Design Build: Two Toroidal Refocusing Mirrors and Four Beamline Vacuum Sections for the Canadian Light Source Inc. Spherical Grating Monochromator (SGM) Beamline

6.8.75.2 Rev. 0

Date: 02-Apr-15

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

	Signature	Date
	Original on File – Signed by:	
Author	Ian Coulthard	
Reviewer #1	Dan Lowe	
Reviewer #2	Brian Yates	
Approver	Emil Hallin	

BLANK PAGE

REVISION HISTORY

Revision	*Date*	*Description*	*Author*
A	02-Feb-03	Original Draft	Ian Coulthard
B	02-Mar-04	Reviewer’s comments incorporated	Ian Coulthard
0	02-Apr-15	Issued for use.	Ian Coulthard

BLANK PAGE

TABLE OF CONTENTS

BLANK PAGE

1. INTRODUCTION

1.1 PURPOSE

This document specifies the requirements for two toroidal refocusing mirrors and four beamline sections to be designed in detail, constructed, and installed on the floor at the Canadian Light Source (CLS). These components will be part of the spherical grating monochromator (SGM) spectroscopy beamline.

1.2 SCOPE

The SGM spectroscopy beamline as specified by the user community requires high resolution and flux combined with a reasonably small beam size at the sample. This specification details the requirements for the detailed design, fabrication, supply, and installation of two toroidal refocusing mirrors and 4 beamline sections. This specification includes but is not limited to:

-detailed design of all specified sections
-2 toroidal refocusing mirrors
-required optical tables and beamline support structures
-required beam pipes and vacuum chambers
-vacuum quality testing
-delivery and installation at CLS
-quality assurance and safety

1.3 BACKGROUND

The Canadian Light Source is a national facility under construction at the University of Saskatchewan campus in Saskatoon, Saskatchewan. This facility is a third generation synchrotron light source that will produce a high intensity source of infrared, visible, ultraviolet, and x-ray radiation. Based upon the needs of the Canadian synchrotron community, a soft x-ray spherical grating monochromator (SGM) spectroscopy beamline is being constructed with a goal of being ready for operation when the facility is declared operational in early 2004. Some components of an existing SGM beamline at a different synchrotron source are being modified to become key components in this new line. However, 2 beamline sections connecting these components and two new sections containing toroidal refocusing mirrors are required to complete the beamline.

2.0 DEFINING SECTIONS REFERRED TO IN THE SPECIFICATION

2.1 REFERENCE DRAWINGS

Refer to the following supplied drawings to aid in the definition of each section requiring design and construction.

a) Detailed design of existing SGM beamline at other synchrotron source (DWG No. 81244) [1].

b) Detailed design of modified components from existing beamline (DWG No. 100-104621) [2].

2.2 SECTION #1

Section #1 may also be referred to as the entrance slit – monochromator transport section. It refers to the vacuum section found between the 4.5-inch bellows of the entrance slit and the monochromator chamber.

2.3 SECTION #2

Section #2 may also be referred to as the monochromator – exit slit transport section. It refers to the section just downstream of the second monochromator chamber 4.5-inch bellows and all the way connecting to the exit slit assembly.

2.4 SECTION #3

Section #3 may also be referred to as the M4 refocusing mirror section. It refers to the section connected downstream to the exit slit assembly, and past the M4 mirror downstream to a pneumatic valve a predefined distance from the final focus spot of the first endstation area.

2.5 SECTION #4

Section #4 may also be referred to as the M5 refocusing mirror section. It refers to the section containing the second refocusing mirror (M5), found between the two endstation areas and defined by pneumatic vales on either side that are a predefined distance from the focal points of the two endstation areas.

3.0 GLOBAL REQUIREMENTS

3.1 All sections shall be capable of sustaining ultra-high vacuum (UHV) conditions. All factory vacuum test results for each section, performed with CLS supplied ion pumps and ion pump controllers, shall be submitted to the CLS for approval prior to section shipment. These tests shall demonstrate a base pressure of better than $1 * 10^{-9}$ torr after bake out and shall include a residual gas analysis (RGA) spectrum. RGA tests should show that the sum of the partial pressures of gases having a mass >46 AMU does not exceed 10^{-11} torr in all chambers.

3.2 All sections of the design are to be separated by UHV pneumatic gate valves of VAT manufacture with metal bonnet seal and viton seal and the valve designed to fail in the closed position. These valves should also have 24 V DC solenoids, have visual position indicators and manual overrides.

3.3 All sections defined by pneumatic gate valves shall contain at least one CLS supplied ion pump (no dead spaces with regards to pumping), a port for a CLS supplied ion gauge, and a manual UHV all-metal valve for the attachment of a turbo-molecular rouging pump with a KF adaptor on the valve. The KF adaptor shall be equipped with a blank that can be removed for pumping.

3.4 All flanges shall be of Conflat™ type.

3.5 All mirrors shall be designed to be approximately 20% longer than their maximum illuminated length.

3.6 To aid in diagnostics and alignment, a design is preferred such that at the front end of mirror mounts for M4, and M5along the direction of the beam are found an electrically isolated blade that will register a current if the beam is misaligned on the upstream end of that particular mirror. All optics tables should also be designed and constructed to contain external fiducial markers for the alignment and placement of these components upon the floor at CLS. The position of these markers relative to the optical pole of any given chamber (i.e. the center of any given optic when inserted into the beam), shall be specified to an accuracy of 250 μm or better.

3.7 Designs shall be made under the assumption that all ion pumps and controllers are to be of Varian manufacture.

3.8 The proponent shall determine an appropriate ion pump capacity based upon standard Varian ion pumps for each section. These pumps and controllers shall be acquired by CLS for installation. Vacuum pressure distribution calculations and graphs shall be provided to the CLS.

3.9 The preferred method of movement of all mirrors is via movement of the support table and vacuum tank as opposed to internal motorization. Mounting of mirrors via the tank is preferred to mounting of mirrors via flanges.

3.10 The proponent shall determine the appropriate capacity of each stepper motor. Choice of motor shall conform to CLS stepper motor and stepper motor control policy [3] as much as possible. CLS shall either acquire the appropriate motors and deliver them for installation or shall authorize the proponent to acquire the motors themselves. Motor controllers and software drivers will also be supplied by the CLS.

3.11 Provisions for ion gauges shall be included in the design. However, CLS shall acquire the appropriate number of ion gauges and deliver them for installation.

3.12 Large chambers and components requiring accurate placement upon the floor shall be designed such that their support structures bolt to the floor via Hilti studs where nuts above and below the flange allow adjustment of the height and tilt of the columns. In addition, a nominal 1.75 inch space between the column and floor is filled with epoxy grout for stability after everything is aligned. (DWG No. 100-104629)[4].

3.13 Lighter areas containing beam pipes and ion pumps that also require support may be mounted with smaller columns that bolt via Hilti studs but do not require the epoxy grout layer.

3.14 The detailed design of any mirrors and mirror mounts shall be given the highest priority to ensure the proponent can ensure the delivery of these long lead time items on time.

3.15 All vacuum chambers shall be capable of sustaining 150 ^{o}C bake-out conditions.

4.0 SECTION #1 SPECIFIC REQUIREMENTS

4.1 This sections slopes downward at 2 degrees in the direction of the beam (refer to DWG No. 100-104621) [2].

4.2 A VAT pneumatic gate valve is required just upstream of the 4.5-inch bellows connected to the monochromator chamber.

4.3 All beam pipes and valves shall use 4.5-inch Conflat™ flanges to mate with the bellows found on either side of this section.

4.4 This section shall require a support column

4.5 The ion pump, ion gauge, and second pneumatic valve for this section are found on the other side of the entrance slit and are not part of this specification.

5.0 SECTION #2 SPECIFIC REQUIREMENTS

5.1 Just upstream of the bellows defining one end of this section is a zero order stop that is part of the monochromator chamber. This stop is being redesigned at the present time and replaced by McPherson Inc. with a model designed to dissipate a potential heat load of several watts. Enough flexibility in terms of length must be made in the design of this section such that a reasonable increase in the length this new zero order stop requires can be accounted for. The exact size of the new stop compared to the existing stop is still to be determined and will be supplied as soon as it is available with a new drawing.

5.2 Just downstream of the bellows connecting to the monochromator chamber shall be placed a VAT pneumatic gate valve.

5.3 Just upstream of the exit slit assembly shall be placed a CLS supplied Varian ion pump, CLS supplied ion gauge, and a retractable phosphor screen, and a view-port. Just upstream of this ion pump shall be placed another VAT pneumatic gate valve.

5.4 Beam pipes, and valves for this section shall use 4.5-inch Conflat™ flanges to mate with the bellows on one end and the exit slit assembly on the other.

5.5 The area of this section between the two gate valves shall contain only beam pipes, and a cross for the mounting of an ion gauge, an ion pump, a retractable phosphor screen, and a view-port.

5.6 This section is sloped upward at an angle of 3 degrees in the direction of the beam (refer to DWG No. 100-104621) [2].

5.7 The proponent shall determine the required number of support columns that must receive review and acceptance by CLS.

6.0 SECTION #3 SPECIFIC REQUIREMENTS

6.1 This section slopes upward at 3 degrees in the direction of the beam until reaching the M4 refocusing mirror. After the mirror the section slopes upwards at 1 degree in the direction of the beam.

6.2 The center of the M4 mirror shall be precisely 2.15 meters distant from the center of the range of travel of the exit slit mechanism (refer to DWG No. 100-104621)[2].

6.3 This section shall have a pneumatic gate valve just downstream of the exit slit assembly to which this section is connected.

6.4 A second gate valve shall be found 0.7 meters upstream of the focal point of the first endstation area, that is to say 1.3 m downstream of the center point of the M4 refocusing mirror. This is to allow ample room for any number of possible endstations that may be placed at the focal point of the M4 mirror.

6.5 The mirror and chamber shall require a motorized optical table and the large column mounting assembly.

6.6 Motorization of the table and subsequently the mirror shall allow for the adjustment of the height, tilt, and transverse/horizontal position of the mirror.

6.7 Vertical motorizations should have a travel range of at least 10 mm adjustable in increments of one micron. Horizontal/transverse motorizations should have a travel range of +- 10 mm adjustable in increments of ten microns.

6.8 There shall be sufficient ports in the mirror chamber to allow not only for beam entrance and egress, but also for: an ion pump, ion gauge, large view-port (at least a six inch flange), a small (2.5 inch flange) on axis view-port for visual examination of the upstream isolated blade should it also be coated with a phosphor, and a pump down port with a manual all-metal UHV vlave

6.9 The refocusing mirror shall be of toroidal shape with an angle of incidence of 1 degree.

6.10 The substrate of the mirror shall be synthetic fused silica.

6.11 The reflective coating of the mirror shall be gold, covering as much of the reflective surface of the mirror as possible. The thickness of the gold shall be sufficient to ensure no attenuation effect on the beam due to the substrate material.

6.12 The Meridional radius of the mirror shall be 118.739 m with accuracy of 0.5% or better.

6.13 The Sagittal radius of the mirror shall be 0.0704 m with accuracy of 1% or better.

6.14 The Meridional slope error shall be 2.5 arcsec or better.

6.15 The Sagittal slope error shall be 2.5 arcsec or better.

6.16 The mirror roughness shall be 1 nm or better.

6.17 The mirror length shall be 300 mm

6.18 The mirror width shall be approximately 30-40 mm.

7.0 SECTION #4 SPECIFIC REQUIREMENTS

7.1 This section slopes upward at 1 degrees in the direction of the beam until reaching the M5 refocusing mirror. After the mirror the section slopes downwards at 1 degree in the direction of the beam.

7.2 This section shall have a pneumatic gate valve 0.7m downstream of the focal point of the first endstation area, that is to say 1.3 m upstream of the center point of the M5 refocusing mirror. The more precise requirements of positions of these valves is to allow maximum flexibility for the size and type of endstations used on this beamline

7.3 A second gate valve shall be found 0.5 meters upstream of the focal point of the second endstation area, that is to say 1.5 m downstream of the center point of the M5 refocusing mirror.

7.4 The mirror and chamber shall require a motorized optical table and the large column mounting assembly.

7.5 Motorization of the table and subsequently the mirror shall allow for the adjustment of the height, tilt, and transverse position of the mirror.

7.6 Vertical motorizations should have a travel range of at least 10 mm adjustable in increments of one micron. Horizontal/transverse motorizations should have a travel range of +- 10 mm adjustable in increments of ten microns.

7.7 There shall be sufficient ports in the mirror chamber to allow not only for beam entrance and egress, but also for: an ion pump, ion gauge, large view-port (at least 6 inch flange), a small (2.5 inch flange) on axis view-port for visual alignment using the upstream isolated blade should is be coated with a phosphor, and a pump down port with a manual all-metal UHV valve.

7.7 The area downstream of the M5 mirror, before the second gate valve shall contain a differential pumping section capable of sustaining at minimum 4 orders of magnitude pressure differential with the vacuum upstream of this differential pumping section being of UHV quality. This are should also contain a pair of manual valves one on either side of the differential pumping section upon which can be mounted windows in the eventuality of users desiring to conduct dirty and/or gas phase experiments in the second endstation area.

7.8 The refocusing mirror shall be of toroidal shape with an angle of incidence of 1 degree.

7.9 The substrate of the mirror shall be synthetic fused silica.

7.10 The reflective coating of the mirror shall be gold. The thickness of the gold shall be sufficient to ensure no attenuation effect on the beam due to the substrate material. The coating shall cover as much of the reflective surface of the mirror as possible.

7.11 The Meridional radius of the mirror shall be 114.597 m with accuracy of 0.5% or better.

7.12 The Sagittal radius of the mirror shall be 0.0349 m with accuracy of 1% or better.

7.13 The Meridional slope error shall be 2.5 arcsec or better.

7.14 The Sagittal slope error shall be 2.5 arcsec or better.

7.15 The mirror roughness shall be 1 nm or better.

7.16 The mirror length shall be 300 mm

7.17 The mirror width shall be approximately 30-40 mm.

8.0 SAFETY, ENVIRONMENTAL, AND RELIABILITY

8.1 The vacuum chambers shall be capable of operation in an ambient temperature range of 10 to 40 degrees C. The normal ambient temperature on the experimental floor is 21 degrees C. The expected temperature stability of the building will be 1 degree C during normal operation.

8.2 The components shall be able to withstand a relative humidity range of 0% to 95%. The expected relative humidity limits under operation are from 25% during the winter months and a maximum of 50% during the summer months. The expected relative humidity range for components under storage will be the same as previously mentioned.

8.3 All equipment and structures shall conform to the BKL report “Vibration Isolation Mechanical Equipment”.[5]

9.0 QUALITY ASSURANCE AND TESTING

9.1 The proponent shall maintain and apply a quality assurance program compliant with ISO-9001 for the design, manufacture, procurement, testing and installation of all four sections.

9.2 Sections shall be vacuum tested after arrival and installation at CLS for the purposes of remediation of vacuum leaks created during transport. This is in addition to vacuum factory testing done before shipment as stated earlier. Proponent shall verify out gassing and leak rate after installation.

10.0 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[6]
- Canadian Light Source Vacuum Component Leak Test Technical Procedure[7]
- Fasteners shall be American standard thread. Proponent may propose metric fasteners if spares are included.

11.0 OTHER REQUIREMENTS

11.1 All components of each section shall be completed, delivered, and installed at CLS by August of 2003.

11.2 Packaging to be used during shipping of components shall ensure protection of the components from water, dust, oil, and vibration during shipping. In the case of the mirrors, the packaging should be hermetically sealed

11.3 Components shall be held securely in the shipping containers to prevent chafing or scratching that could damage the components and / or generate contaminants.

11.4 Vacuum chambers should be shipped pressurized with dry nitrogen gas at a pressure slightly above the highest ambient atmospheric pressure.

11.5 The shipping containers shall be properly labeled in English to ensure proper care during shipment.

11.6 All documentation to the CLS shall be in English and conform to CLS document specification[8].

11.7 Documentation supplied to the CLS shall be provided in hard copy in triplicate plus one electronic copy if available. All drawings shall be supplied in AutoCAD format. All drawings and other documentation should also be appropriately labeled, numbered, and include a revision history.

12.0 REFERENCES

1 McPherson Inc., “Assy., SGM 70m Beamline”, 81244, Oct. 17, 1997.
2 McPherson Inc., “Layout, SGM”, 100-104621, Jan. 22, 2002.
3 E. Mattias, “Control System Technical Specification”, 7.4.39.1 Rev. 2
4 McPherson Inc., “Column Mounting Assy.”, 100-104629, Nov. 1, 2001.
5 BKL Consultants Ltd “Vibration Isolation Mechanical Equipment”. 0395-99A, June 3, 1999.
6 Canadian Light Source Vacuum Component Cleaning Technical Procedure, 8.7.33.1, September 13, 2000.
7 Canadian Light Source Vacuum Component Leak Test Technical Procedure, 8.7.33.2, September 13, 2000.
8 D.S. Lowe. “CLS Document Specification”, 0.4.1.1 Rev. 2 14 Dec 2000

RFP Selection Criteria

a)	Technical -understanding the scope of the work -fabrication, assembly, installation plan -ability to meet minimum functional and performance requirements -performance ability -quality and duration of proposed warranty periods -proposed delivery if different from stated	35%
b)	Cost -proposal pricing -cost saving proposals -value added benefits and incentives -proposed payment structure	35%
c)	Proponent Qualifications -corporation structure and ownership -demonstrated ability to satisfy the University requirements -relevant experience, competence, and reliability in handling similar projects, based upon references -international scientific reputation of company	20%
d)	Economic Benefits and Incentives Program -national, regional, and local benefits	5%
e)	Any other factors the CLS may consider appropriate	5%
		100 %

Note: All bids are to be submitted in Canadian dollars or currency of companies country.

SCOPE OF WORK

The Proponent shall provide all material, labour, equipment, and services required to complete the Work as set out in the RFP. The Work shall be that which is called for in specifications and drawings. The Work shall include but is not limited to the following:

1. Supply and complete the planning, design, and engineering to carry out the Work.

2. Plan and implement the procurement of materials, equipment, and services to carry out the work.

3. Provide and implement a Quality Assurance and Control Program (QA/QC) for the Work. The QA/QC program to include the testing, certifications, and inspections specified within this RFP.

4. Carry out, document, and distribute the results of testing, certifications, and inspections as specified within this RFP.

5. Provide documentation as specified within this RFP.

6. Provide the components specified in this document including all four beamline sections.

7. Provide all measurement and testing as defined or required to perform the work. Provide copies of all results to the CLS.

8. Provide packaging and transportation of finished product to designated CLS site.

9. Assemble and vacuum test finished product on the experimental floor at CLS.

PROPOSAL COST SUMMARY FORM

Proponents shall provide their proposal cost summary using the following format in Canadian dollars and/or currency of companies' country:

RFP Design Build of Two Toroidal Refocusing Mirrors and Four Beamline Sections for the Canadian Light Source Spherical Grating Monochromator (SGM) Beamline

Item#	Description	Quantity	Unit Rate	Total
1	Detailed design for all 4 sections	1		
2	Fabrication Section #1	1		
3	Fabrication Section #2	1		
4	Fabrication Section #3	1		
5	Fabrication Section #4	1		
6	Fabrication Mirror M4	1		
7	Fabrication Mirror M5	1		
8	Factory Testing	1		
9	Testing at CLS	1		
10	Subtotal			
11	PST			
12	GST			
13	Duties			
14	Shipping			
15	Subtotal			
14	Total			

SPECIAL REQUIREMENTS TO BE INCLUDED IN RFP

1. Proponent shall provide examples of previous work that demonstrates the proponent's capacity to fabricate beamline components with similar performance to the components specified in this document.

2. Provide names and phone numbers of two references to whom the proponent has supplied synchrotron beamline components to that may be contacted by the CLS.

3. Proponent shall provide a list of any exceptions or alterations to statements, parameters, and tolerances in this document and attached drawings.

4. CLS reserves the right to visit the proponent's facility before awarding a contract.

5. CLS reserves the right to inspect components and facilities during fabrication.

6. Radius, RMS slope error and micro-roughness for all mirrors shall be measured and results sent to the CLS for review and acceptance. The proponent shall describe in the bid statement, the measuring technique (s) to be used to verify these parameters.

7. The proponent shall propose a schedule with the following milestones:

    -start
    -completion of detailed design
    -completion of vacuum chambers
    -completion of support structures
    -factory vacuum tests
    -completion of mirrors
    -shipment to CLS
    -assembly vacuum tests at CLS

The proponent shall also propose a schedule of site visits by representatives of the CLS. It is suggested that these visits occur at approximately the following milestones:

-factory vacuum tests
-just before shipment to the CLS