FERMILAB
Technical Division
Superconducting Radio Frequency Development Department

Specification and Measurement Procedures of Magnetic Properties of Parts for LCLS II Cryomodule Assembly

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Revision History

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Table of Contents

1. PURPOSE 4

2. AUTHORIZED PERSONNEL 4

3. PPE, CLOTHING 4

4. TOOLS 4

PROCEDURE FOR MEASURING MAGNETIC PROPERTIES 5

4.1. PERMEABILITY 5
4.2. REMNANT MAGNETIC FIELD OF SMALL PARTS 5
4.3. REMNANT MAGNETIC FIELD OF LARGE PARTS 5

5. MAGNETIC PROPERTY SPECIFICATION (PARTIAL LIST) 6

6. EXCEPTIONS 7

1. Purpose

Maintaining high quality factor (Q_0) of LCLS-2 cavities requires a very low residual magnetic field near cavity RF surfaces. The basic requirement is for any part of the cryomodule to add no more than 5 milliGauss of magnetic field at the surface of the RF cavity.

Mechanical parts that have a permeability that is greater than unity can become magnetized. Combined with other similar components, this can increase the ambient magnetic field at a cavity surface even inside a local magnetic shield. All the components assembled onto the cavity are expected to be surveyed by a magnetometer and/or permeability reader.

Parts that have no residual magnetic field but high permeability can gain a high residual magnetic field if they are in a close proximity to magnetic sources such as high power RF circulators, ion pumps, permanent magnets, activated electro magnets or solenoids, or heavily magnetized steel structures.

Parts that have a residual magnetic field but permeability close to unity can be demagnetized. Typically, parts should have permeability less than 1.1. Parts that are custom made may exceed a permeability of 1.1 due to machining or welding. If the part requires long lead procurement time, deviation can be accepted if demagnetization successfully reduced the remnant field to within specification. Once they are demagnetized, care should be taken so they are not exposed to magnetic sources.

2. Authorized Personnel

No authorization is needed to operate the magnetometer and permeability reader. Follow the operation manual for the two instruments. No one who has an electrical medical implant should be allowed near a demagnetizing tool while it is in operation. Such personnel should be excluded from the area of the magnetizer for a distance sufficient so that the maximum stray magnetic field is less than 5 Gauss.

3. PPE, Clothing

No PPE is required to operate the magnetometer and permeability reader.

Other PPE requirements that may be specific to handling of parts to be measured are included in part or tooling specific procedures.

4. Tools

Permeability Reader: Ferromaster Permeability Meter
Magnetometer: 3-axis Coliy G93 DC milliGauss meter
Zero gauss chamber: Custom made A4K cylinders, FNAL/ILC Cryoperm magnetic shields, or equivalent.

Procedure for measuring magnetic properties

4.1. Permeability

4.1.1. Make sure the permeability reader is away from sources of strong magnetic fields (< 20 Gauss)

4.1.2. Check the battery by turning on the permeability reader.

4.1.3. Use the included known permeability material to check the value of the permeability (1.3). Contact the vendor if the reading does not match, which indicates the instrument is defective.

4.1.4. Move the probe to the surface of the subject item to within a distance of 0.25 inches, as permeability is a localized effect. If the surface contact with the probe is allowed, it is preferred. As an example, the permeability can vary from bolt hole to bolt hole in a con-flat flange. Record a few of the highest permeability readings.

4.2. Remnant magnetic field of small parts

4.2.1. Check the battery by turning on the magnetometer

4.2.2. Check the probe reading in a zero gauss field chamber. Zero the probe reading if necessary.

4.2.3. Keep the probe un-disturbed inside the zero gauss field chamber and move the subject part close to the probe within a specified distance (for example, 0.25 inches for a field probe). Record a few of the highest readings.

4.3. Remnant magnetic field of large parts

4.3.1. Check the battery by turning on the magnetometer

4.3.2. Check the probe reading in a zero gauss field chamber. Zero the probe reading if necessary.

4.3.3. Outside of the zero-gauss chamber, stabilize the probe with a holder fixture that provides large clearance around the probe. Zero the probe reading again to null-out the effects of the ambient magnetic field. Keep the probe un-disturbed and move the part close to the probe within 0.25 inches. Record a few of the highest readings.

5. **Magnetic property specification (Partial List)**
   Please refer to the corresponding engineering specification document for updated values.

   Note that this list is a work in progress and will be updated in subsequent revisions of this document.

	Description	Remnant field [mG]	Distance [in]	Relative Permeability	Document Number With Permeability Specification	Note
1	2-3/4" Conflat copper gasket					N/A
2	Field probe	1	0.25	1.1		
3	Nut M8					N/A
4	Nut silicon bronze					N/A
5	Blank-off flange studs M8 50mm lg	1	1	1.1		
6	Studs M6 40mm lg	1	0.25	1.1		
7	HHCS silicon bronze M6 20mm lg					N/A
8	SHCS M4 20mm lg	1	0.25	1.1		
9	Mini Conflat copper gasket					N/A
10	Burst disk	1	1	1.1		
11	Right angle valve	5	3	1.1		
12	Washer M8 od:15.50mm	1	1	1.1		
13	Washer M6 od:11.50mm	1	0.25	1.1		
14	Washer M4 od:8mm	1	0.25	1.1		
15	Conflat blank-off flange	1	1	1.1		
16	Probe tip 11mm					N/A
17	Blank-off flange	1	2	1.1		
18	HOM blank-off flange	1	0.25	1.1		
19	Fixed coupler	1	0.25	1.1		
20	Burst disk port weldment	1	2	1.1		
21	Silicon bronze nut plate					N/A
22	Beampipe flange seal					N/A

23	**HOM couplers & field probe flange seal**					**N/ A**
24	**Main coupler flange seal**					**N/ A**
25						

6. Exceptions

a. Invar Rod

Mitigation: In-situ demagnetization in the cryomodule

b. Tuner Motor

Mitigation: Local Cryoperm Shield

c. Superconducting Magnets

Mitigation: In-situ demagnetization in the cryomodule (if necessary. Modelling indicates that this will not be the case)