In-Vacuum Undulator Support Structure and Vacuum Chamber

5.8.25.2 Rev. 0

Date: 2003-JAN-20

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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	I. Blomqvist	
Reviewer #1	D. Lowe	
Reviewer #2	Curtis Mullin	
Reviewer #23	J. Ransom	
Approver	E. Hallin	

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REVISION HISTORY

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A	02-NOV-19	Original Draft	I. Blomqvist
B	03-JAN-09	Review comments added	I. Blomqvist
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1.0 INTRODUCTION

1.1 PURPOSE

The Canadian Light Source requires an in-vacuum small gap undulator. This device will be used in the storage ring to produce hard x-rays with energies between 6 and18 keV.

1.2 SCOPE

This document specifies and details the requirements for the design, and fabrication for the support structure, vacuum chamber, girders and the interfaces to the storage ring vacuum system and to the magnet assemblies for a 20 mm period in-vacuum hybrid undulator to be used at the Canadian Light Source, Inc (CLS).

1.3 BACKGROUND

The Canadian Light Source, CLS, is a national facility under construction on the University of Saskatchewan campus in Saskatoon, Saskatchewan. This facility will be a 3rd generation synchrotron light source with an electron beam energy of 2.9 GeV, which will produce high intensity beams of infrared, visible, ultraviolet and x-ray radiation.

An in-vacuum undulator with a magnetic length of 1.6 m is needed for the CLS protein crystallography beam line. The undulator will be used to produce high brilliance hard x-rays with energies between 6 and 18 keV using the 3th to 11th harmonics. This requires a short undulator period but still a k-value of the order of 1.5-2 to get a good tuning range.

To accomplish this we have chosen a hybrid layout with a period length of 20 mm and a minimum gap of about 4 mm.

The high harmonic numbers used also require very tight tolerances on the undulator taper and the girder deformation to preserve a small RMS phase angle error at all gaps.

In an in-vacuum undulator the vacuum chamber is an integral part of the undulator assembly, and the magnet assemblies are in a UHV vacuum.

The magnetic design of the undulator is described in the Conceptual Design Report [1].

2.0 REQUIREMENTS

2.1 GENERAL

2.1.1 In-vacuum small gap insertion device assembly shall consist of the following major components supplied by the Proponent:

- Support structure with adjustable height.
- Wheel arrangement to transport the undulator to its position in the storage ring.
- UHV vacuum chambers.
- UHV bellows for the suspension rods.
- Electrical power bussing, thermal sensors, limit switches, and wiring.
- Hydraulic assembly including input/output water manifold, hoses and fittings.

- Mechanical fasteners and supports.
- Long correction coil with vertical field and power supply.
- Hardware needed to mount the magnet assemblies inside the vacuum chamber.

2.1.2 CLS will supply the following:

- Vacuum pumps. The Proponent shall specify the pumps needed.
- Vacuum gauges and the associated controllers.
- Magnet assembly with holders.
- Conductive foil.
- RF fingers.
- Correction coils with horizontal fields & power supplies.

2.2 SUPPORT STRUCTURE

The drawing SR1/ME/0044810 shows the ID straight #8 with vacuum chambers, vacuum pumps and valves, photon absorbers, bellows, chicane magnets and correction coils for two identical in vacuum undulators. Also indicated in the horizontal view are the vertical members of the support structure and the spindles.

The drawing SR1/STRC/SPT/0080200 shows a schematic side view of the in-vacuum undulator, and the drawing SR1/PPL/0077200 shows the free space for the undulators in the storage ring. The present undulator will occupy the left position in the ID straight section. The cooling water pipes are at Ceiling height in the tunnel.

2.2.1 The **support structure** consists of five sets of basic components (see drawing SR!/STRC/SPT/0080200):

1. The four alignment shoes that can move the undulator in the horizontal plane.
2. The base frame that is supported on the alignment shoes and can adjust the height of the undulator.
3. The top frame, which supports the vacuum chambers and the ball screw spindles with its drive mechanism.
4. The out-of-vacuum beams (or girders), which supports the in-vacuum beams.
5. The spindle drive system to move the girders for changing the undulator gap. The drive system consists of motor, gearboxes, linear guides and encoders.

2.2.2 The Proponent shall also design and build detachable wheel units to move the undulator from the magnet measurement area to its place in the storage ring.

2.2.3 **Base Frame**: The base frame shall be a welded steel frame resting on the four (x,y)-alignment shoes via four mechanical jacks driven by a single motor. The mechanical jacks shall provide fine adjustments of the undulator height with a resolution of 0.005 mm. The mechanical jacks shall be individually adjustable to provide the initial levelling of the undulator.

2.2.4 The **(x,y) Alignment Shoes** shall allow an adjustment of <u>+/-10 mm in both directions</u>. All adjustment screws shall have precision threads.

2.2.5 The **Top Frame** is bolted to the base frame. It shall be a welded steel C-frame providing the framework to hold the magnetic assemblies and the drive system, which controls the undulator gap. The top frame also provides the framework to hold the undulator vacuum chamber and the vacuum pumps.

2.2.6 The **Drive System** consists of a centrally mounted single motor, gearboxes, two lead screws (spindles), linear bearings and the out-of-vacuum girders. A phase shifter might be needed to keep the undulator taper to less than 0.005 mm (see section 2.4.11).

2.2.7 **Gap Range**: The undulator magnetic gap shall be continuously variable from 4.0 mm to 40 mm.

2.2.8 **Out-of-Vacuum Girders**: The out-of-vacuum girders support the in-vacuum girders via suspension rods. The out-of-vacuum girders shall be a welded steel construction with a very rigid moment of inertia for minimal deflection under the magnetic forces. They are coupled to the spindles by pre-loaded ball- or tapered roller bearings, and kept vertical by linear bearings bolted to the top frame.

2.2.9 The linear guides shall be dimensioned to limit the roll of the out-of-vacuum girders to maximum 0.05 mrad when the undulator gap is varied between 4.0 and 15 mm. The variation of the vertical magnetic forces with the gap is shown in Figure 1. At the minimum gap of 4.0 mm the calculated force is 14 kN, at 15 mm gap it is essentially zero.

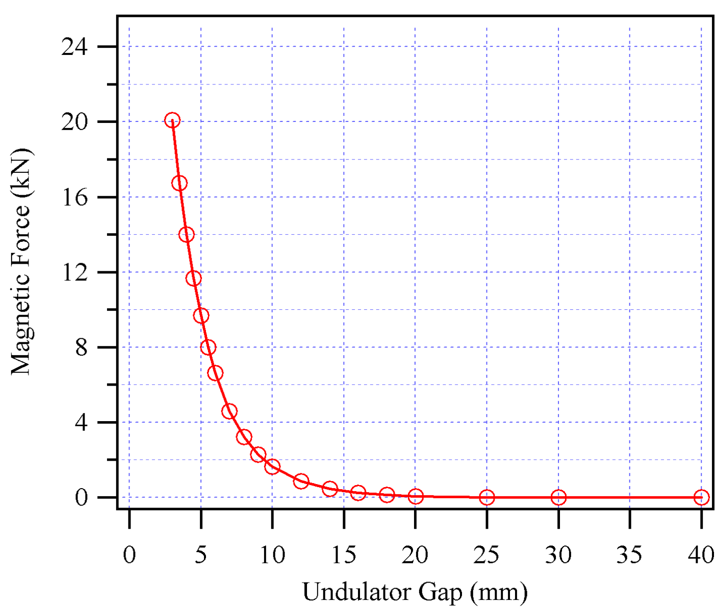

Figure 1 The variation of the vertical magnetic force for undulator gap sizes between 3 and 40 mm. At the minimum gap of 4.0 mm the force is 14 kN.

2.2.10 The **In-Vacuum Girders**: The in-vacuum girders are placed inside the vacuum chamber, connected to the out-of-vacuum girders by suspension rods. The magnet assemblies are mounted on the in-vacuum girders.

2.2.11 The **Suspension Rods**: The suspension rods are part of the undulator vacuum system. They connect the in-vacuum girders to the out-of-vacuum girders. They are also used to adjust the flatness and parallelism of the in-vacuum girders.

2.2.12 **Compensating Springs**: Compensating springs may be used to buck the magnetic forces at small gaps to reduce the load on the motor and reduce the friction, increasing the reproducibility of the system. They can also eliminate any discontinuity when the force of gravity becomes larger than the magnetic force for the lower girders. The Proponent shall decide if a compensating spring system is needed.

2.2.13 **Transport of Undulator**: The undulator must be transported from the loading dock to the crane area by forklift or pallet jack. A 10 ton overhead crane will be used to lift the undulator over the ring tunnel to the magnet measurement area. The free height under the crane hook is 3.5 meters. The Proponent shall design lifting fixtures, and supply any hardware needed to lift the device with the 10 ton crane. The centre of gravity shall be shown on the structure.

From the magnet measurement area to the position in the storage ring the undulator must be transported using detachable wheel units. The Proponent shall design the detachable wheel units and the interface between the wheel units and the undulator support. The wheels shall be rotatable through 360^{o} and individually steerable and lockable. The width of the completed undulator and the wheel units not to exceed 2500 mm (preferably less than 1900 mm), and the height not to exceed 2900 mm (preferably less than 2600 mm) to be able to pass through the storage ring tunnel.

2.2.14 Materials used that are subject to surface corrosion shall be anodized, passivated, or painted wherever possible.

2.2.15 All sub-assemblies shall be stress relieved before final machining to minimize material creep.

2.2.16 The welded out-of-vacuum girders shall be stress relieved after welding, rough machined, again stress relieved and then given the final machining.

2.2.17 **Connection Box**: There shall be one or more electrical connection boxes located on the undulator support structure.

2.2.18 The cables from motors, brakes, encoders, limit switches, RTDs and steering coils shall be connected to coupling strips in the connection box. The boxes shall have the necessary contacts to connect the undulator to the undulator control system, located outside the storage ring tunnel subject to review by CLS prior to construction.

2.2.19 All cables and connections shall be in accordance with the Saskatchewan Electrical Standards and certified by a CSA or another inspection agency.

2.2.20 The boxes shall be placed well below the electron beam height to reduce the radiation levels.

2.2.21 The height of the undulator median plane shall be 1400 mm with the vertical adjustment of the alignment shoes and the spindles on the undulator bottom frame in the middle position.

2.3 UNDULATOR VACUUM SYSTEM

The undulator vacuum system is schematically shown in the drawing SR1/ME/0044810. Included are two 300 l/s ion pumps and four NEG pumps with a pumping speed of 1100 l/s for hydrogen. The two NEG pumps on the outside of the ring are shown at 45^o angle to the horizontal to clear the bend magnet beam line front end.

2.3.1 The undulator vacuum system consists of the main vacuum chamber, the upstream RF finger chamber, the downstream RF finger chamber and the bellows around the suspension rods.

2.3.2 The undulator vacuum system shall be designed to form an ultra high vacuum system, which contains the in-vacuum girders, the suspension rods, the magnet assemblies, the RF fingers and the water-cooling pipes. Ultimate vacuum pressure shall be < 5 nPa ($5x10^{-11}$ torr) without magnet assemblies and beam, and < 500 nPa ($5x10^{-9}$ torr) with magnet assemblies and beam.

2.3.3 The undulator vacuum system shall be fabricated from stainless steel grade 316LN. All forgings for flanges and milled pieces shall be stainless steel of grade 316LN. The reason is that the undulator vacuum chamber will be absent in the undulator shimming stage and disturbances from large relative permeability in welding seams etc. might affect the magnetic properties of the

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2.3.6 The undulator vacuum system shall be fabricated from stainless steel grade 316LN. All forgings for flanges and milled pieces shall be stainless steel of grade 316LN. The reason is that the undulator vacuum chamber will be absent in the undulator shimming stage and disturbances from large relative permeability in welding seams etc. might affect the magnetic properties of the undulator in unforeseen ways. All parts of the vacuum system, including the weld seams, shall have a relative magnetic permeability of less than 1.01.

2.3.7 All connection ports unless otherwise specified shall use Conflat ™ flanges of standard commercially available sizes.

2.3.8 The system contains flanges for connection of vacuum pumps, vacuum diagnostics, water-cooling pipes and 8 three-wire RTDs for measurement of magnet and RF finger temperatures. All interfaces shall be clearly labelled and where possible from CLS list of standard connections.

2.3.9 The vacuum chambers and the flanges shall allow a maximum bake-out temperature of 250^oC.

2.3.10 The Proponent shall follow the Canadian Light Source Vacuum Component Cleaning Technical Procedure [2]. Proponent may propose alternative cleaning procedures for CLS review and acceptance.

2.3.11 Proponent shall select and size the vacuum pumps required to meet the pressure specification in Section 2.3.2. CLS will procure the specified pumps. Ion pumps shall be selected from standard Varian sizes.

2.3.12 Vacuum system shall be equipped with MKS Series 423 Cold Cathode Ionization sensor and be controlled with a MKS Series 943 Digital, Cold Cathode Vacuum Sensor system.

2.3.13 Vacuum system shall be equipped with a Granville-Phillips Series 375 Convectron Vacuum Gauge Controller and gauge. Pressure readout shall be in torr.

2.3.14 Overall length of the vacuum system shall not exceed the length shown in Drawing SR1/ME/0044810.

2.3.15 The vacuum chamber diameter shall be sufficient for a maximum undulator gap of 40mm.

2.3.16 CLS will provide the upstream photon absorber-bellow unit and the spool piece-photon absorber behind the undulator.

2.3.17 Beam transport opening at upstream interface shall be 16 mm high by 50mm wide, see Drawing SR1/0042908.

2.3.18 Beam transport opening at downstream interface shall be 16 mm high. The width shall be 80 mm distributed with 25 mm inboard and 55 mm outboard, see Drawing SR1/0042908.

2.3.19 The undulator vacuum system shall have a helium leak rate $Q_L < 2 \times 10^{-8}$ Pa l/s and a specific desorption rate $Q_{sp} < 1 \times 10^{-10}$ Pa l/s/cm^2 after cool down from a 24 hour bake out at 150^{o}C.

2.3.20 The proponent shall design and install a bake out system for the vacuum chamber that allows the vacuum chamber to be baked out to 150^{o}C when installed in the beam line.

2.4 INTERNAL SUPPORT GIRDERS

2.4.1 The in-vacuum girders shall be water cooled to eliminate temperature gradients and to protect the magnet assemblies from high temperatures during baking of the vacuum chamber.

2.4.2 The in-vacuum girders shall be fabricated from Aluminum alloy or Copper to improve the efficiency of the water-cooling.

2.4.3 The magnet assemblies are secured to the in-vacuum girders by Al blind nuts in T-slots machined in the girders. The dimensions of the T-slots are given in the drawing SR1/ME/MAG/0071678. The manufacturer shall determine the width needed for the in-vacuum girders.

2.4.4 The nominal total length of the magnet assemblies including the holders for the correction magnets is given in drawing SR1/ME/MAG/0071680. There is an uncertainty of about +/- 2 mm in this number due to the tuning of the end sections in the shimming process. A 10 mm thick Cu plate will be added to each end of the magnetic assemblies to attach the RF fingers. CLS is responsible for the magnet assembly hardware and shimming.

2.4.5 The magnet holders will rest on 0.5 mm Al shims. The nominal height from the top surface of the in-vacuum girder to the top of the magnets is 40.5 mm.

2.4.6 The number of suspension rod pairs for each girder is determined by the requirement the deflection of the in-vacuum girders shall be less than 0.003 mm when the undulator gap is changed from 4 mm to 15 mm.

2.4.7 The suspension rods shall be made of 316 L stainless steel. They shall have adjustable lengths using counter rotating precision threads to allow adjustment of flatness and parallelism of the in-vacuum girders.

2.4.8 At the out-of-vacuum girders, the suspension rods are attached to linear guides to allow for different thermal expansion during bake out.

2.4.9 The suspension rods shall be sealed by UHV bellows supplied by CLS.

2.4.10 The Proponent shall adjust the suspension rods to make the sides of the in-vacuum girders facing the electron beam flat within +/- 0.025 mm, both for the upper and lower in-vacuum girder.

The two surfaces shall be parallel within +/- 0.050 mm at the vertical distances between them corresponding to undulator gaps from 4.0 mm to 15 mm.

After adjustment for flatness and parallelism the suspension rods shall be pinned.

2.4.11 The maximum taper of the in-vacuum undulator shall be less than 0.005 mm for gaps in the range 4.0 to 15 mm to preserve the intensity for the high harmonics.

2.4.12 The maximum taper of the in-vacuum undulator shall be less than 0.005 mm for gaps in the range 4.0 to 15 mm to preserve the intensity for the high harmonics.

2.5 GAP DRIVE SYSTEM

2.5.1 The gap drive system shall use a single motor to avoid damage to the linear guides etc.

2.5.2 The design of the gap drive system shall allow gap speeds in the range from 0.0005 mm/s to 1 mm/s. The minimum speed is intended for scans, the maximum speed allows a change of gap from minimum to maximum in less than 40 seconds.

2.5.3 A phase shifter may be needed for one of the spindles to assure the undulator taper can be kept to < 0.005 mm (see 2.4.11), both for opening and closing the gap.

2.5.4 The gearboxes and couplings shall have very low backlash to allow us to approach a given gap from both directions.

2.5.5 The gear boxes shall be self-locking.

2.5.6 The motor (preferably a stepper motor) shall have a brake that is normally on.

2.5.7 The cables from motors and brakes shall be routed to the electrical connection box.

2.6 VERTICAL ADJUSTMENT SYSTEM

2.6.1 The vertical adjustment system shall allow the height of the undulator to be adjusted remotely.

2.6.2 A single stepper motor shall drive four vertical jacks supporting the undulator.

2.7 ENCODERS FOR GAP MEASUREMENT

2.7.1 The undulator gap and taper shall be measured with a resolution of at least 0.00025 mm.

2.7.2 The encoders shall be absolute encoders of rotating type. An encoder shall be attached to the free end of each ball spindle.

2.7.3 The encoders shall be shielded with lead against the radiation in the storage ring tunnel.

2.7.4 The encoder cables shall be routed to the electrical connection box.

2.8 ENCODERS FOR VERTICAL ADJUSTMENT

2.8.1 The vertical position of the undulator shall be measured with a resolution of at least 0.002 mm.

2.8.2 An absolute rotating encoder shall be attached to two of the four vertical jacks on the bottom frame of the undulator.

2.8.3 The encoder cables shall be routed to the electrical connection box.

2.8.4 The encoders shall be shielded with lead to protect them from radiation damage.

2.9 MAGNET ASSEMBLY PROTECTION

2.9.1 The magnet assemblies shall be protected by sets of limit switches and hard stops.

2.9.2 The limit switches shall have a repeatability of +/- 0.001 mm.

2.9.3 **Limit Switches for Minimum Gap**: Two limit switches shall be mounted at each end of the out-of-vacuum girders. The limit switches shall be easily and accurately adjustable for gap sizes from 4.0 mm to 8 mm.

2.9.4 **Limit Switches for Maximum Gap**: Two limit switches shall be mounted at each end of the out-of-vacuum girders. The limit switches shall be fixed at the maximum gap.

2.9.5 The Proponent shall provide the limit switches and the arrangement for adjusting the position of the switches. The Proponent shall also provide the cables from the switches to the electrical connection box. CLS is responsible for integrating the switches in the undulator control system.

2.9.6 **Hard Stops for Minimum Gap**: Adjustable hard stops shall be placed close to the ball spindles to stall the motor if the minimum gap limit switches fail. The hard stops shall be adjustable for gap sizes from 3.9 mm to 8 mm using precision threads.

2.9.7 **Hard Stops for Maximum Gap**: Adjustable hard stops shall be placed close to the ball spindles to stall the motor if the maximum gap limit switches fail. The hard stops shall be fixed at maximum gap.

2.10 RF FINGERS

2.10.1 The RF fingers are flexible water-cooled tapers that provide continuous paths for the image current from the undulator entrance flange to the magnet assemblies and from the magnet assemblies to the undulator exit flange. The RF finger assemblies will be supplied by CLS. A sketch of a proposed layout for the RF fingers is shown in drawing SR1/ME/CLM/0080300.

2.10.2 The Proponent shall make the end flanges for the RF finger chambers to CLS provided drawings.

2.10.3 Conducting foils made of Cu coated Ni foils will form the image current paths along the magnet assemblies.

2.10.4 The RF finger chambers shall have access flanges needed for the assembly of the RF fingers when the in-vacuum girders with the magnet assemblies are mounted inside the undulator vacuum system after the shimming process is finished.

2.11 CORRECTION COILS

2.11.1 The Proponent shall provide a long correction coil with vertical field.

2.11.2 The coil shall be placed outside the undulator vacuum chamber and run the full length of the chamber. The coil position shall be determined in collaboration with CLS.

2.11.3 The coil shall either be able to stand the baking temperature of the vacuum chamber, or easily demountable during baking.

2.11.4 The coil shall provide a field integral of 10^{-3} Tm. CLS will dimension the coil when the coil position is fixed.

2.11.5 The power supply shall have a resolution of better than 10^{-6} Tm.

2.11.6 The correction coils with horizontal field will be supplied by CLS and placed outside the undulator.

2.12 TOOLING FOR ASSEMBLY OF IN-VACUUM GIRDERS IN THE UNDULATOR VACUUM CHAMBER

2.12.1 The Proponent shall provide the necessary guides and tools for the assembly of the undulator in the vacuum chamber after the shimming is finished.

2.13 FIDUCIALS

2.13.1 Proponent shall provide 6 fiducial locations. 4 locations shall be on the elevation of the undulator centerline and 2 locations on the ends of the top out-of-vacuum girder. Final positions to be determined in conjunction with CLS.

2.14 OTHER REQUIREMENTS AND CONSTRAINTS

2.14.1 The support structure shall be able to withstand a relative humidity range of 0% to 90%. The expected relative humidity limits under operation are from 25% during the winter months to 50% during the summer months.

2.14.2 The ambient temperature in the magnet measurement area is $(22 +/- 1)^{o}$C. The ambient temperature in the storage ring tunnel is $(27 +/- 0.1)^{o}$C.

2.14.3 All components shall be designed to operate in a radiation environment. The manufacturer shall avoid using materials that are subject to damage by ionizing radiation or provide adequate shielding incorporated into the design to allow for long service life of the component. All components shall have a minimum mean time between failures of 5 years in the typical radiation environment.

2.14.4 In the tunnel environment there will be a small production of radioactive air and noxious gases. These are estimated to be:

- For N-13, O-15 and C-11: 0.0002 Bq/cc
- For ozone: 5.6×10^{-8} mol/cc
- Nitrogen Dioxide: 2.7×10^{-8} mol/cc
- Nitric Acid: 0.8×10^{-8} mol/cc

2.14.5 All small tubing water-cooling connections shall be American standard Swagelok fittings.

2.14.6 Water cooling is supplied at $(26 +/- 1)^{o}$C, maximum pressure drop across equipment is 915 kPa. The cooling water conductivity is maintained at 6×10^{-6} S/cm.

2.14.7 All control wiring, sensor data sheets, connectors and control hardware shall be submitted to CLS for review and acceptance prior to construction.

2.14.8 2.14.8 Tolerances, where not defined or where difficult to achieve, are subject to negotiation.

3.0 APPLICABLE CODES, STANDARDS AND PROCEDURES

This work shall meet the following standards. The issue of any standard shall be the issue in effect as of the date of request for tender. Any conflicts between this specification and the referenced documents shall be brought to the attention of the CLS in writing for resolution before any related action is to be taken by the Proponent.

- American Welding Society (AWS)
- American Society for Testing and Material (ASTM)
- American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (ASME-BPVC)
- American National Standards Institute (ANSI)
- International Standards Organization (ISO)
- Canadian Light Source Vacuum Component Cleaning Technical Procedure [2]
- Canadian Light Source Vacuum Component Leak Test Technical Procedure [3]

4.0 QUALITY ASSURANCE

The Proponent shall maintain and apply a quality assurance program compliant with ISO-9001 for the design, manufacture, and testing of the support structure and the vacuum chambers.

5.0 INSPECTION, TESTING AND COMMISSIONING

The inspection sheets shall be filled out, signed, and dated by the technicians performing the tests and inspections listed below. The completed inspection sheet for each coil, yoke, and assembly shall be signed and dated by the technician supervisor.

5.1 VACUUM

5.1.1 Proponent shall develop an inspection sheet for the vacuum acceptance test. This sheet shall be reviewed and accepted by the CLS.

5.1.2 The information contained within the inspection sheet shall include at least the following:

- Names of technician(s) inspecting
- Date of Inspection
- Procedure followed
- Ultimate vacuum pressure achieved.
- Leak rate.

5.1.3 Proponent shall file the original completed and signed inspection sheet.

5.1.4 A copy of the original completed and signed inspection sheet for all inspected laminations shall be delivered to CLS.

5.1.5 During tests, the assembly shall contain all components except for the magnetic assembly, and water lines pressurized to 1.4 MPa. All water lines must be free of contamination inside and outside.

5.1.6 Tests shall also be made during motion of the internal support girder.

5.2 GAP CHANGE MECHANISM

5.2.1 Proponent shall develop an inspection sheet for the gap change mechanism. This sheet shall be reviewed and accepted by the CLS.

5.2.2 The information contained within the inspection sheet shall include at least the following:

- Names of technician(s) inspecting
- Date of Inspection
- Ambient Temperature
- Gap dimensions and tolerances

5.2.3 Proponent shall file the original completed and signed inspection sheet.

5.2.4 A copy of the original completed and signed inspection sheet shall be delivered to CLS.

5.2.5 Gap dimensions and tolerances shall be checked at 4.5mm, 6mm, 8mm, 10mm, 12mm, and 15mm.

5.2.6 Limit switches shall be verified to open upon activation.

5.2.7 Hard stop shall be verified to stop motion during full speed operation.

5.3 COIL

5.3.1 Proponent shall develop an inspection sheet for the coil. This sheet shall be reviewed and accepted by the CLS.

5.3.2 The information contained within the inspection shall include at least the following:

- Results of visual inspection, with technician name and date
- Measurement & Inspection results, with responsible technician name and date
- Electrical Test Results, with responsible technician name and date
- Names of technicians winding the coil and date
- Names of technicians attaching interlock and terminal blocks and dates

5.3.3 Proponent shall file the original completed and signed inspection sheet.

5.3.4 A copy of the original completed and signed inspection sheet for the coil shall be delivered to CLS with the assembly.

5.3.5 Proponent shall provide resistance of the coil.

5.3.6 Proponent shall inspect the coil for internal shorts.

6.0 RELIABILITY AND MAINTAINABILITY

6.1.1 The expected lifetime shall be greater than 10 years.

6.1.2 Water connections shall be readily accessible for maintenance, and clearly labelled as supply and return.

7.0 COMPONENT IDENTIFICATION AND COLOUR

7.1.1 Support structure shall be black. A color sample shall be submitted to CLS for review and acceptance.

7.1.2 Assembly shall be labelled with a permanent unique serial number "ID-08-1".

7.1.3 All assemblies shall be affixed with a nameplate with the following format:

CLS In-Vacuum Undulator ID -08-1

Net Weight (kg):
Cooling Water Flow Rate (l/s):
Pressure Drop (kPa):
Date:
Manufacturing Company Name
Serial No.:

7.1.4 All lettering on nameplate shall be in 14 point font size.

7.1.5 The position of the nameplate shall not interfere with magnet operation.

7.1.6 All motors, switches and instrumentation shall follow the CLS naming convention. All cables shall be labelled with CLS cable numbers.

8.0 PREPARATION FOR SHIPMENT AND DELIVERY

8.1.1 The water channels of the assembly shall be blown out to insure there is no water remaining in the lines.

8.1.2 The vacuum chamber shall be backfilled with 99.99% pure dry nitrogen to above atmospheric pressure and sealed.

8.1.3 Crates shall be designed such that it can be moved using a standard handling device (forklift or pallet jack).

8.1.4 8.1.4 Support structure shall be capable of being craned into measurement facility. Crane space between underside of hook and bottom of support shall not exceed 3.5 m.

8.1.5 The assembly shall be wrapped or covered to protect it from moisture within the shipping crate.

9.0 REFERENCES

1. I. Blomqvist, Canadian Light Source, Saskatoon, SK. CLS Conceptual Design Report 6.2.25.4 Rev. 0, Magnetic Design of a 20 mm Hybrid Undulator for CLS.
2. Canadian Light Source Vacuum Component Cleaning Technical Procedure
3. Canadian Light Source Vacuum Component Leak Test Technical Procedure
4. D.S. Lowe, Canadian Light Source, Saskatoon, SK. CLS Specification 0.4.1.1 Rev. 2, CLS Documentation Specification, 2000-12-15.

10.0 LIST OF DRAWINGS

Drawing Number	Title
SR1/ME/0044810	Storage Ring 1 Cell #8 Insertion Device Straight Assembly (In-Vacuum Chamber).
SR1/PPL/0077200	Storage Ring Cell 8 ID Straight.
SR1/0042908	SR1 Raytracing Cell #8 (RM 1408).
SR1/STRC/SPT/0080200	In-Vacuum Undulator Support Structure
SR1/ME//CLM/0080300	Storage Ring 1 08ID, In-Vacuum Undulator Flexible Taper Absorber.
SR1\ME\MAG\0071678	20 mm hybrid Undulator In-Vacuum Girder T-Slot Layout
SR1\ME\MAG\0071680	20 mm Hybrid Undulator Magnet Assembly