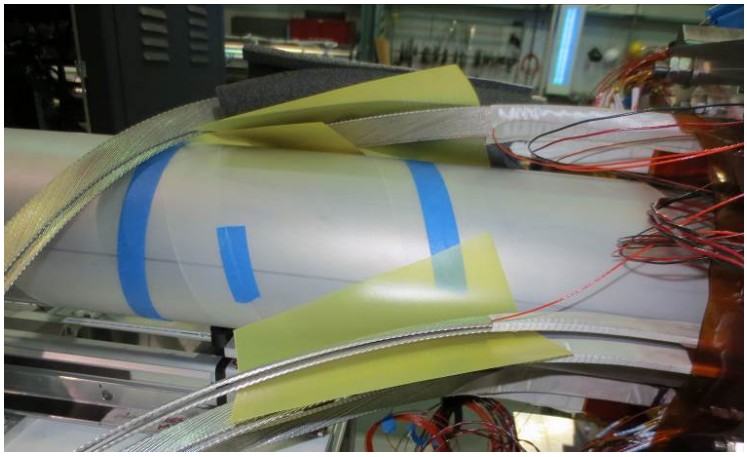

Figure 5: Use plastic sheet to insulate leads near the coils

8. Verify leads are isolated.

VERIFICATION POINT 2

9. Check that resistance between leads and loadpads is "O.L." (open loop) on a multimeter.
10. Connect cable shielding to the chassis ground close to the DAQ side.
11. Verify the gain of the amplifier chain.

VERIFICATION POINT 3

12. Attach red wire from power supply to sector 1, outer coil
13. Attach blue wire from power supply to sector 3, inner coil

4 Coil Pack Measurements

Before the coil pack is inserted into the shell-yoke assembly, measure:

- The geometric field errors along the magnet aperture.

Measurement parameters:

a. Probe rotation speed: 3 Hz

b. Nominal measurement current: ±15 A

c. Displacement: 108.74 mm (probe effective length) at both ends: 54.37 mm

d. Probe rotation direction: counterclockwise, viewed from either lead or return end

14. Move to the scan location
15. Measure the level angle
16. Measure at one current polarity
17. Stop probe rotation and survey the probe retroreflectors
18. Reverse current polarity, rotate the probe and take measurements
19. Move to the next position and repeat steps 15-18
20. Record the magnet voltage at the nominal current for each measurement. Compare to the nominal magnet resistance.

VERIFICATION POINT 4

5 Preparation for Splice Box Measurements (Including Survey)

21. Insulate voltage tap wires at both lead and return ends. (Cover in tape).
22. Measure the magnet fiducials

6 Splice Box Measurements

After the magnet has been preloaded and the splice box has been installed, measure:

- Geometric field errors along the magnet aperture
- Magnetic center with respect to external fiducials along the magnet
- Relative main field twist angle along the magnet aperture

23. Move to the scan location
24. Measure the level angle
25. Measure at one current polarity
26. Stop probe rotation and survey the probe retroreflectors
27. Reverse current polarity, rotate the probe and take measurements
28. Move to the next position and repeat steps 23-27
29. Record the magnet voltage at the nominal current for each measurement. Compare to the nominal magnet resistance.

VERIFICATION POINT 5

7 Fiducialization

30. Calibrate the probe rotation axis and A, B, C, D retroreflectors. Glue a retroreflector to the rotating probe and manually rotate the probe for the laser tracker measurements. Repeat this calibration for [each magnet/annually]
31. Use the same magnetic survey tooling block (SU-1006-1710, the part, SU-1006-1719, the assembly) at each tack block position. See drawing SU-1011-7026 for tooling block locations.
32. Use at least 4 different set-ups of the laser tracker and 13-14 floor points to capture all the points and get a minimal amount of uncertainty.
33. Provide a table with point name, X, Y, Z coordinates, Uncertainty in X, Y, Z, and magnitude of uncertainty.

VERIFICATION POINT 6

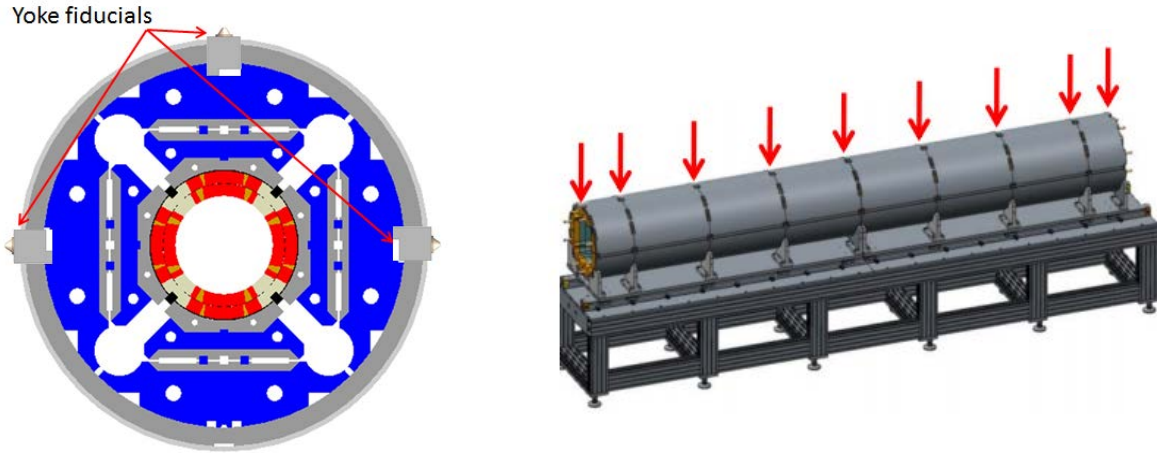

Figure 6: Survey tooling block locations. 27 total.

8 Data Reduction

34. For data reduction, use: L. Bottura, "Standard analysis procedures for field quality measurement of the LHC magnets – part I: harmonics" LHC/MTA, Tech. Rep. LHCMTA-IN-97-007, 2001.

VERIFICATION POINT 7

9 Completion

35. Attach results to these instructions
36. Ensure all component serial numbers are entered in the Verification Signoff Sheet.
37. Enter the completion date and temperature in the Verification Signoff Sheet.
38. Have Verification Signoff Sheet signed and dated by Quality Assurance.

Verification Signoff Sheet

EACH MECHANICAL SYSTEM IS REQUIRED TO HAVE A COMPLETED VERIFICATION SHEET.
VERIFICATION MUST BE DONE BY AN ENTITY OTHER THAN THE ASSEMBLY TECHNICIAN.

SERIAL NUMBER:	
MEASUREMENT START DATE:	**MEASUREMENT COMPLETION DATE:**
COMPLETE ASSEMBLY VERIFIED BY (Sign and Date):	

VERIFICATION POINT	ASSEMBLY TECHNICIAN (Sign & Date)	RECORDED INFORMATION	CAL INFO	VERIFICATION BY (Sign & Date)
1		Verify voltage tap wires are electrically isolated	TOOL ID LAST CAL DATE	
2		Verify leads are electrically isolated	TOOL ID LAST CAL DATE	
3		Verify the gain of the amplifier chain	TOOL ID LAST CAL DATE	
4		Coil Pack Raw Measurement Data stored	N/A	

5		Full Magnet Raw Measurement Data stored		N/A	
6		Fiducialization Data stored		N/A	
7		Magnet Measurement Report stored		N/A	
		Coil Pack	Full Magnet		