504313.001 Magnet specification

Magnet specification for Phase Shifter

Revision History Log:

Date:	Rev.:	Init:	Changes:
2024-02-09	A	FRBO/ DANA	Initial version

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1. Introduction

1.1 Purpose

This document covers the specification of magnets for arrays for 29 Phase shifters.

1.2 Scope

This request covers:

- Manufacturing and magnetization of the Neodymium Iron Boron magnets.
- Measurement and reporting of B_r, H_{cB} and H_{cJ} for the batch(es) of material used for manufacturing of the magnets.
- Full mechanical measurement and reporting of all magnets.
- Measurement and reporting of the three components of the average magnetization of the magnets for the Phase Shifter arrays.
- Measurement and reporting of north/south effect.
- Coating of magnets.
- Marking of magnets.

Complete compliance with this specification is expected. Any desired deviation from the procedures outlined in this specification will be reviewed and must be approved by Danfysik A/S in writing prior to use. This specification is based on the SLAC requirement LCLSII-HE-1.3-ES-0244-R2 with a few extra requirements.

Many of the processes documented in this specification are subject to regulations by local health and safety legislation. Any party using this specification must ensure that the procedures they implement are compliant with any such legislation.

1.3 Background

Danfysik A/S is a privately owned company situated in Denmark. We have since 1964 served science and industry customers worldwide, primarily in the fields of particle acceleration.

2. Quantity

2.1 Quantity of magnets to manufacture

A total of 456 permanent magnets are required. They are divided into the following categories as shown in the following table.

Table 1. Magnet types used for the phase shifters.

Magnet Identifier	Number of Blocks	Drawing Number
SXRHE-HL	66	7103050675
SXRHE-VL	130	7103050674
SXRHE-HS	130	7103050673
SXRHE-VS	130	7103050672

3. Physical and magnetic properties

3.1 Material and magnetic properties

All magnets must be manufactured from a single lot of dysprosium or terbium diffusion hardened Neodymium Iron Boron (NdFeB). The blocks shall be made by transverse die-pressed. The closed circuit remanence shall be $B_R \geq 1.3$ T and the intrinsic coercive field (H_{cj}) shall not be less than 1990 kA/m (25 kOe) at 20°C for a surface layer at least 1 mm deep.

The bulk intrinsic coercive field (H_{cj}) shall not be less than 1670 kA/m (21 kOe) as measured at 20°C. The normal coercive field (H_{cb}) shall not be less than 970 kA/m (12.2 kOe) at 20°C.

3.2 Pressing method

The magnet blocks must be made with the highest uniformity of magnetization and therefore the magnet block shall be manufactured with the transverse die-pressing method.

3.3 Single block

The magnets must be made as single blocks without the use of gluing.

3.4 Marking and identification

Each magnet must be marked with an identifier and a serial number as defined on the drawings. The marking method proposed is laser printing, but other permanent marking might be proposed. The marking method shall be approved by Danfysik before commencing manufacturing. Further, the direction of magnetization shall be marked as indicated on the drawings (i.e. on both the top and bottom surface such that a label is visible for when mounted in standard phase shifter keepers).
The position and orientation of the engraving must be able to define the coordinate system for the magnetic measurements. The coordinate system must be the same for all blocks and explicitly defined by a drawing delivered to Danfysik.
See also 3.9 concerning magnetization directions.

3.5 Magnetic distribution and angular deviation

For all blocks of a given type, the distribution of the magnetization shall be less than ±1.0%. More precisely, no magnet block have an absolute magnetization different by more than 2% from any other block of the same type.
The magnetization shall be precisely parallel to the appropriate faces, as shown on the attached drawings, the maximum deviation angle shall be less than ±1.1° (20 mrad).

3.6 Closed circuit remanence

The difference between the average closed circuit remanence of all 4 types of magnets must be minimized. This implies that care must be taken at the selection of material and blocks used for production of the thin magnets. We can calculate the thickness effects on the average observed magnetization due to demagnetizing effects, so we do expect the measured observed magnetization to reflect this in the form of reduced average magnetization for the thin magnets. If needed, we can inform you about the expected ratio of average magnetization for the different magnet types.

3.7 North/South effect

The difference between the field on the north pole (B_N) and south pole (B_S) sides

$$\Delta_{NS} = \frac{|B_N| - |B_S|}{0.5 * (|B_N| + |B_S|)}$$

shall be less than ±2.5% as measured in the middle of the magnet faces at a distance of 10 mm. The average value of the north/south effect must be close to zero when it is averaged for each of the individual types of magnets.

3.8 Coating

The magnet shall be coated with Aluminum using an IVD process. The coating thickness shall be between 5 µm and 10 µm.

3.9 **Magnetization**

The magnets shall be magnetized after coating. Half of the magnets shall be magnetized in one direction regarding the pressing direction and the other half shall be magnetized in the opposite direction (180 degrees) to reduce the effect of any possible systematic errors from the pressing.

3.10 **Helmholtz measurements**

The Helmholtz coil measurements of the three components of the average magnetization shall be performed with the following requirements:

- The data must be referenced to the magnet block frames clearly defined when delivered to Danfysik (see the magnet specifications drawings).
- The results shall be delivered to DANFYSIK as an electronic text file.
- The induced voltage integration is to be measured with a precision of at least 0.1%.
- The reproducibility of the Helmholtz coil measurements shall be 0.1% or better for the main dipole component and 0.1 degrees or better for the angular deviation.
- The measurements are to be made a room temperature (20°C is preferred).
- The temperature shall be stable within ±1°C.
- The temperature of the magnet blocks shall be measured to an accuracy of 0.3°C.
- The measurements shall start after the magnets have obtained thermal equilibrium.

4. Delivery

Internal packing shall be adequate to prevent movements and vibrations during transportation.
The magnets must be packed individually with the serial number marked on the outside of the protection.
The manufacturer shall ensure that the blocks are fully and satisfactory protected during handling and transportation. Packing cases shall be of robust nature for lifting and transportation.
The magnets must be stored in dry areas to avoid moisture degradation and must not be subjected to temperatures above 60°C.

5. Acceptance

Any block showing:

- important surface defects (cracks, broken edges, non-uniform coating, non-coated areas),
- wrong mechanical tolerances (defined in the attached drawings),
- wrong magnetic characteristics, as defined earlier.

will be rejected