

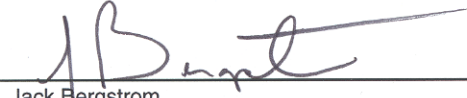



THE OSR CHICANE AND PRIMARY FOCUS SYSTEM

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TABLE OF CONTENTS

1.0	INTRODUCTION	1
2.0	REQUIREMENTS.....	2
3.0	SAFETY, ENVIRONMENTAL AND RELIABILITY	7
4.0	QUALITY ASSURANCE.....	8
5.0	APPLICABLE CODES, STANDARDS, AND PROCEDURES	8
6.0	INSPECTION, TESTING AND COMMISSIONING.....	8
7.0	OTHER REQUIREMENTS	8
8.0	REFERENCES	9

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1.0 INTRODUCTION

1.1 PURPOSE

This document specifies the requirements for a OSR Optical Chicane and Primary Focus System to be supplied and delivered to the CLS for use as part of a diagnostic beamline.

1.2 SCOPE

The specifications of the optical chicane in the OSR (Optical Synchrotron Radiation) diagnostic beamline are herein described, including the containment vessel (both the high vacuum section and the atmospheric pressure section), the mirrors, vacuum window, and the primary focusing lens. The resolution tolerances on the supporting translation and tilt stages are presented. If it happens that the tolerances exceed commercial technology, or if significant economic benefit obtains by relaxing certain specifications, we are open to negotiation with the proponent.

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. It is critical to provide a means of measuring the beam quality during the initial stages of commissioning and then later during operation. The OSR beamline is being constructed with a goal of being ready for commissioning of the Storage Ring and operation when the facility is declared operational in early 2004.

2.0 REQUIREMENTS

2.1 CONTAINMENT VESSEL

- 2.1.1** The containment vessel houses 2 mirrors (one in ultra-high vacuum, and one in air), an x-ray beam dump, a variable-aperture slit system, and an imaging lens. Each is discussed in detail below.
- 2.1.2** The containment vessel should be stainless steel.
- 2.1.3** The ultimate pressure shall be less than 10 nPa (1×10^{-10} torr) with no beam, and less than 100 nPa (1×10^{-9} torr) with beam.
- 2.1.4** Proponent shall size ion pumps from standard Varian pump sizes. CLS will procure specified pumps.
- 2.1.5** Pumps should be orientated such that they are located below the vacuum chamber.
- 2.1.6** Containment vessel 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.
- 2.1.7** Containment vessel shall be equipped with a Granville-Phillips Series 375 Convectron Vacuum Gauge Controller and gauge. Pressure readout shall be in torr.
- 2.1.8** Where dimensions have not been specified, the vendor has complete freedom, providing the final assembly does not conflict with nearby hardware. In some cases the interior dimensions are constrained by the apparatus housed within, Item 2.7 below being a case in point.
- 2.1.9** The UHV chamber and the air chamber shall be separated by an optical window. At the vendors discretion, the two chambers may be mated by a pair of flanges, or alternatively they may form a continuous structure.
- 2.1.10** Access to all instrumentation shall be gained through removable side panels.
- 2.1.11** The proponent shall devise a supporting structure for the containment vessel, including provisions for final alignment of the vessel with respect to the incoming and outgoing transfer lines.
- 2.1.12** Support structure should be of welded steel construction.
- 2.1.13** Support structure should be primed and painted with the final color determined by CLS.

- 2.1.14** Fiducial points shall be produced using a precession 8 mm diameter hole perpendicular to a machined surface.
- 2.1.15** Proponent shall provide vibration isolation for the assembly, presumably incorporated into the containment vessel supporting structure. The horizontal distance from the mirrors to the optical table instrumentation is 7-8 meters, where the beam image size is the order of 100-200 μm . Image stability is therefore sensitive to vibrations of the primary and secondary mirrors.
- 2.1.16** Technical vibrations are typically at frequencies less than 100 Hz.
- 2.1.17** The containment vessel shall interface to the entering and exiting beam pipes by means of 6-inch Conflat™ flanges.

2.2 PRIMARY MIRROR

- 2.2.1** The primary mirror deflects the visible portion of the incoming synchrotron light downward, through an angle of 90° , to the secondary mirror. The primary mirror is positioned such that it only intercepts the top half of the light fan, allowing the hot x-ray core to pass just below the lower edge.
- 2.2.2** The reflecting surface should be aluminum deposited on a square Glidcop substrate of dimension 50 x 50 mm.
- 2.2.3** There shall be no protective optical coating on the mirror.
- 2.2.4** The mirror should be flat to at least $\lambda/10$ (peak-to-valley) at $\lambda = 633 \text{ nm}$, with a maximum roughness of 1 nm.
- 2.2.5** The substrate thickness is at the discretion of the manufacturer.
- 2.2.6** The flatness requirements shall be met to within 0.4 mm, or less, of the lower edge of the mirror.
- 2.2.7** A thermo-probe shall protrude about 0.5 mm below the lower edge of the mirror. The probe is used to sense the edge of the x-ray core and thus control the mirror position in order to prevent a thermal overload. For reference, the total power in the radiation fan is 70 watts per horizontal mrad. The corresponding power in the visible region (400-900 nm) is about 1.4 milliwatts per horizontal mrad.
- 2.2.8** Although the heat load on the mirror is only about 1 watt during normal operation, provision should be made for water-cooling, even if only a single channel is incorporated. This will restabilize the mirror quickly if it encounters transient x-ray flashes from an unstable beam.
- 2.2.9** Temperature fluctuations across the mirror should not exceed $\pm 0.5^\circ \text{ C}$.

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- 2.2.10** Mirror design shall be compatible with low conductivity water (LCW) with conductivity less than $6 \mu\text{S/cm}$.
- 2.2.11** Nominal water supply temperature will be $26 \pm 1^\circ\text{C}$.
- 2.2.12** Nominal water supply pressure will be 350 kPa.
- 2.2.13** Pressure drops across the mirror shall be less than 300 kPa.
- 2.2.14** Water interface points shall be clearly labeled as inlet or outlet, and identify the component supplied.
- 2.2.15** Direct water to vacuum joints should not be used in the design.
- 2.2.16** The mirror shall be mounted on a translation stage driven by a DC or stepping motor situated outside the vacuum chamber. This mechanism controls the mirror position with respect to the x-ray core, in a direction parallel to the mirror surface.
- 2.2.17** Travel parallel to the mirror surface shall be +30 mm (upward sense) to -5 mm (downward sense), where the null position locates the lower edge of the mirror directly on the radiation centerline.
- 2.2.18** Travel resolution should be at least $5 \mu\text{m}$.
- 2.2.19** Maximum pitch/yaw over the full travel should be held to a minimum, preferably less than $\pm 10 \mu\text{rad}$.
- 2.2.20** The stage shall include a position encoder to permit remote readout.
- 2.2.21** The proponent shall devise a method to establish the angular disposition of the mirror. The angular disposition of the mirror, once established, will remain fixed. Remote control of the angle may not be required.
- 2.2.22** The Proponent shall provide a feed-back system which controls the mirror position in order to keep the temperature of the thermo-probe at a temperature $T \pm \Delta T$ (for example, $T = 50^\circ\text{C}$ and $\Delta T = \text{few degrees}$). The time response of the loop should be roughly 100 ms or better.

2.3 BEAM DUMP

- 2.3.1** After passing below the primary mirror, the x-ray beam is removed by a beam dump. The critical energy of the synchrotron radiation is about 7 keV, and, as noted, the total power is about 70 watts per horizontal mrad.

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- 2.3.2 For a horizontal acceptance of 4 mrad, the beam dump must dissipate 280 watts over an area roughly 20 mm wide x 1.6 mm high, for a heat load of roughly 9 watts/mm². The dump width should be 60 mm to accommodate beam steering errors.
 - 2.3.3 The beam dump shall be water-cooled. The choice of material for the dump must have UHV characteristics since the vacuum here is contiguous with the Storage Ring vacuum.
 - 2.3.4 The beam dump shall be sufficiently removed (or sufficiently cooled) such that thermal transfer to the primary mirror causes negligible distortions of this mirror.
 - 2.3.5 Water interface points shall be clearly labeled as inlet or outlet, and identify the component supplied.
 - 2.3.6 Beam dump shall interface with the containment vessel using Conflat™ flanges.

2.4 VACUUM WINDOW

- 2.4.1 The vacuum window separates the UHV in the primary-mirror chamber from the atmospheric pressure in the secondary-mirror chamber. Preliminary considerations are based on a sapphire window 50 mm in diameter and 1 mm thick. Hydrostatic burst pressure for this window is 24 psi, at a safety factor of 3.
- 2.4.2 Proponent shall design window such that it will withstand a vacuum to atmosphere loading on either side of the window (eg. either side of the window may be under vacuum while the other side is at atmospheric pressure).
- 2.4.3 Proponent should consider mounting the window at a slight angle in order to minimize interference and reflective disturbances to the overall transmission characteristics. A tilt of a few degrees should be adequate.
- 2.4.4 Sapphire exhibits birefringence. Since the synchrotron radiation is strongly polarized in the horizontal plane, care must be taken with the orientation of the crystal optic axis with respect to the plane of the window.
- 2.4.5 The exact position of the window with respect to the primary and secondary mirrors is at the discretion of the proponent.

2.5 SECONDARY MIRROR

- 2.5.1 The secondary mirror is situated 500 mm below the primary mirror, and redirects the light onto the horizontal plane. It can be a copy of the primary mirror (50 x 50 mm; aluminum over a nickel-coated Glidcop substrate, although this may be “overkill” in view of the low power absorbed by the mirror).

- 2.5.2** Optical quality must be consistent with the primary mirror, namely flatness to at least $\lambda/10$ (P-V) and maximum roughness of 1 nm. However, these requirements can be relaxed near the mirror edges.
- 2.5.3** The chamber enclosing the mirror is at atmospheric pressure. Water cooling of the mirror is not required.
- 2.5.4** The mirror controls alignment of the light beam onto the instrumentation optical table situated 6-7 m downstream, and therefore must be mounted on a high-resolution tilt-rotate platform remotely controlled by DC or stepping motors. Three degrees of motion are required: mirror tilt, rotation about the vertical axis, and vertical linear motion. The resolution on the angular degrees of freedom should be 15 μ rad or better. The resolution in the vertical motion should be 10 μ m or better. Vertical travel should be about +10 mm (up) to -20 mm (down). The downward travel is sufficient to remove the mirror from the straight-through line-of-sight for alignment purposes with respect to the optical table instrumentation. However, if the proponent can suggest an alignment procedure involving both mirrors simultaneously, then the vertical travel of the secondary mirror can be relaxed to about \pm 10 mm.
- 2.5.5** Unlike the primary mirror, frequent motion is not anticipated. Although angle encoders are therefore not a requirement, a position encoder of modest resolution should be included.

2.6 SLIT SYSTEM

- 2.6.1** An adjustable slit system is required to control the angular acceptance of the subsequent optics. The minimal angular acceptance is roughly 4 x 4 mrad, which translates into a limiting aperture of about 24 x 24 mm at the slit location. In order to accommodate a larger light fan, the maximum aperture should be 40 x 40 mm. The minimum aperture should be essentially zero.
- 2.6.2** The system shall be comprised of two units consisting of 2 jaws each.
- 2.6.3** Each unit shall be capable of being centered with respect to the beam by remote control. There are 2 options that meet these requirements.
- Each of the 2 jaws in each unit is independently controlled by a DC or stepping motor. Each jaw is supplied with a position encoder for remote readout.
 - Each pair of jaws is driven by a single motor. In this case, each unit sits on its own centering stage (one stage provides vertical motion, the other provides horizontal motion). Position encoders are again required.
- 2.6.4** Resolution and reproducibility on all positions should be at least 100 μ m.

2.7 FOCUS SYSTEM

- 2.7.1** Focusing of the visible light, from the dipole magnet source point to the image plane on the optical table, will be accomplished by a simple lens that provides a 1:1 image (unit

magnification). Both the source and the image are 6.0 m from the lens. The focal length of the lens is therefore $f = 3.0$ m.

- 2.7.2** For reason of economy, an off-the-shelf item is preferred rather than a custom made lens. The only supplier located so far for such a lens is Melles Griot. This lens is actually a cemented double-lens achromat with a diameter of 150 mm. If required, the CLS could forward this lens to the proponent.
- 2.7.3** The lens shall be mounted on a translation stage, driven by DC or stepping motors, allowing independent motion along 3 degrees of freedom (i.e. x, y, z).
- 2.7.4** Travel in the longitudinal direction should be ± 180 mm from the center, with a resolution of 1 mm or better.
- 2.7.5** Travel in the transverse directions should be at least ± 15 mm from the center, with a resolution of 0.10 mm or better.
- 2.7.6** Position encoders shall be provided for all three directions.
- 2.7.7** Encoder resolution should be approximately 1 mm.

3.0 SAFETY, ENVIRONMENTAL AND RELIABILITY

- 3.1** The system shall be capable of operation in an ambient temperature range of 10 to 40°C.
- 3.2** The normal ambient temperature within the tunnel is 27 ± 0.1 °C.
- 3.3** The normal ambient temperature within the optical table enclosure is 21 ± 1 °C.
- 3.4** The components 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 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.
- 3.5** All components shall be designed for operation in a radiation environment. The vendor shall avoid all materials that are subject to damage by ionising 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 failure (MTBF) of 5 years in the typical radiation environment.
- 3.6** In the tunnel environment, there will be a small amount of production of radioactive air and noxious gasses. These are estimated to be:
 - 1. For N-13, O-15, and C-11: 0.0002 Bq/cc.
 - 2. For ozone: 5.6×10^8 mol/cc.
 - 3. Nitrogen dioxide: 2.7×10^8 mol/cc.
 - 4. Nitric acid: 0.8×10^8 mol/cc.

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- 3.7** The tunnel environment will have a maximum vibrational movement of less than 0.4 microns at frequencies less than 100 Hz.
- 3.8** All equipment/structures shall conform to the BKL report "Vibration Isolation Mechanical Equipment".
- 3.9** All small tubing water connections shall be American standard Swagelok fittings. All large water tubing shall use NPT threads.
- 3.10** Compressed air (instrument quality) will be available in the tunnel at 827 kPa (120 psi).

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 all magnets.

5.0 APPLICABLE CODES, STANDARDS, AND PROCEDURES

- 5.1** 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]

6.0 INSPECTION, TESTING AND COMMISSIONING

7.0 OTHER REQUIREMENTS

- 7.1** Fasteners shall be American standard thread. Proponent may propose metric fasteners if spares are included.
- 7.2** Packaging to be used during shipping of the equipment shall ensure protection of the components from water, dust, oil, and vibration during shipping.

- 7.3** The equipment shall be held securely in the shipping container to prevent chafing or scratching that could damage the component and / or generate contaminants.
- 7.4** Vacuum chambers should be shipped pressurized with dry nitrogen gas at a pressure slightly above the highest ambient atmospheric pressure.
- 7.5** The shipping containers shall be properly labeled in English to ensure proper care during shipment.
- 7.6** All documentation to the CLS shall be in English and conform to CLS document specification [4].
- 7.7** 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.

8.0 REFERENCES

1. E. Matias, "Control System Technical Specification", 7.4.39.1 Rev. 2
2. Canadian Light Source Vacuum Component Cleaning Technical Procedure, 8.7.33.1, September 13, 2000.
3. Canadian Light Source Vacuum Component Leak Test Technical Procedure, 8.7.33.2, September 13, 2000.
4. D.S. Lowe. "CLS Document Specification", 0.4.1.1 Rev. 2 14 Dec 2000