| LCLS Engineering Specifications Document # 1.2-146 | Injector | Revision 0 |
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# LCLS Injector Dogleg Dipole Magnets

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*Check the LCLS Project website to verify that this is the correct version prior to use.*

Brief Summary:

Change History Log

| Rev Number | Revision Date | Sections Affected | Description of Change |
|---|---|---|---|
| 000 | 7-22-05 | All | Initial Version |
| | | | |
| | | | |

## 1.0 Introduction

The Linac Coherent Light Source (LCLS) project at the Stanford Linear Accelerator Center (SLAC) is intended to create a free electron laser source of 1.5 Å x-ray pulses of unprecedented brightness and short time duration. The LCLS injector requires two 'dogleg' magnets to steer an electron beam from a photocathode injector into the main linear accelerator to generate the electron beam required for the LCLS. Further information can be found at: http://www-ssrl.slac.stanford.edu/lcls

## 2.0 Description of Assembly

This magnet will be fabricated according to the requirements in this ESD and drawing package SA-380-300-00 and all of its subassemblies. If there is any confusion, the drawings take precedence over this document. The magnet assembly comprises the following main components.

- Magnet iron yokes.
- Copper coils with electrical and cooling terminations.
- Trim coils and terminations
- Thermal switches and wiring terminations
- Safety covers for electrical terminations
- Mechanical fiducial mounts

- Identification and test certification plate

## 3.0 Engineering Requirements

### 3.1 Magnet Design Parameters

The basic parameters of the magnet are shown in table 1:

| Parameter | Value | Units |
|---|---|---|
| | | |
| Pole-to-pole gap | 30 | mm |
| Maximum field on-axis | 10.03 | kG |
| Pole length | 173.2 | mm |
| Effective length | 20.32 | cm |
| Maximum current | 333 | A |
| Maximum voltage drop | 8.98 | V |
| Dipole field integral at maximum current | 2.038 | kG-m |
| Maximum power dissipation | 2963 | W |
| Maximum current density | 8.08 | $A/mm^2$ |
| Coil Turns | 36 | Per coil |
| Minimum cooling water flow $\Delta P$ = @100psig/coil | 0.26 | Gallons/m |
| Round Cu conductor outer diameter - bare | 0.3125 | in |
| Round conductor outer diameter - insulated | 0.335 | in |
| Round conductor inner diameter | 0.125 | in |

Table1: LCLS Injector dipole magnet parameters

This document calls for the Vendor to build these magnets according to the drawings, materials specifications, and processes described in the enclosed drawings and the text below.

### 3.2 Poles and Flux Returns

#### 3.2.1 Material Specification

The poles, mirror plates, and flux return yokes shall be made from

laminated, grain-oriented silicon steel that is coated with a thin polymeric insulation. The drawing package specifies a standard size lamination available pre-punched from Tempel Steel, (http://www.tempel.com/). The laminations are epoxied together, and the entire assembly has connecting members welded to the outside. External brackets are to be of 304 or 316 stainless steel. The vendor shall indicate choice of epoxy in his response to this bid request.

### 3.2.2 Fasteners

Fasteners must be either non-ferromagnetic or if they are ferromagnetic, they must not contribute to remnant fields. They must be satisfactorily corrosion resistant. Weld filler must be of a soft, low carbon steel or stainless steel.

### 3.2.1 Tooling Balls

A set of four stainless steel tooling ball sockets shall be welded to the external yoke of the magnet to facilitate optical survey alignment. These sockets shall be designed to fit precisely the Sphere Mount p/n 1.5 NMSM-1.000-2500 manufactured by Hubbs Machine & Manufacturing, Cedar Hill Missouri.

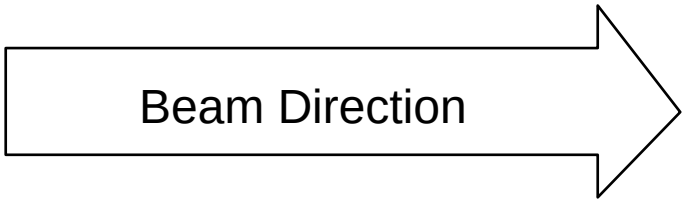
### 3.2.3 Identification

Each magnet assembly shall have affixed to the outer surface of an upper part of the yoke a metal identification plate stating:

- The identifier “LCLS Injector-to-Linac Dipole Magnet”
- Number of magnet within this production schedule
- Name of Vendor, and date of completion
- Indication of successful completion of mechanical tests
- Indication of successful completion of electrical tests
- “SLAC Drawing Number SA-380-300-00, rev. 0”
- Total weight of magnet in pounds.

Each magnet shall also have a large white painted arrow on each side pointing in the direction towards the terminals, with ‘Beam Direction”

lettered on the shaft of the arrow, thus:




## 3.3 Coils

### 3.3.1 Requirements

The coils for these magnets shall be of a hollow copper conductor, water-cooled design. The conductor in each coil shall be continuous, with no internal joints. The terminal blocks shall be protected by a removable cover that prevents contact with exposed magnet and power supply conductors.

The Vendor may fabricate or procure the coils required for these magnets. The Vendor shall make available to SLAC details of the winding process, including the design of the winding fixtures, if SLAC requests these.

### 3.3.2 Epoxy and Ground Wrap

SLAC recommends the following technique for the application of epoxy to the magnet coils. As the conductor is wound around its winding form it is to be painted liberally with this epoxy: P.D.George/Sterling® E-300HB Thermopoxy® compound available from the P.D. George Company, 5200 North 2nd Street, St Louis, MO 63147, phone 314-621-5700 or one of their distributors. The SLAC recommended cure cycle for this (highly thixotropic E300HB) epoxy is 8 hours at 150ºC. It is not necessary to cure for 16 hours, nor to do a postcure at 180 ºC.

The main coils are to be ground wrapped with a 'B-stage' epoxy impregnated tape, and liberally applied with E300HB epoxy, and cured for 8 hours at 150ºC. Trim coils are to be wound using wet layed-up E300HB epoxy also, but they should not be ground wrapped.

The vendor shall supply a detailed description of the process and materials

they propose for this fabrication step, as part of their response to this bid request. The processes and materials shall be those described in the drawings, or shall be proven to be equivalent and must approved by SLAC.

### 3.3.3 Coil Tests after Final Cure

Coil resistance measurements shall be made with a micro-ohmeter resistance bridge at room temperature, with the coil temperature uniform throughout and steady state conditions prevailing. The resistance of each coil shall be within ± 5% of the value calculated from the resistance on the design data sheet in drawing package, adjusted for temperature, and within ± 1.5% of each other.

An impulse ("ring") test shall be performed on each coil, in which pulses of 500 volts shall be impressed across an LC circuit including the magnet, and the test shall verify that there are at least 20 oscillation peaks above noise. There must be no high frequency noise on the oscillating signal

The Vendor shall specify his protocols for these coil tests as part of the response to this bid request.

### 3.3.4 Burn-in

After full assembly, the magnets shall be operated with coils at maximum current for a period of not less than 4 hours continuously, with cooling water with a pressure drop of 100 psig and flow as specified in Table 1. If necessary, SLAC will loan the vendor a suitable power supply, with shipping cost covered by the vendor.

## 4.0 Tests and Measurements

### 4.1 – Materials Qualification

Specification data for the materials used for the ferromagnetic flux returns and poles, copper coils, and insulation materials shall be supplied.

## 4.2– Mechanical Qualification

When fully assembled, the gap between the poles shall be measured for parallelism. The gap shall vary less than ±0.001" over the entire pole faces.

## 4.3 – Electrical Measurements

After full assembly of the magnet, the main and trim coils shall be tested individually for resistance and found to be within ±1.5% of each other at room temperature, The main coils shall be hi-pot tested at 1 kV DC for 1 minute, and found to have less than 100 μA leakage to the yoke. The trim coils shall be hi-pot tested at 500 VDC for 1 minute, and found to have less than 100 μA leakage to the yoke, and to the other coils.

## 4.4 – Flow and Hydrostatic Measurements

The vendor shall measure the flow of cooling water through each coil at room temperature, with pressure drop of 100 psig. The output flow shall meet the specification in Table 1 within 10%.

The vendor shall also show that when the cooling channels are filled with water, at 250 psi, there is no appreciable loss of hydrostatic pressure after a period of 15 minutes, and no detectable leakage. The coils must be blown thoroughly dry before shipping.

The vendor may substitute a suitable vacuum leak check for pressure test, and should detail his proposed testing strategy in the response to this bid request.

## 5.0 Measurements at SLAC

SLAC will perform quality assurance tests on the magnets upon receipt. These measurements may include testing of:

- The materials, to assure that they meet specifications.

- The mechanical construction, to assure that it conforms to design drawings.
- The coils, to assure that they meet electrical, flow, and hydrostatic specifications.
- Magnets that do not pass any of these tests at SLAC may be rejected or returned to the Vendor for rework, with shipping at the Vendor's expense.

## 6.0 Delivery

### 6.1 Shipping Crates

Magnets shall be fully assembled and packed individually in crates. The shipping crate shall be attached to a pallet so that it can be moved using standard handling devices (forklift or pallet jack). Irreversible indicators that record vertical shock loads of more than 10 G shall be attached to each crate.

### 6.2 Environmental Protection

The magnet shall be covered or wrapped to protect it from moisture and dust within the shipping crate. It shall be properly braced and cushioned within the shipping crate so that it will not shift within the crate during handling and shipment.

### 6.3 Marking

Each crate shall be labeled on the outside with:

- The identifier "LCLS Injector-to-Linac Dipole Magnet"
- the name of the receiver, Carl Rago. Bldg 26
- the address of SLAC, 2575 Sand Hill Road, Menlo Park, CA 94025,

USA

- the serial number of the magnet inside
- the gross weight of each crate,
- conspicuous arrows to indicate its upright position.