M1 mirror technical specification for the SM ID10-1 beamline

Technical Specification 6.8.76.3Rev0

April 3, 2002

	Signature	Date
	Original on File – Signed by:	
Prepared by:	_____ K. Kaznacheyev	_____
Reviewed by:	_____ Brian Yates	_____
Reviewed by:	_____ Jeremy Ransom	_____
Reviewed by:	_____ David Loken	_____
Approved by:	_____ Emil Hallin	_____

Canadian Light Source Inc.
101 Perimeter Road
University of Saskatchewan
Saskatoon, Saskatchewan Canada S7N 0X4

REVISION HISTORY

Revision	*Date*	*Description*	*Author*
A	Feb.7/02	Draft	Kaznacheyev
B	Feb.22/02	Simplified and modified	Warwick
0	April 3, 2002	Internal review completed; CLS drawing attached	Kaznacheyev

Table of Contents

1.0 INTRODUCTION

1.1 PURPOSE

This document contains the Technical Specifications for the M1 mirror of SM 10ID-1 beamline at the Canadian Light Source.

1.2 SCOPE OF TECHNICAL SPECIFICATION

This technical specification establishes the requirements for the fabrication, inspection, testing and delivery of the x-ray mirror.

The technical specification covers both substrate fabrication and mirror polishing requirements.

Water-cooled mirror substrate assembly includes mirror upper face plate with water and air guard machined channels, mirror body with mirror air and cooling water distribution channels, two stainless steel fittings, two teflon tubes, quantity three of the mirror mounting foot assembled and bonded as described below.

This specification includes, but is not limited to:

- Materials
- Detail drawings
- Fabrication requirements
- Quality Assurance and Testing

1.3 BACKGROUND

The Canadian Light Source is a national facility under construction on the University of Saskatchewan campus in Saskatoon, Saskatchewan. This facility is a 3rd generation synchrotron light source, which will produce a high intensity source of infrared, ultraviolet and x-ray radiation.

SpectroMicroscopy Beamline (SM) is a soft x-ray microscopy desiccated facility, which will provide intense soft x-ray light for Scanning Transmission X-ray Microscope and Photoelectron Emission Microscope. It will be built in the 10ID sector of the CLS main ring.

M1 mirror is the first optical element of the SM beamline. It is placed ~16m away from an Elliptically Polarized Undulator (EPU) and reflects the synchrotron radiation (SR) beam horizontally by 3 degree inboard (to the right as seen along the photon beam). The mirror orientation is vertical. The mirror has a cylindrical optical surface, with the cylinder axis parallel to the lengthier side of substrate. The cylinder radius is chosen so that the mirror provides a vertically collimated SR beam for the plane grating monochromator placed approximately 5m downstream. The power load absorbed by the mirror out of the EPU may be up to 1000W, with peak density as high as 0.7W/mm^2. To keep the elastic deformation below 5μrad, the mirror is internally water-cooled. The thickness of the hot wall (the distance between the top of the embedded channels and the mirror optical surface) is approximately 1.5mm.

The mirror will be mounted in a mirror manipulator through a 3 point kinematical mounting. For alignment purpose the upper side of the mirror should have a mirror-lake polished surface, parallel to the mirror cylinder axis. The size and location of this surface is defined in the attached drawing package.

The main optical surface area is 360 mm long by 20 mm wide. Surface figure errors and micro-roughness should not exceed the specified tolerances. The optical surface of the mirror shall be gold coated.

The mirror must be capable of being operated in an ultra high vacuum environment and subjected to hard x-ray radiation. It should withstand baking to 150^{o}C for 24 hours, and retain its shape and performance characteristic upon cooling to room temperature. The maximum operating temperature at the mirror surface is not to exceeded 40^{o}C.

Further background information can be found in the SM Preliminary Design Review CLS #6.2.76.10.

1.4 DEFINITIONS AND ABBREVIATIONS

CLS – Canadian Light Source

RMS - root mean square

SM- SpectroMicroscopy beamline.

SR – Synchrotron Radiation

EPU – Elliptically Polarized Undulator.

UHV - Ultra high vacuum

2.0 MIRROR SUBSTRATE REQUREMENTS

2.1 GENERAL REQUREMENT AND DRAWINGS

2.1.1.The mirror substrate shall be manufactured, as specified in CLS DWG 10ID-1/ME/MIR/0065204, M1 Mirror Assembly. Overall dimensions of the mirror substrate are approximately 380 mm (long) x 60 mm (wide) x 60 mm (thick) with features for mounting and water fittings as shown in Fig. 1. The mirror substrate assembly includes:

- Mirror upper face plate water and air guard channels are machined as shown in CLS DWG 10ID-1/ME/MIR/0065205.
- The mirror air and cooling water distribution details are defined in CLS DWG 10ID-1/ME/MIR/0065206.
- Two stainless steel fittings as defined by CLS DWG 10ID-1/ME/MIR/0065210 shall be bonded to the mirror substrate as shown in the M1 Mirror Assembly drawing, CLS DWG 10ID-1/ME/MIR/0065204.
- Two Teflon tubes, CLS DWG 10ID-1/ME/MIR/0065139, fit into the water manifold using o-ring seals. Cooling water is provided to the inside tube and vacuum is applied to the air guard between the tube and the steel fittings. It may be necessary to manufacture this item to adequately meet the leak test requirements below.
- Quantity three of the Mirror Mounting Foot as defined by CLS DWG 10ID-1/ME/MIR/0065114.

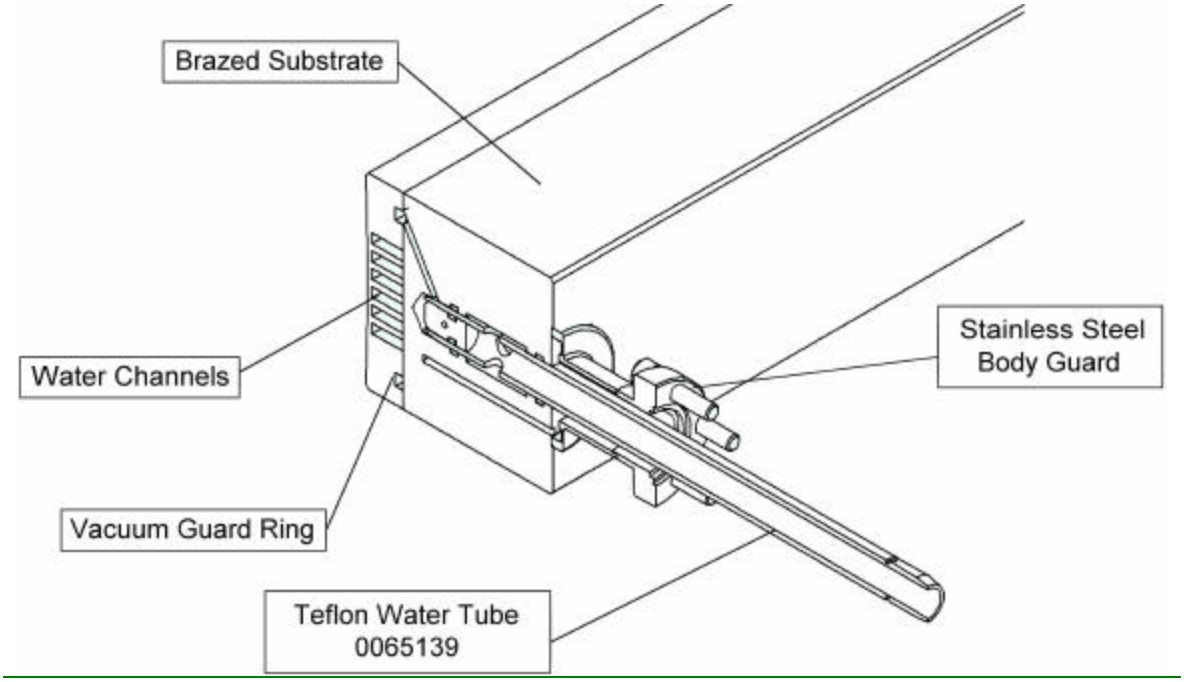

Fig.1. The mirror assembly sectioned along the water supply line. The kinematical mounting points (3) are on the bottom of the main mirror body but not shown.

2.1.2. The cooling channels which carry water beneath the optical surface shall be machined in the faceplate. The air guard channel and water-cooling channels geometry shall be, as shown in CLS DWG 10ID-1/ME/MIR/0065205.

2.1.3. The body of the substrate shall be machined with inlet and outlet channels as required to carry the water through from the metal water fittings to the cooling channels beneath the optical surface and to connect these channels together. These inlet and outlet channels are to have a cross-section large enough that the flow velocity in them is no higher than the flow velocity in the cooling channels beneath the optical surface. The channel geometry is shown in CLS DWG 10ID-1/ME/MIR/0065205 and CLS DWG 10ID-1/ME/MIR/0065206.

2.1.4. The metal water fittings shall connect to the machined inlet and outlet channels that pass through the body of the substrate so that water can flow in the cooling channels under the optical surface. The geometry of the metal fitting shall be as defined by CLS DWG 10ID-1/ME/MIR/0065210. Standard 1.33" CONFLAT vacuum fittings seal to the metal water fittings using metal seals around the water lines to make up the guard volume. See drawing CLS DWG 10ID-1/ME/MIR/0065109.

2.1.5. The mirror upper face plate, the mirror main body and stainless steel fitting shall be bonded together with a leak free UHV compatible permanent bond. The bonding shall not clogged or obscure the water and air guard channels. The bonding shall be uniform along the face plate to the body of substrate joint surface. The geometry of the permanent bond shall provide a guard volume as required to eliminate the possibility of any water through the UHV joints. This guard volume shall be evacuated and must be connected by a channel through the body of the substrate to the guard volume in the metal water fittings.

2.1.6. Teflon water tubes are to be manufactured as shown in CLS DWG 10ID-1/ME/MIR/0065109. To conduct the water flow measurements and leak tests these Teflon tubes shall be fasten into the metal water fittings and the substrate body using o-ring seals.

2.1.7. Quantity three of the Mirror Mounting Foot are to be fastened to the bottom of the substrate to provide an anchored kinematic mounting. See drawing CLS DWG 10ID-1/ME/MIR/0065114.

2.1.8. The finished mirror substrate shall be cleaned and all faces of the mirror shall be free of any dents, gouges or scratches.

2.1.9. The mirror substrate shall be ultra high vacuum compatible. Refer to CLS Technical Specification, 8.7.33.1.

2.1.10. The mirror substrate shall withstand an in-vacuum baking of 150C for 24 hours.

2.1.11. The contractor shall review the drawings and other documentations provided be the CLS for errors, and to inform the CLS of any discrepancies and errors. The contractor is free to make modification of the drawing, as required by substrate bonding/ brazing technique, but any changes or corrections must be documented by the contractor as “marked drawing” changes and submitted to CLS for approval.

2.1.12. After the completion of the tests, the water shall be drained out of water channels, the Teflon tubes shall be removed, the water and air guard channels shall be filled with dry nitrogen and the metal water fitting shall be sealed with standard 1.33” CONFLAT flanges.

2.2 MATERIALS

2.2.1. The mirror substrate body and faceplate may be either Glidcop AL15 or single crystal silicon.

2.2.2. Metal water fittings shall be 304SS stainless steel, although another type of steel may be substituted, with CLS approval, if required for bonding.

2.2.3. The spherical head bolt used as the Mirror Mounting Foot shall be made from AMPCO18 aluminum bronze.

2.2.4. Any and all material substitutions must be pre-approved by CLS.

2.3 FABRICATION REQUIREMENTS

2.3.1. The mirror substrate shall be machined in accordance with common acceptable industrial procedures applicable to the selected substrate material.

2.3.2. The optical surface of the mirror substrate shall be machined flat.

2.3.3. The optical surface shall not contain any intrusions, scratches, contaminants and other defects, which prevent it from the further fine polishing.

2.3.4. The machining process used shall be compatible with UHV applications. In particular

- No silicone or sulfur-based cutting fluids, lubricants or waxes, which may result in contamination, shall be used
- No operation causing contaminants to be embedded into the mirror substrate surface shall be permitted. Grinding under power with resin-bonded wheels, using rouge, emery cloth, crocus cloth, or similar abrasives are prohibited.
- The finished mirror substrate shall be cleaned and all side of the mirror shall be free of dents, gouges and scratches. Lint-free and talcum-free nylon gloves are to be worn when handling the mirror substrate after cleaning.

For other, refer to CLS Technical Specification, 8.7.33.1 for vacuum component cleaning specification.

2.4 IDENTIFICATION

2.4.1. The mirror shall be permanently marked with identifying letters plus number combination of the type SMxx engraved into the side face of the mirror at the location indicated in the drawing. The two digit number (xx) will be issued by the CLS at the time of contract award. The location and size of the identification number is defined in CLS DWG 10ID-1/ME/MIR/0065204.

2.5 QUALITY ASSURANCE AND TEST REQUIREMENTS

2.5.1 Certification, inspection during fabrication

2.5.1.1. The contractor shall submit with the proposal an Inspection and Test Plan for different stages of fabrication prior to the initiation of any procurement or fabrication activities.

2.5.2 Final inspection and acceptance

2.5.2.1.The bonded mirror substrate shall be inspected by the contractor to verify conformance with all the drawing and specification requirements.

2.5.2.2. If two separate contracts are awarded, one for mirror substrate fabrication and bonding and another for mirror polishing, the final mirror substrate acceptance test shall be verified by the polisher and the polisher shall assume the final responsibility for the mirror performance.

2.5.2.3. To ensure the uniform bonding of the upper plate to the main mirror body, a hydrostatic test shall be performed. The water channels volume shall be pressurized to 1040 kPa (150psig) for half an hour followed by an Helium leak test, as described below.

2.5.2.4. A flow test is required to verify that the flow resistance is within acceptable limits. The contractor shall measure the pressure drop at a water flow rate of $1.8*10^{-4} m^3/s$ (2.9 gallons per minutes) through the mirror. Flow tests must be performed after bonding the assembly, but prior to polishing. Flow tests are to be made with the O-ring sealed Teflon water tubes to verify a seal between the water and air guard volume.

2.5.2.5. Following the hydrostatic test and prior to the water flow measurements, a leak test using a helium leak detector is required for all internal volumes: air guard volume to outside, water channels volume to outside, and water channel to air guard volume. The following total leak rate shall be achieved, by having the assembly bagged in at least a 50% helium atmosphere for one minute:

1. water channel volume to ambient-- less than $2x\ 10^{-10}$ std atm cc/sec ($2.67x10^{-8}$ Pa L/s),
2. air guard volume to ambient-- less than $2x\ 10^{-10}$ std atm cc/sec ($2.67x10^{-8}$ Pa L/s),
3. water channel volume to air guard volume with Teflon tubes assembled -- less than $2x\ 10^{-9}$ std atm cc/sec ($2.67x10^{-7}$ Pa L/s),

For other procedures, applicable for vacuum component leak test, referee to CLS Technical Specification, 8.7.33.2.

2.5.2.6. Test results shall be provided to CLS as soon as possible after the tests are performed. A copy of the original test data shall be provided to the CLS within one month after the test has been completed.

2.5.2.7. Acceptance tests may be done at another facility, subject to approval by the CLS.

2.5.2.8. The CLS has a right to conduct its own performance measurements or have a CLS representative be present during the test measurements at the contractor's facility. At least two weeks notice shall be provided prior to the performance of acceptance tests.

3.0 POLISHING AND COATING REQUIREMENTS

3.1 GENERAL SPECIFICATIONS

3.1.0.1. The contractor shall prepare the mirror surface for polishing. This preparation may involve grinding to the approximate dimensions with a subsequent process to add a coating of material into which the finished surface is to be polished. The thickness of the hot wall (the distance between the water channels beneath the optical surface and main optical surface itself) shall be in the range 1.48mm to 1.53mmon a finished mirror.

3.1.0.2. Two polished optical surfaces are required.

1. The flat surface ~45 mm wide by 60 mm long, as shown in CLS DWG 10ID-1/ME/MIR/006065204, will be used in the mirror alignment procedure. The optical surface quality, of 40-30 or higher as defined by MIL-O-13830 specification is acceptable. The plane surface shall be parallel to the mirror cylindrical axis to within better than 100μrad. The plane surface shall be perpendicular to the surface tangential to the mirror pole (center) to within better than 100μrad.
2. The main active optical surface of the mirror is 360 mm long *20 mm wide. This is the primary optical surface, which sees the SR. Inside this area both mirror shape and mirror roughness shall meet the specified accuracy. This specification includes two technical options: (Option A) relaxed specification, and (Option B) tight requirements, both are specified below. The specifications on the drawing are for reference only.

3.1.0.3. An 'optical chamfer' is required around the surface of the mirror substrate to break the edge of the optical surface and prevent peeling of the optical coating. The polisher is free to polish a larger area as required.

3.1.0.4. The polisher is also responsible for optical coating the main optical surface.

3.1.1 Mirror shape

3.1.1.1.The active optical surface of the mirror shall have a cylindrical shape, with the cylindrical axis along the mirror long edge, as shown in CLS DWG 10ID-1/ME/MIR/0065204. The nominal cylindrical radius is r=0.833460 m. The relative accuracy of the mirror radius is 10%, and is left to the manufacturer to determine the most appropriate value, based on their manufacturing and testing techniques. Once the mirror radius is chosen, it shall be reported to CLS for approval.

3.1.1.2. The mirror pole shall be at the center of the mirror substrate. The deviation from the center shall not exceed +/- 0.2mm in the sagittal direction.

3.1.2 Surface roughness

3.1.2.1.Surface roughness shall be defined as the root mean square (*RMS*) of the surface amplitudes with spatial wavelengths between 10 μm and 1 mm.

3.1.2.2.The average surface roughness measured shall not exceed: Option A- 8.0 Å when measured with a 5X objective and 12 Å when measured with a 40X objective, Option B- 5.0 Å when measured with a 5X objective and 7.5 Å when measured with a 40X objective

3.1.3 Slope error

3.1.3.1. Slope error shall be defined as the root mean square (*RMS*) of the slope of the mirror surface with spatial wavelengths between 1 mm and 350 mm.

3.1.3.2. The mirror surface deviation from flat in tangential direction (along the mirror long edge) shall not exceed: Option A- 7 μrad, Option B- 3 μrad.

3.1.3.3. The mirror surface deviation from circle in sagittal direction (along of the short side) of the mirror shall not exceed: Option A- 20 µrad, Option B- 10 µrad.

3.1.4 Optical Coating

3.1.4.1. After polishing and cleaning an optical coating is to be applied to the mirror cylindrical surface.

3.1.4.2. The coating material is Gold.

3.1.4.3. Coating thickness is 500 angstrom +/-10% and shall be uniform over the entire active optical surface.

3.2 FABRICATION REQUIREMENTS

3.2.1 Grinding and Polishing

3.2.1.1. The mirror optical surface shall be ground to the thickness as specified in CLS DWG 10ID-1/ME/MIR/006065204 to provide the required hot wall thickness.

3.2.1.2. In the case of Glidcop, as the mirror substrate, an additional Ni electroplating layer shall be provided by the polisher.

3.2.1.3. No operation that results in contaminants becoming embedded in the material shall be used. Grinding under power with resin-bonded wheels, using rouge, emery cloth, crocus cloth, or similar abrasives are prohibited. No lubricant or wax may be used which might result in contamination that cannot be removed by acceptable cleaning procedures.

3.2.2 Cleaning

3.2.2.1. The polished mirror substrate shall be cleaned and thoroughly degreased. Pure de-ionized water must sheet on all surfaces to verify the absence of surface contamination prior to preparation for polishing.

3.2.2.2. The mirror shall be cleaned before applying the coatings.

3.2.2.3. The finished mirror shall be clean and ready for use in UHV. Residual materials that are not compatible with a UHV environment shall not be present, especially organics and high vapor-pressure inorganics, may not be left on any part of the finished mirror.

3.2.2.4. The contractor shall provide the CLS with its proposal a summary of the cleaning procedures to be used on the mirror. Refer to CLS Technical Specification, 8.7.33.1.

3.2.3 Coatings

3.2.3.1. The gold material used for optical coating shall be 99.99% pure.

3.2.3.2. Contractor shall specify for approval by the CLS any additional coating(s) (e.g. adherence layers) deemed necessary.

3.2.4 Workmanship, handling

3.2.3.1. The parts shall be free of dents, gouges and scratches. Lint-free and talcum-free nylon gloves are to be worn when handling the mirror substrate after cleaning. No fingerprints are permitted.

3.3 QUALITY ASSURANCE AND TEST REQUIREMENTS

3.3.0.1. Acceptance testing shall be performed on the finished mirror.

3.3.0.2. The contractor shall submit with the proposal an Inspection and Test Plan for different stages of fabrication prior to the initiation of any procurement or fabrication activities and a list of methods and instruments that will be used for measurements of the surface figure and roughness. The CLS will review and approve the proponent's Inspection and Test Plan.

3.3.0.3. For a partial contract for the mirror polishing only, the contractor shall submit a verification test, which shall be followed by the mirror substrate vendor to verify the substrate performance. When completed, the mirror polishing contractor shall have the final responsibility for the mirror.

3.3.0.4. The CLS may conduct its own performance measurements using the same methods and one of the acceptable instruments as specified below for the minimum tests.

The following items are minimum requirements for inclusion in the acceptance tests.

3.3.1 Surface figure slope error

1. The surface figure of the finished mirror substrate shall be measured with a long trace profiler. Acceptable instruments are manufactured by Ocean Optics, Inc. Alternates need to be approved by the CLS.
2. Two profile traces of 350 mm length shall be measured along the centerline of the mirror, at a distance of 2.5 mm to either side of the centerline (minimum requirement). The step size or camera resolution shall be 1 mm.
3. Four profiles of 20 mm length shall be measured perpendicular to the centerline, as shown in Fig.2.
4. The slope error is acceptable if none of the average of the root mean square (*RMS*) of the slope errors determined separately for each profile does not exceed the specification value.

3.3.2 Surface roughness

1. The surface roughness of the mirror substrate shall be measured with a non-contacting optical profiler using a phase measuring interferometer technique. The instrument shall have objectives of approximately 5X and 40X magnification, capable of 20 μm and 5 μm camera resolution, respectively, and have at least 0.2 nm height resolution. Acceptable instruments are manufactured by Wyko, Zygo, and Micromap. Alternates need to be approved by the CLS.
2. The surface roughness shall be measured at the following locations (minimum requirement): eight test spots, formed as the crossed points between longitudinal and meridianal lines for slope error traces, as shown in Fig.2.
3. Surface roughness shall be measured two dimensionally as the root mean square of all surface height deviations from the average height measured in a rectangular sample area of size specified below at a certain step size specified below.
4. The surface roughness shall be determined at two different magnifications, camera resolution, and sampling sizes: (a) with 5X objective, 20 μm camera resolution and a sampling area of 2 *2 mm and (b) with 40X objective, 5 μm camera resolution and a sampling area of size 0.25 *0.25 mm.

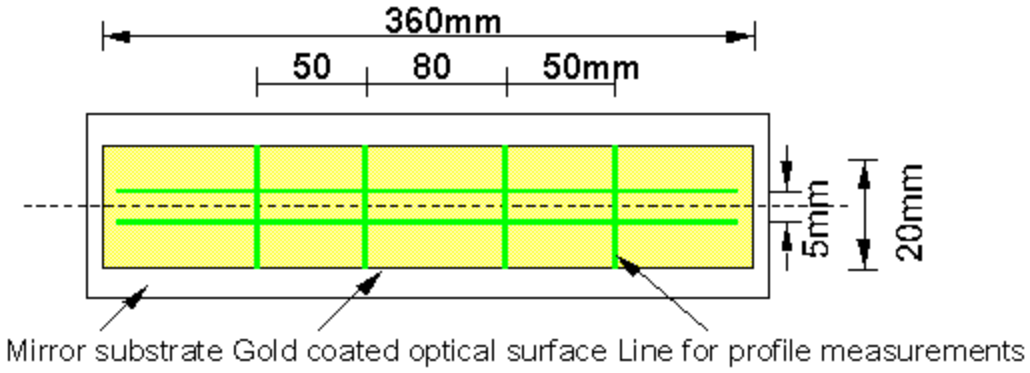

Fig.2. The location of the slope profile measurement lines. The figure is not scaled and for illustration purposes only.