Hall Probe Bench Specification

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Canadian Light Source Inc.
101 Perimeter Road
University of Saskatchewan
Saskatoon, Saskatchewan Canada

	Signature	Date
	Original on File – Signed by:	
Author	Ingvar Blomqvist	02-05-08
Reviewer #1	Dan Lowe	
Reviewer #2	Elder Matias	
Reviewer #3	Les Dallin	
Approver	Emil Hallin	

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REVISION HISTORY

Revision	*Date*	*Description*	*Author*
A	02-03-25	Original Draft	Ingvar Blomqvist
B	02-04-12	Revised Draft	Ingvar Blomqvist
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1.0 INTRODUCTION

1.1 PURPOSE

A Magnet Measurement Facility [1] will be set up at the Canadian Light Source, Inc (CLS) for assembly and shimming of Insertion Devices (IDs). This document contains the mechanical specification for the Hall Probe Bench in the facility.

1.2 SCOPE

This document specifies the requirements for the CLS Magnet Measurement Facility Hall probe bench. This work includes, but is not limited to:

- All tooling
- Materials
- Equipment
- Commercial components
- Detailed drawings
- Fabrication
- Assembly
- Testing & Inspections
- QA/QC documentation
- Delivery to the CLS site
- Assistance in setting up the bench at CLS

1.3 BACKGROUND

CLS is a 3rd generation synchrotron light source, where the most intense synchrotron light will be produced by magnetic IDs installed in the 4.97 m long straight sections of the ring. The ring has 12 straight sections, of which 10 will be available for IDs. To maximize the number of IDs most straight sections will have two IDs, the light cones will be separated from each other by a chicane. The maximum length of an ID in a shared straight section is about 1.7 m. In some cases there might be a single undulator in a straight section; the maximum length of such a single undulator is about 3.6 m.

Most of the IDs will be assembled and shimmed at CLS, and we need a number of specialized measurement devices to help in the assembly and to measure the components of the magnetic flux density, the first and second field integrals and the integrated multipoles. Each ID must be very carefully shimmed to maximize the intensity of the synchrotron light from the ID and to minimize the interaction between the ID and the stored electron beam. This requires very high accuracy of the measurements, both in terms of the accuracy of the field components and the exact position where the components were measured. An in-vacuum undulator with short period might have gradients of 300 T/m, and 1 μm longitudinal error in the position of the measurement point means an error in the flux density measurement of 0.3×10^{-3} T.

To achieve the highest accuracy in the longitudinal position measurement a laser interferometer will be used.

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1.4 DEFINITIONS

A co-ordinate system with the y-axis vertical, the z-axis along the bench and the x-axis transverse to the bench will be used in the following.

A schematic view of a possible Hall probe bench configuration is shown in Figure 1. It consists of a heavy granite block, placed on a number of supports with adjustment jacks for alignment. On top of the granite block a wagon can move along the z-axis with constant speed. The wagon carries an (x,y)-table, on which the Hall probe holder is mounted on a shelf.

The Hall probe contains three Hall elements, measuring all three components of the magnetic flux density. A precision current source provides current to the elements, and each element is connected to a digital multimeter measuring the Hall voltage. The Hall voltage is converted to magnetic flux density by a calibration polynomial.

During the measurement the Hall probes are moved along the z-axis with constant speed. An external clock triggers the readout of the Hall voltage and a laser interferometer, which measures the z-position of the Hall probe. The arrangement of the equipment in the magnet measurement area is shown in [1].

The Hall probe bench will also be used to align the ID relative to the bench and to assist in the assembly of the ID magnetic structure. The Hall probes are then replaced with a micrometer clock.

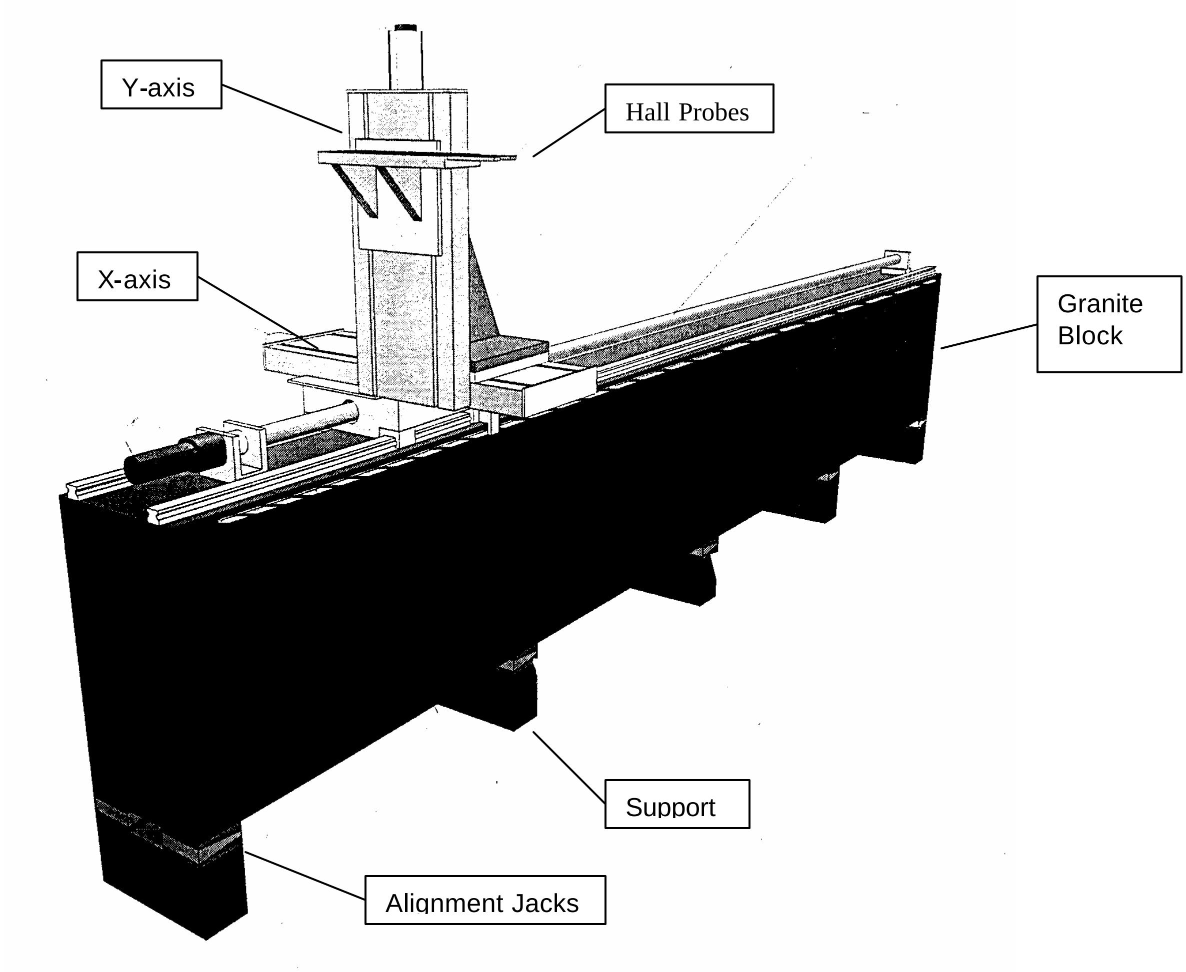

Figure 1. Hall Probe Bench.

2.0 REQUIREMENTS

2.1 FUNCTION

2.1.1 If the bench uses air bearings for the wagon, the manufacturer shall specify the air pressure and the rate and the equipment necessary to provide the air quality needed.

2.1.2 The manufacturer shall provide all software and hardware required for the operation of the bench itself. The hard- and software to control the flux density measurements will be provided by CLS.

2.1.3 CLS will use an industrial PC to control the measurements. The Hall probe bench can be controlled from this PC, or if a dedicated computer is used to control the Hall probe bench it shall be connected to the industrial PC via Ethernet.

2.1.4 All computer hardware and software shall meet the requirements of CLS Technical Specification 7.4.39.1, Appendix A-F [3].

2.1.5 CLS has developed controllers for stepping motors, and prefer to use this system if possible [4]. The vendor shall state the requirements for the controller, and provide a quote for their own controllers in case the CLS system is not applicable.

2.1.6 The Hall probes with holder; current source and digital multimeters will be supplied by CLS.

2.1.7 The laser interferometer to read out the longitudinal position will be supplied by CLS.

2.1.8 There shall be an arrangement to determine the zero for the three axis. For the x-axis the zero shall be at the left end of the slide as seen in Figure 1 of [1], for the y-axis at the top of the y-slide, and for the z-axis at the top end of the bench in Figure 1. The reproducibility of the zero position should be +/-1 μm for the x-and y-axis.

2.1.9 The Hall probe will be mounted on a 1.4 mm thick and about 50 mm long fiberglass plate. This arrangement is sensitive to vibrations, and the driving mechanism must be as free from vibrations as possible.

2.1.10 The cable carrier shall have room for six twisted pair cables for the Hall element signals, current source and PT100 thermal sensor.

2.2 PERFORMANCE

2.2.1 The electron beam height is 1.400 m above the floor at CLS. Measurements should be possible at any height between 1.250 m and 1.550 m above the floor.

2.2.2 The x-slide shall have a scan length of minimum 300 mm. The length of the Hall probe holder will define the horizontal position of the measurement area. The measurement area in the (x,y) plane is shown in Figure 2 in ref [1].

2.2.3 The longitudinal scan length (along the z-axis) shall be minimum 4500 mm.

2.2.4 The resolutions for the x-and y-axes, the travel velocity and limits for straightness, flatness, pitch, roll and yaw are given in the Table 1. The Hall probes must move on a straight line through the magnetic field. Table 1 below specifies the limits and the repeatability for the straightness, flatness, pitch, roll and yaw. It also specifies the useful travel, velocity and resolution for the different axis. The speed for the z-axis should be variable between 10 and 100 mm/s, for the x- and y-axis the speed can be constant at 100 mm/s.

Table 1 Performance Specifications

	X	Y	Z
Useable Travel	300 mm	300 mm	4500 mm
Velocity	100 mm/s	100 mm/s	10 mm/s – 100 mm/s
Resolution	+/- 1 µm	+/- 1 µm	*)
Straightness	+/- 20 µm	+/- 20 µm	+/-50 µm
Repeatability of Straightness	+/- 1 µm	+/- 1 µm	+/- 3 µm
Flatness	+/- 50 µm	+/- 20 µm	+/- 20 µm
Repeatability of Flatness	+/- 20 µm	+/- 20 µm	+/- 20 µm
Pitch	150 µrad	150 µrad	150 µrad
Repeatability of Pitch	10 µrad	10 µrad	10 µrad
Roll	150 µrad	150 µrad	150 µrad
Repeatability of Roll	10 µrad	10 µrad	10 µrad
Yaw	150 µrad	150 µrad	150 µrad
Repeatability of Yaw	10 µrad	10 µrad	10 µrad
Ortogonality X:Y:Z	50 µrad		

*) The position of the z-axis will be read out by a laser interferometer.

2.3 SAFETY AND ENVIRONMENTAL

2.3.1 The Hall probes will be used to measure IDs with gaps down to 5 mm. A wrong command can easily destroy the very thin Hall probes, and a programmable PLC or similar is required to protect the Hall probes.

2.3.2 Emergency stop buttons shall be placed at each end of the bench.

2.3.3 Limit switches should be placed at each end of the bench.

2.3.4 The top surface of the granite block shall be covered with folding bellows to keep out dust etc.

2.3.5 The temperature in the Magnet Measurement Laboratory will be 22^{o}C +/- 1^{o}C. The relative humidity is expected to vary between 35 and 50%.

2.4 APPLICABLE CODES, STANDARDS AND PROCEDURES

Not applicable.

2.5 QUALITY ASSURANCE

The manufacturer shall maintain and apply a quality assurance program compliant with ISO-9001 for the design, manufacture and testing of the equipment.

2.6 INSPECTION, TESTING AND COMMISSIONING

2.6.1 The manufacturer shall propose a test program to verify the specifications listed in Table 1. The test program and the test equipment used shall be reviewed and accepted by CLS.

2.6.2 The acceptance test will take place at the manufacturer's plant.

2.6.3 The room temperature during the tests shall be 22^{o}C +/- 1^{o}C.

2.6.4 The measurements to verify the specifications for the z-axis shall be done at y = 1.400 m and x= 200 mm.

2.6.5 Parts of the acceptance test shall be repeated after the bench is installed at CLS.

2.7 RELIABILITY AND MAINTAINABILITY

2.7.1 The expected useful life time for the Hall probe bench is 10 years.

2.7.2 The manufacturer shall provide a maintenance manual.

2.7.3 The manufacturer shall provide a list of spare parts.

2.8 LAYOUT

The layout of the Magnet Measurement Facility with the different benches is shown in [1]. The dimensions of the granite block have been estimated to 5.5 m long and 0.5 m wide. The manufacturer shall give the final dimensions for the Hall probe bench as soon as possible to allow CLS to finalize the dimensions of the room.

2.9 VIBRATION AND ACOUSTIC NOISE

The vibrations in the main floor of the CLS hall have amplitudes in the sub-micrometer range, and will not affect the measurements. The manufacturer shall minimize the vibrations from the driving mechanism of the bench as stated in 2.1.8.

2.10 SERVICES

2.10.1 Manufacturer shall state the requirement on water, pressurized air etc, needed for the operation of the bench.

2.10.2 The electrical services available are 120 V and 208 V, 60 Hz.

2.11 OTHER REQUIREMENTS AND CONSTRAINTS

2.11.1 Manufacturer is responsible for setting up and commissioning the bench at CLS with the assistance of CLS personnel.

2.11.2 Crates shall be designed such that they can be moved using standard handling devices (forklift or pallet jack).

2.11.3 The allowed floor loading on the main floor is 29000 N/m^2.

2.11.4 A crane with 10-ton capacity services the main floor at CLS. The Magnet Measurement Facility is placed between the storage ring and booster synchrotron tunnels, and the bench must be lifted over the storage ring tunnel. The free height under the crane hook is 4 m.

2.11.5 The required engineering, design, and test documents shall follow the rules stated in the CLS Documentation Specification, Note 0.4.1.1 Rev 2.

2.11.6 Tolerances and specifications, where not defined or difficult to achieve, are subject to negotiations.

3.0 REFERENCES

[1] I.Blomqvist, Canadian Light Source, Saskatoon, SK. CLS Design Note 6.2.25.5, CLS Magnet Measurement Facility.

[2] CLS Documentation Specification, Note 0.4.1.1 Rev 2.

[3] CLS Technical Specification 7.4.39.1. Control System technical Specification.

[4] CLS Report, CLS Microstep Motor Driver, August 21, 2000.