

# Technical specification for the SM PGM

Technical Specification 6.8.76.7 Rev. 0

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Signature

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## REVISION HISTORY

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A	June 15, 2002	<p>Drafts of Mono vacuum vessel technical specification, Mono Vacuum Pumping Stage, Mono Cooling System, completed with engineering drawings, as a part of CLS-ALS technical transferee</p> <p>Addition of testing procedure (after ALS test, completed by T. Warwick (ALS)).</p> <p>Substantially modified by David Loken for Built-to-print specifics</p> <p>Correct Drawing Numbers</p> <p>Incorporate comments from review</p> <p>Change Sign-off List (Jeremy to Sitnikov)</p> <p>Incorporate the comments from internal review (Sitnikov)</p>	Loken; Kaznachev
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## 1.0 INTRODUCTION

### 1.1 PURPOSE

This document contains the Technical Specifications for the Plane Grating Monochromator (PGM) 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, assembly, testing & acceptance and delivery of the PGM for SM beamline. As the components design is the responsibility of the CLS and first prototype was successfully tested, PGM is effectively a build-to-print procurement process. The Vendor must demonstrate that the components are manufactured correctly and assembled correctly.

The technical specification does not cover the fabrication of x-ray mirror and grating, which are specified in CLS Technical Note 6.8.76.3Rev0 and 6.8.76.2Rev0 respectively. For the testing purposes “dummy” optical substrate, as described below, shall be fabricated. Other major PGM components are:

- cradle for water-cooled plane mirror
- cradle for water-cooled plane grating
- internal assembly that supports the two cradles
- internal water cooling lines and air guard for the internally cooled mirror and grating
- vacuum vessel base
- vacuum vessel lid with viewport flanges
- linear stages and optical encoder for independent motion of the two optical elements.
- a rotary stage and ball screw mechanism for moving the Monochromator between the grating rulings.
- Stands, struts and optical table

This specification includes, but is not limited to:

- Material requirements
- Detailed drawing requirements
- Fabrication requirements
- Quality Assurance and Testing requirements
- Packaging and Delivery requirements

### 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 3<sup>rd</sup> generation synchrotron light source, which will produce a high intensity source of infrared, ultraviolet and x-ray radiation.

The SpectroMicroscopy Beamline (SM) is a soft x-ray microscopy dedicated facility, which will provide intense soft x-ray light for a Scanning Transmission X-ray Microscope and a Photoelectron Emission Microscope. It will be built at source point 10ID.1 of the CLS main ring. Both branches will use a single Plane Grating Monochromator (PGM) to monochromatize the SR light. The information below is provided as an additional background information. The vendor is not required to demonstrate overall optical performance of the Monochromator with SR.

The monochromator working range is 100-2000eV, with nominal resolving power exceeded 7000. The maximum flux, which is of the order of  $10^{12}$  ph/s onto the sample for PEEM branch and  $10^9$ ph/s for STXM branch is requested for 3000 resolving power. The total acceptance angle of PGM shall exceed  $200 (H) \times 200 (V) \mu\text{rad}$  and the ray pupil shall be no less than  $10 (H) \times 5 (V) \text{ mm}$ . The PGM shall preserve the polarization properties of EPU, and both may be synchronously scanned at the speed of 1eV/sec.

The PGM is located 5 m downstream from the M1 mirror, or approximately 21 m from SM Elliptically Polarized Undulator (EPU). There are two optical elements inside PGM: the plane mirror placed upstream and plane grating downstream.

The plane mirror orientation is horizontal with the active optical surface facing up. The mirror substrate size is 80mm wide x 450mm long x 75mm thick. The mirror moves in coordination with the grating, so the grazing angle is varied from 5 to 1.5 degree, depending on PGM scanning parameters. It may also be set parallel to the horizontal plane if needed for alignment purposes.

The grating orientation is horizontal with the active optical surface facing down. The substrate size is 76mm wide x 168mm long x 50mm thick. The grating has three regions with different groove densities. Groove densities are: 250 lines/mm, 500 lines/mm, 1200 lines/mm. The grating substrate rotates around the horizontal axis, passed through its pole.

The water-cooled plane mirror and the water-cooled plane grating are mounted inside their respective cradles. The mirror and grating are not part of this specification and are being procured separately.

For normal operation, when the upstream EPU directs one beam towards the SM branch, the power loads on plane mirror and grating are approximately 150W and 15W respectively. Although such operation does lead to elastic deformation of the optics, it does not degrade the beamline performance below the 6000 resolving power limit. Worst case, the PGM is capable of accepting two EPU beams so that the power loads are doubled. For these worst case loads, the water flow rates through the plane mirror and grating are  $1.2 \times 10^{-4} \text{ m}^3/\text{s}$  (1.9 US gallons per minute), and  $8.8 \times 10^{-5} \text{ m}^3/\text{s}$  (1.4 US gallons per minute) respectively. As additional protection, the cradles are equipped with water-cooled screens to protect the leading edges of the optics from direct irradiation by SR.

PGM scanning mechanism is a two- fixed axis rotation scanner that can independently control the rotation of the plane mirror and the grating using an external linear stage. Both scanners use the pivot flexure stages for highly reproducible, no backlash rotation and the plane mirror axis is placed approximately 7.5mm above the grating rotational axis. The incoming light and outgoing light are parallel to each other and vertically separated by 15.0 mm. The accuracy and reproducibility for each movement are better than  $0.1 \mu\text{rad}$ . Such resolution and reproducibility of the mutual movement are essential to satisfy the 10 000 resolving power requirement for SM beamline. The scanning mechanism has the following limits:

- total pre-mirror angle range = 170-178 deg.,
- diffraction angle range = 80-89 deg.

These limits are compatible with a photon energy range of 100-2000 eV.

As a whole, the vacuum vessel assembly may be moved horizontally, perpendicular to the beam by approximately 25 mm to illuminate the different parts of the grating.

The PGM must be certified to operate within its specifications in an ultra high vacuum ( $1.33 \times 10^{-8} \text{ Pa}$  ( $10^{-10} \text{ Torr}$ )) environment and when subjected to hard x-ray radiation. It should withstand baking to  $150^\circ\text{C}$  for 24 hours, and retain its shape and performance characteristics upon cooling to room temperature.

Further background information can be found in the SM Preliminary Design Review, CLS #6.2.76.10 and in the CLS Design Note #6.2.76.13 Rev 0, "Alignment tolerances and procedure for the SM beamline."

### 1.3.1 Description of PGM

The Plane Grating Monochromator (PGM) consist of: L shaped invar frame, which holds two cradles with flexures; the sine bars (one for mirror and one for grating on the another side of the frame) connected to the linear stages with water cooling tubes running along the sine bars; vacuum chamber base, which hold the L shaped frame; the chamber lid, which is sealed against the chamber base with Helicoflex seal; two linear optical encoders, outside of main vacuum chamber; the translational stage, which mount on the vacuum camber bottom and provide a side translation of the entire vacuum chamber to access the different groove regions (3) of the grating; the PGM stand, which holds the entire PGM assembly with an adjustable 6 strut system. Other auxiliary systems include the Ion Pump with Ti sublimation pump build in, motors with encoders and travel limit switches, outside water supply lines for cooling the grating and mirror, and an optional laser interferometer system (not part of this RFQ), which provide an independent read-out of the scanning angles. The vacuum components will be provided by CLS, the interferometer system construction will be done by CLS, the vendor only needs to install the backreflector on the cradles.

Mirror cradle holds a 450mm long plane mirror, the water supply line for the mirror with air guard, the leading edge protecting water cooled absorber mounted upstream, the L shape arms to hold the back reflector for interferometer system, and the sine bar.

Grating cradle holds the 167 mm long grating, the water supply line in an air guard protection cover, long sine bar, and the water-cooled upstream mask. The back reflector for the grating angular position is mounted directly on the cradle.

For testing purposes dummy optics shall be fabricated and installed. Dummy optics will include a continuous water cooling path, and a complete air guard path, and will also be volume representative of the actual mirrors for verifying the UHV anti-crash switch.

The sine bars are connected with the flexure stages to the Monochromator feed through actuators. The water lines, enclosed into the air guard lines, run along the sine bars, inside the Monochromator feed through actuators to the outside of the vacuum chamber and are terminated with standard Swagelok-type connectors. The air guard lines cover the water supply line and are terminated with quick-connects.

The grating cradle is mounted on the invar main frame with the Cam adjuster with the offset flexure couplings. The axis, as determined by the center of the flexure shall be horizontal and pass through the grating pole. The mirror cradle rotation axis is also fixed and offset by about 7.5mm up from the grating rotation axis.

The invar frame is bolted directly to solid Al monochromator base.

The Mono Chamber Lid shall enclose the vacuum volume of the mono, but has no mechanical contact with any of the internal components. The viewports are used to verify the mirror and grating positions, rotational axis, and access for the interferometer laser. The 6" flanges from upstream and downstream side will be used to connect the PGM to other components of the CLS SM beamline.

The vacuum system components shall be provided by CLS and includes the Ion Pump with an integral Ti sublimation pump, the cold cathode gauge, the UHV valve for the turbo pump.

The translational stage provides a 3" side movement of the entire PGM vacuum chamber and is build around commercially available components, as listed below. It is mounted on the top of a modified commercial optical table, which provides a stiff, vibration free support for entire PGM.

The stands are weldments of rectangular structural steel tubes. It will be filled with a vibration dumping media, when install at CLS. The stands support the monochromator optical table with a 6 strut system.

## 1.4 DEFINITIONS AND ABBREVIATIONS

*RMS* - root mean square

*SM*- SpectroMicroscopy beamline.

*PGM*- Plane Grating soft x-ray Monochromator.

*SR* – Synchrotron Radiation

*EPU* – Elliptically Polarized Undulator.

*UHV*- Ultra high vacuum

*IP*- ion pump

*CLS*-Canadian Light Source

*ALS*- Advanced Light Source, Berkeley, California

## 2.0 GENERAL REQUIREMENTS

### 2.1 SAFETY AND ENVIRONMENTAL

**2.1.1.1** The normal ambient temperature of the experimental hall is 23° C. The expected temperature stability will be better than 1° C during normal operation.

**2.1.1.2** 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 25-50%.

### 2.2 IDENTIFICATION, TRANSPORTATION AND INSTALLATION

**2.2.1.1** The Monochromator body shall have fiduciary marks at the location as shown in the detail drawings. The 1.5" reflected spheres used for alignment will be supplied by CLS. They will be installed during the commissioning of the beamline by CLS staff, so the PGM body shall only the fiduciary mounting holes (f8H7), but the manufacture of the PGM shall also provide a precise measurement of the location of the mirror and grating rotation axis with respect to the fiduciary points.

**2.2.1.2** The successful proponent (Vendor) shall prepare a packing & shipping plan, which complies with the main requirements as outlined below, for review by CLS.

**2.2.1.2.1** Monochromator shall be shipped in several separate subassemblies. Each assembly shipped shall be identified by the appropriate purchase order number, assembly number and a sequential identity or serial number. The warning signs and handling instruction shall be clearly visible. Each sub-assembly that is to be shipped separately shall be packaged as per the following:

**2.2.1.2.2** The UHV components shall be shipped in sealed container. No plastics are permitted as internal parts of such container. To prevent deformation of delicate internal components, the locks and dampers shall be added, where needed.

**2.2.1.2.3** The main vacuum vessel shall be shipped under vacuum, with the water lines drained and dried.

**2.2.1.2.4** The primary component packaging shall be placed in another outer shipping container. The outer container must contain clean, non-chafing packing material, which prohibits contact between the inner and outer containers during shipment.

**2.2.1.2.5** The packaging shall be sufficient to survive a 1.2m drop , in any orientation, and prevent damage or degradation of the assembly performance. The inner and outer packaging

must remain intact. Conformance to this requirement shall be confirmed by testing per ASTM D 5276, A2.2.2, Ten Drop Cycle (boxes). Packaging shall be of sufficient size to discourage inappropriate handling.

2.2.1.2.6 The assemblies will be palletized and all assemblies will have suitable lifting points for removal from their packaging.

2.2.1.3 The Vendor shall be permitted to affix their logo to the PGM support structure. Such plate/ identification sign shall not complicate the normal operation of the PGM.

2.2.1.4 The CLS is equipped with a 10 ton overhead crane. The crane has coverage extending from the loading area to beamline sector ID-10 installation area. The PGM in its transportation case shall be transferred close to its installed location, where it will be unpackaged and reassembled by CLS staff.

## 2.3 APPLICABLE CODES, STANDARDS AND PROCEDURES

2.3.1.1 In addition to PGM engineering drawings, the following documents shall be considered as part of this specification. All equipment shall be built in strict accordance with the following standards:

- CLS Design Specification 8.4.33.1 - Canadian Light Source High Vacuum Specification
- CLS Technical Procedure 8.7.33.1 - Canadian Light Source Vacuum Component Cleaning Technical Procedure
- CLS Technical Procedure 8.7.33.2 - Canadian Light Source Vacuum Component Leak Test Procedure

2.3.1.2 Unless otherwise specified, the issue date or revision level shall be that in effect on the date of the Request for Proposal. Exceptions to these standards shall be reviewed and accepted by the CLS.

## 2.4 QUALITY ASSURANCE

### 2.4.1 General Requirements

2.4.1.1 The Vendor shall complete and execute a set of acceptance test procedures to verify that the PGM has been fabricated and assembled correctly. The Vendor acceptance tests for the PGM shall include, but not be limited to, all of the testing procedures specifically outlined in this document.

2.4.1.2 The acceptance test results are subject to review and acceptance by the CLS. Two (2) sets of measurements in hardcopy and an electronic copy on magnetic media shall be sent to CLS after all major assembly and measurement procedures. Frequent data transfer is encouraged. Any review and acceptance process done by the CLS shall not release the vendor from its responsibility to correct errors, oversights and omissions to ensure conformance to the specifications in this document.

2.4.1.3 The vendor shall provide the facilities and instrumentation, if not specified otherwise, to perform all relevant tests to ensure compliance with this specification.

2.4.1.4 The Vendor shall maintain and apply a quality assurance program compliant with ISO-9001 for the design, manufacture, and testing of all components.

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## 3.0 FABRICATION

### 3.1 MECHANICAL DRAWINGS AND BRIEF DESCRIPTION

#### 3.1.1 Assembly Drawings

- 3.1.1.1 Monochromator Assembly, 10ID-1\ME\MNC\0065000;
- 3.1.1.2 Optics Assembly, 10ID-1\ME\MNC\0065067;
- 3.1.1.3 Chamber Lid Assembly, 10ID-1\ME\MNC\0065028
- 3.1.1.4 Chamber Base Assembly, 10ID-1\ME\MNC\0065020
- 3.1.1.5 Chamber Stage Assembly, 10ID-1\ME\MNC\0065100
- 3.1.1.6 Mirror Cradle Sub-Assembly, 10ID-1\ME\MNC\0065047
- 3.1.1.7 Grating Cradle Sub-Assembly, 10ID-1\ME\MNC\0065058
- 3.1.1.8 Cradle Stand Assembly, 10ID-1\ME\MNC\0065039
- 3.1.1.9 Dummy Mono Grating, 10ID-1\ME\MNC\0071516
- 3.1.1.10 Dummy Mono Mirror, 10ID-1\ME\MNC\0071517
- 3.1.1.11 Stands Assembly, 10ID-1\ME\MNC\0065092

These drawings will all be provided as part of this RFP. All components required to fabricate the Monochromator will be identified on these drawings.

The Optical Grating, Optical Pre-Mirror, and Interferometer Assembly are not considered part of this procurement.

Detailed fabrication drawings are not provided as part of this RFP, but will be supplied to the successful proponent. All detailed drawings will contain all of the information required to generate the entire fabricated assembly. All drawings conform to ASME Y14.5M-1994.

### 3.2 STANDARD PURCHASED COMPONENTS

The following is a listing of the major purchased components used for the PGM fabrication. A complete listing, which includes all purchased components including shall be provided as a part of a detail drawing package. Any substitutions must be pre-approved by CLS. Appendix A contains an indented partslist of the PGM including fabricated and purchased parts.

#### 3.2.1 Vacuum system

- 3.2.1.1 The Ion Pump shall be provided by CLS.
- 3.2.1.2 The UHV vacuum gauge shall be provided by CLS.
- 3.2.1.3 The UHV valve for the Turbo Pump connection will be defined in the drawing package.
- 3.2.1.4 All other Conflat flanges shall be sealed with blank flanges or viewport as indicated in the drawings.
- 3.2.1.5 All electrical connections and wiring shall withstand baking to 150°C for 24h.

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## 3.2.2 Stepper Motors

**3.2.2.1** Stepper motors are Parker Model OS21A-DNFL-YRE Size 23 Stepper motors with rotary encoders (on the top of the cover plate, see position 36 on CLS dwg 0065067 for monochromator plane mirror and grating motions and position 3 on CLS dwg. 0065100 for PGM vessel side shifting).

## 3.2.3 Gearhead

**3.2.3.1** The gearhead on the two mirror stages stage is a Parker Zenith NEMA 23 Gearhead model NEN-023-010 with a 23-ADAPT-0011 motor adapter and a 3/8" to 1/4" shaft coupling (beneath the cover, see position 36 on CLS dwg 0065067).

## 3.2.4 Optics Linear Stages

**3.2.4.1** Both linear stages for the Mirror and Grating are Parker Daedal Linear Stage Model 806010CTEPD1L2C7M1E1 (beneath the cover, see position 36 on CLS dwg 0065067). Stages require some modification prior to installation. Changes are specified in the complete drawing package.

## 3.2.5 Mono Linear Stage

**3.2.5.1** Mono linear stage requires IKO Rail and Linear Rollers (as indicated on CLS dwg. 0065100, item 18), LRWH25C2R660T1SP and bellows with a Kuroda GP series Ball Screw P/N: GP1205DS-BALR-0300B-C3S. The ball screw is driven by the standard stepper motor mounted to a Parker Daedal Rotary stage: 2-05-05-RT-E-P-H1-C4-M1-E1-T3 (item 3-4 on CLS dwg 0065100).

## 3.2.6 Linear Optical Encoder

**3.2.6.1** Optical encoders on the two mirror stages are Heidenhain Model LF501 linear glass scale optical encoder (shown beneath the monochromator feed-through yoke, position 10 on CLS dwg 0065067) with a model EXE610C Interpolation/Digitizing unit plus requisite electronics and cabling.

## 3.2.7 Fasteners and Hardware:

**3.2.7.1** The fasteners and hardware should be described on the appropriate assembly drawing or partslist contained in the drawing package. Any additions or substitutions should be discussed with and pre-approved by CLS.

**3.2.7.2** All fasteners should be made of Stainless Steel unless specifically defined differently on the partslist. All fasteners that are to be utilized in the UHV environment shall be silver plated. No lubricants of any type can be used without CLS approval.

**3.2.7.3** Most aluminum parts with threads will utilize heli-coils as described on the appropriate drawings. Helicoils shall be standard stainless steel heli-coils. Locking type heli-coils are not to be used. Substitutions must be pre-approved by CLS. Lubricants or liquid pre-treatments are not to be used.

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### 3.3 VENDOR SUPPLIED SYSTEMS

### 3.4 BAKE-OUT SYSTEM

#### 3.4.1 Design/Build:

The vendor shall provide a system for baking out the assembled Monochromator. The system shall be designed, and installed by the Vendor. The system shall be developed in compliance with the Control System Technical Specification, #7.4.39.1. The main features are outlined below:

- 3.4.1.1 Each vacuum vessel shall be equipped with permanently affixed strip heaters or stand alone heater, capable of 150°C baking of the vessel.
- 3.4.1.2 A removable thermo-cover (blanket) shall be build to cover the entire vacuum vessel.
- 3.4.1.3 At least two thermocouples shall be installed to monitor the baking temperature. The positions of these sensors shall be appropriate to best represent the temperature of the overall assembly.
- 3.4.1.4 The system shall allow for a programmable heating of the vacuum vessel, the setting points, determined by the setting of the vacuum gauge as well as signals from the thermocouples. The design shall permit a programmed baking cycle to be safely performed without an operator. An system shall provide a data channel for monitoring the cooling water flow rates.
- 3.4.1.5 All electrical connectors and wires shall be compatible with a 150°C 24 h bake-out.

### 3.5 FABRICATION REQUIREMENTS

#### 3.5.1 Materials

- 3.5.1.1 Materials for all components are as described on the detailed fabrication drawings. Any substitutions must be pre-approved by CLS.
- 3.5.1.2 Aluminum parts are typically manufactured from 6061-T6 aluminum or 7075-T6/T651. These materials must be provided as specified. If a specific grade is not specified, other grades of aluminum can be substituted.
- 3.5.1.3 Stainless steels shall be provided as specified. If not specified, a 300 series stainless steel shall be used. Other grades must be pre-approved by CLS.
- 3.5.1.4 Conflats can be supplied by MDC, Varian, or others provided they meet the material and dimensional requirements.
- 3.5.1.5 All conflats shall be made from stainless steel. The exception to this will be weldable conflats on aluminum vacuum chambers. These shall be bi-metal conflats with a standard stainless steel surface and copper gaskets.
- 3.5.1.6 The optical table used is a modified Melles Griot "Performance" Grade Optical Table part number 070TR034.
- 3.5.1.7 Bellows suppliers and part numbers are specified in the partslists. Substitutions are permissible provided the critical dimensions and design intent are maintained. Discussion with CLS is recommended.
- 3.5.1.8 The seals are as follows:
  - 3.5.1.8.1 **Main Vacuum Chamber:** Helicoflex gasket manufactured by Garlock Helicoflex a division of BF Goodrich. Previously purchased part number is H-306903.

3.5.1.8.2 **Flat square seals:** The upstream rectangular flanges, which provide the vacuum cover for the sine bar mechanism and water supply line and shall be manufactured from a bi-metal stainless steel to aluminum weldment and utilize VAT VATSEAL flat metal seals.

3.5.1.8.3 **Conflats:** All vacuum flanges are standard bi-metal or stainless steel CF flanges. Details and part numbers are contained in the detailed drawings. Several different vendors are available to supply this standard components.

3.5.1.8.4 **Kwik-Lock connectors:** the air guard lines shall be terminated with KF flanges, as one developed by MDC or Varian.

3.5.1.8.5 **Water connectors:** All of the cooling water supply lines shall be terminated by Swagelok-type stainless steel connections.

## 3.5.2 Material Surface Treatments

**3.5.2.1** Surface treatments are called out on the detailed fabrication drawings. The following is a list of the call-outs from the drawings and the appropriate specifications:

3.5.2.1.1 **Electroless Nickel Plate (Electrode less):** Standard commercial processing to achieve a uniform coating of 0.008mm to 0.020mm (0.0003" to 0.0008").

3.5.2.1.2 **Degrease:** Clean using an appropriate process as defined in CLS Technical Procedure 8.7.33.1. These are typically UHV parts.

3.5.2.1.3 **Powder Paint Black, Powder Coat Blue, etc.:** Using standard commercial process powder paint in colour as specified. Confirm final colour selection with CLS prior to application. Surface application must be complete and even with a consistent colour.

3.5.2.1.4 **Anodize Black, Black Anodize, Blue Anodize, etc.:** Utilizing a commercial sulfuric anodizing process generate a coating thickness of between 0.0013mm to 0.008mm (0.00005" to 0.0003"). Dye and seal to appropriate colour.

3.5.2.1.5 **Bright Dip:** This is a process for stainless steel. Passivate as per a commercially acceptable standard and conformance to CLS Technical Procedure 8.7.33.1 if a UHV part.

3.5.2.1.6 **Satin Finish:** Clean using an appropriate process as defined in CLS Technical Procedure 8.7.33.1. These are typically UHV parts.

## 4.0 ASSEMBLY, VERIFICATION AND CHARACTERIZATION

### 4.1 PERFORMANCE TESTING

#### 4.1.1 Rationale

**4.1.1.1** The PGM design is derived from a unit that was successfully manufactured and installed. To minimize the risk associated with the fabrication of the CLS PGM, the following minimum assembly and test sequence is specified as guidance to the Vendor. Although the Vendor shall be responsible for verifying that the unit satisfies all of it's requirements, this sequence will be used to evaluate the assembly and test procedures that the Vendor shall propose for approval by CLS.

**4.1.1.2** Since this is a build-to-print procurement, when it is completed the PGM should have the same mechanical performance as the original unit. As a result, a complete end-to-end verification is not required and can not be conducted since the final mirror and grating will only be available after the PGM is delivered. Instead, the verification process shall consist of a number of verification tests of the critical functions that are integral to the

successful operation of the PGM. During assembly, key measurements will be made and recorded such that the process of aligning and calibrating the PGM is optimized.

**4.1.1.3** Steps in this procedure that use the word “Verify” shall be considered as verification tests and must satisfy the acceptance criteria.

**4.1.1.4** Steps in this procedure that use the word “measure” shall be considered as characterizations and although they must be executed do not have an acceptance criteria.

**4.1.1.5** The Vendor shall allow a representative from CLS to witness, at their discretion, each stage of this assembly and test sequence. The Vendor shall provide CLS with at least 14 days notice of the commencement of assembly.

## **4.1.2 Mechanical Check-out**

**4.1.2.1** The selected vendor shall demonstrate that all fabricated parts have been manufactured as per the applicable drawings and specifications. An inspection report shall be provided for all fabricated parts to demonstrate this conformance. Any parts delivered with known non-conformances must have these non-conformances pre-approved by CLS.

## **4.1.3 First Assembly**

**4.1.3.1** Assemble all parts of the PGM, except vacuum system, in accordance with approved the assembly drawings and using the approved handling and assembly procedures.

**4.1.3.2** Install the dummy optics onto the mirror and grating cradles. The dummy optics will have water channels that form a closed circuit such that the water continuously flows from input, through the water-cooling channels to output and then back into the input. The dummy optics will also have an air guard volume.

**4.1.3.3** Verify by inspection, that all blind holes are vented to UHV and that no virtual leaks exist.

**4.1.3.4** Performed the tests as described in section #4.1.4 (leak testing, except #4.1.4.5), #4.1.5 (water flow), #4.1.6 (actuation), #4.1.7 (limit switches) and #4.1.8 (crosstalk).

## **4.1.4 Leak testing**

**4.1.4.1** This section defines the leak tests and their acceptance criteria.

**4.1.4.2** The PGM system consists of three separate volumes.

- The main vacuum vessel, which is a UHV volume.
- Inside the vacuum vessel, the plane mirror and grating are internally water-cooled, and the channels in the water-cooled masks form the second volume.
- To prevent direct exposure of the water joints to UHV, there is an evacuated air guard volume which is a protective circuit around water loops.

**4.1.4.3** Helium leak checks shall be performed as per CLS Technical Specification 8.7.33.2. Acceptance shall be less than  $2 \times 10^{-8}$  std atm cc/sec ( $2.67 \times 10^{-6}$  Pa L/s) for test #1 and  $2 \times 10^{-9}$  std atm cc/sec ( $2.67 \times 10^{-7}$  Pa L/s) for test #2 and test #3.

**4.1.4.4** The Vendor shall use a helium leak detector to conduct acceptance tests to prove that there are no leaks between the volumes in the PGM. The following leak tests shall be executed at various points during PGM assembly and acceptance tests:

- Leak test #1: Water-cooling channel volume to air guard volume
- Leak test #2: Air guard volume to vacuum vessel volume

- Leak test #3: Vacuum vessel volume to outside

**4.1.4.5** After the final assembly, cleaning and baking the UHV in the main chamber pumped by an Ion Pump alone shall be better than  $1 \times 10^{-9}$  torr.

## **4.1.5 Water flow**

**4.1.5.1** This test shall verify the absence of any pressure induced displacement for both grating and mirror, as well as the absence of leaks between the water circuit and other volumes under pressure. To perform the test, the mechanical dial gauges (Heidenhain height gauges or similar) shall be attached to dummy mirror and grating front surfaces (two gauges in upstream and downstream points for each optical element). Water flow circuit shall be pressurized to 60psi and the pressure induced displacement shall be measured to an accuracy better than 0.1 micron. The pressure in the sealed air guard circuit shall be monitored with an accuracy of better than  $\pm 0.01$  atmosphere and must show no sign of rising during the measurements. The pressure in the water flow circuit shall remain steady after closing the valves for at least an hour. The test shall be repeated for grating and plane mirror separately and for both of them simultaneously. Prototype testing indicates that there will be as low as  $4 \mu$  radians of deflection due to the water pressure. The Vendor will measure the mirror deflections and provide this information to CLS for interpretation.

**4.1.5.2** Verify that no water leaks into the air guard volume

**4.1.5.3** With water flow off, use a mechanical height gauge (0.1micron resolution) mounted on the aluminum chamber base to measure the height of one end of the dummy mirror.

**4.1.5.4** Turn on the water and measure the deflections.

**4.1.5.5** With water flow off, use a mechanical height gauge (0.1micron resolution) mounted on the aluminum chamber base to measure the height of one end of the dummy grating.

**4.1.5.6** Turn on the water and measure the deflection.

## **4.1.6 Actuation**

**4.1.6.1** The stepper motors shall be operated to their full extents to verify that the mechanism operates as intended without binding, interference, or excessive torque requirements. Correct operation of the encoders and limit switches must be verified. Refer to 4.1.6.4 for required motions.

**4.1.6.2** The vendor will supply the stages, gearboxes, couplings and motors and defined by the drawings and this specification. However, the stepper motor drivers are not part of this specification and the vendor must provide their own method of operating the stages for this mechanical check-out.

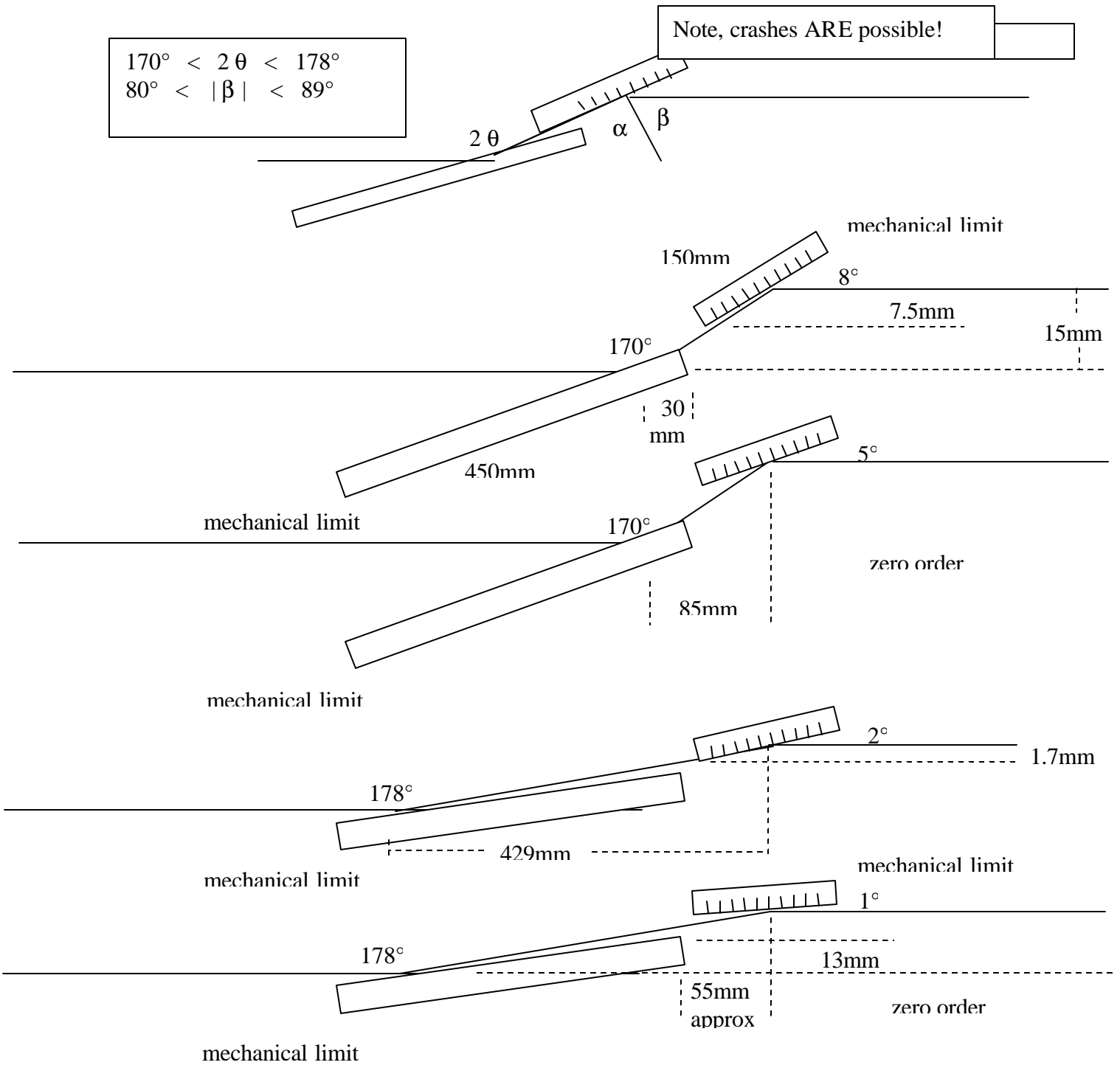
**4.1.6.3** Using the stepper motor, drive the stage along its full range of motion. Choose the location of 5 positions along its full range of motion and for each point verify the reproducibility of such movement by cross comparison of mechanical gauge (better than 0.1micron resolution, directly attached to the optical element) reading and linear optical encoder. Repeat a pass through the points in both directions.

4.1.6.4 Motion Ranges:

$$170^\circ < 2\theta < 178^\circ$$

$$80^\circ < |\beta| < 89^\circ$$

Note, crashes ARE possible!



### 4.1.7 Limit switches

- 4.1.7.1 Due to the configuration of the grating and pre-mirror it is possible to move the relative mechanisms in such a way as to cause the grating assembly to contact the mirror assembly. The proper operation of the UHV micro-switch must prevent this operational scenario from occurring in all testing and operational configurations.
- 4.1.7.2 Using the stepper motors, drive the stages to the ends of their travels and verify that the limit switches are activated at the required positions.

### 4.1.8 Crosstalk

- 4.1.8.1 Monitor the position of the grating using the vertical height gauges while moving the mirror through its complete range of travel.
- 4.1.8.2 Monitor the position of the mirror using the vertical height gauges while moving the grating through its complete range of travel. There should be no more than 1  $\mu\text{m}$  of mechanical deflection of the mirror while the grating is moved through its full range of motion.
- 4.1.8.3 Verify that there is no mechanical "cross talk" between the mirror stage and the grating stage.

### 4.1.9 UHV Preparation

- 4.1.9.1 Remove the optical assemblies from the vacuum chamber.
- 4.1.9.2 Clean the chamber base and chamber lid by scrubbing and washing with solvent. Refer to CLS Technical Procedure 8.7.33.1. All internal tapped holes to be cleaned. Helicoils are to be removed for cleaning. Assemble the vacuum system. The IP and IP controller, as well as the vacuum gauges will be provided by CLS.
- 4.1.9.3 Seal the entire chamber with the Helicoflex gasket and conflat seals.
- 4.1.9.4 Verify with Leak Test #3 that there are no leaks from the UHV volume to the outside. Use an RGA to scan and verify that there are no peaks above mass 40 greater than  $1 \times 10^{-12}$  Torr partial pressure.
- 4.1.9.5 Make a low temperature bake ( $150^{\circ}\text{C}$ ) to achieve  $1 \times 10^{-9}$  Torr base pressure or better for the PGM chamber pumped by IP alone.
- 4.1.9.6 Either degrease and electro-polish or vacuum bake all components to  $400^{\circ}\text{C}$ , including all UHV fasteners not included in the previous empty vessel RGA test to evaporate hydrocarbons.
- 4.1.9.7 Wrap all clean components for packing and shipping to CLS.

## 5.0 APPENDIX A: PARTSLIST

NOTE: TO COMPLETE ALL PART NUMBERS BEGINNING WITH "0065", ADD THE PREFIX:  
10ID-1\ME\MNC\

IE.: PART 0065000 IN FULL FORM READS: 10ID-1\ME\MNC\OO65000

PART NUMBER	QTY.	DESCRIPTION	SUPPLIER	MATERIAL
0065000	1	MONOCHROMATOR ASSEMBLY		
0065067	1	OPTICS ASSEMBLY		
0065047	1	CRADLE SUB-ASSEMBLY		
0071517	1	DUMMY MONO MIRROR ASSEMBLY		
0071532	1	DUMMY MONO MIRROR	FAB	COPPER
0065007	1	PRE-MIRROR MANIFOLD	FAB	S.S. 304
0065008	2	PRE-MIRROR FLANGE ASSEMBLY	FAB	
110004	1	1.33" CONFLAT FLANGE	MDC	
480003	1	VACUUM TUBING	MDC	
0065044	1	MIRROR CRADLE	FAB	S.S. 304
0065046	1	MIRROR SINEBAR	FAB	S.S. 304
C-1010-A	4	SOCKET HD. CAP SCREW, 10-32UNF x 15.7LG.	UC-COMP	
0065051	1	COOLING MANIFOLD BLOCK MIRROR\MASK	FAB	S.S. 304L
0065048	1	MIRROR MASK BRAZE SUB-ASSY	FAB	
0065050	1	MIRROR MASK COOLING LINE		S.S. 304
100001	A/R	FLANGE, CFF, 1.33" ROTATABLE	MDC	
0065049	1	MIRROR MASK	FAB	COPPER, OXYGEN FREE, C10100 ALLOY

1185-06CN-276	2	THREAD INSERT, 6-32UNC x 2 DIA. S.S	EMHART	
0065053	1	COOLING MANIFOLD SUPPORT BLOCK, MIRROR/MASK	FAB	S.S. 304
0065086	2	OPTIC BELLOWS ASSEMBLY		
103-55-6-EE	1	BELLOWS 1.05"Odx.55"ID	SBC	
110004	1	MINI CFF, THRU HOLES, NON-ROT	MDC	
0065087	1	OPTIC BELLOWS FLANGE	FAB	
100004	1	CFF MINI, ROT., THRU HOLES	MDC	
0065088	1	OPTIC BELLOWS RING	FAB	S.S. 304
0065035	3	OPTIC ADJUSTER BODY	FAB	AMPCO 18
0065036	3	OPTIC ADJUSTER NUT	FAB	AMPCO 18
0065090	3	OPTIC V-MOUNT	FAB	S.S. 304
THREADED ROD	3	THREADED ROD, 6-32UNC x 47.6 LG., S.S.		S.S.
0065052-2	2	MIRROR/GRATING COOLANT TUBE	FAB	TEFLON-NATURAL PFA
0065054	1	MIRROR PRISM MOUNTING BRACKET	FAB	S.S. 304
C0600-49-1000	3	COMP. SPRING, S.S., DIA15.2 x DIA1.2 WIRE x 25.4 LG.	ASSOC.	
C0360-38-1000	3	COMP. SPRING, S.S., DIA9.14 x DIA.96 WIRE x 25.4 LG.	ASSOC.	
191000	6	COPPER GASKET, DIA1.33" CFF	MDC	
C-810-A	36	SOCKET HD. CAP SCREW, 8-32UNC x 15.9 LG, S.S. SLIVER PLATED	UC-COMP	
MIRROR PRISM	1	MIRROR PRISM		
SCREW	2	SOCKET HD. CAP SCREW, 5/16-24UNF x 114.3LG, S.S. SILVER PLATED		
SCREW	1	SOCKET HD. CAP SCREW, 5/16-24UNF x 88.9LG, S.S. SILVER PLATED		
SCREW	2	SOCKET HD. CAP SCREW, 5/16-24UNF x 69.9 LG, S.S., SILVER PLATED		
SCREW	2	SET SCREW, HEX DRIVE, 1/4-28UNF x 19.05 LG, S.S., SILVER PLATED		
C-616-NA	2	SOCKET HD. CAP SCREW, 6-32UNC x 25.4LG, S.S.	UC-COMP	

		SILVER PLATED		
		SOCKET HD. CAP SCREW, 1/4-20UNC x 114.3 LG, S.S.		
SCREW	2	SILVER PLATED		
2-013	6	ORING, VITON, DIA 7/16"ID x 1/16"C/S (0.070")	PARKER	
2-010	2	ORING, VITON, DIA 1/4"ID x 1/16"C/S (0.070")	PARKER	
0065211	1	PRE-MIRROR MOUNTING PIN	FAB	S.S 304
0065212	1	PRE-MIRROR INTERFACE BLOCK	FAB	S.S. 304
0065058	1	GRATING CRADLE SUB-ASSEMBLY		
0071518	1	DUMMY MONO GRATING ASSEMBLY	FAB	
0071531	1	DUMMY MONO GRATING	FAB	S.S.
0065011	2	GRATING COOLANT FITTING	FAB	S.S. 304
ROLL PIN	1	ROLL PIN, DIA .066" x DIA .3125" LG STN STL		
0065022	1	GRATING CRADLE WIRE	FAB	
0065021	1	GRATING CRADLE	FAB	S.S. 304
0065063	1	GRATING SINEBAR	FAB	S.S. 304
C-1010-A	4	SOC. HD. CAP SCREW, 10-32UNF x 15.7 LG., CRES SILVER PLATED, VENTED	UC-COMP	
C-1016-A	1	SOC. HD. CAP SCREW, 10-32UNF x 25.4 LG., CRES SILVER PLATED, VENTED	UC-COMP	
0065066	1	COOLING MANIFOLD BLOCK, GRATING/MASK	FAB	S.S. 304
0065082	1	GRATING MASK BRAZE SUB-ASSY	FAB	
0065098	1	GRATING MASK COOLING LINE	FAB	
TUBING	A/R	TUBING, STAINLESS STEEL-304, DIA .25"OD x .065"WALL		
100001	1	CONFLAT FLANGE, DIA 1.33" ROT.	MDC	
0065083	1	GRATING MASK	FAB	COPPER, OXYGEN FREE, C10100 ALLOY
1185-06CN-276	2	THREAD INSERT, 6-32UNC x 2 DIA. S.S	EMHART	
0065075	1	PIVOT STUB, GRATING CRADLE	FAB	S.S. 304

0065086	2	OPTIC BELLOWS ASSEMBLY		
103-55-6-EE	1	BELLOWS 1.05"Odx.55"ID	SBC	
110004	1	MINI CFF, THRU HOLES, NON-ROT	MDC	
0065087	1	OPTIC BELLOWS FLANGE	FAB	
100004	1	CFF MINI, ROT., THRU HOLES	MDC	
0065088	1	OPTIC BELLOWS RING	FAB	S.S. 304
0065035	3	OPTIC ADJUSTER BODY	FAB	AMPCO 18
0065036	3	OPTIC ADJUSTER NUT	FAB	AMPCO 18
0065090	3	OPTIC V-MOUNT	FAB	S.S. 304
THREADED ROD	3	THREADED ROD, 6-32UNC x 47.6 LG., S.S.		S.S. TEFLON-NATURAL
0065052-1	2	MIRROR/GRATING COOLANT TUBE	FAB	PFA
		COMP. SPRING, S.S., DIA 0.6" x DIA .049" WIRE x 25.4		
C0600-49-1000	3	LG.	ASSOC.	
C0360-38-1000	3	COMP. SPRING, S.S., DIA 0.36" x.038"WIRE x 25.4 LG.	ASSOC.	
191000	6	COPPER GASKET, DIA1.33" CFF	MDC	
C-810-A	36	SOC. HD. CAP SCREW, 8-32UNC x 15.9 LG, S.S. SLIVER	UC-COMP	
		PLATED		
SCREW	3	SOC. HD. CAP SCREW, 6-32UNF x 44.5 LG, S.S. SLIVER		
		PLATED		
C-824-NA	2	SOC. HD. CAP SCREW, 8-32UNC x 38.4 LG, S.S. SLIVER	UC-COMP	
		PLATED		
SCREW	2	SET SCREW, HEX DRIVE, 1/4-28UNF x 35 LG, S.S.,		
		SILVER PLATED		
C-620-A	2	SOC. HD. CAP SCREW, 6-32UNC x 38.1 LG., S.S.,	UC-COMP	
		SILVER PLATED		
C-1012-NA	2	SOC. HD. CAP SCREW, 10-32UNF x 19.05 LG., S.S.,	UC-COMP	
		SILVER PLATED		
C-1014-A	2	SOC. HD. CAP SCREW, 10-32UNF x 22.1 LG., S.S.,	UC-COMP	
		SILVER PLATED		
MIRROR PRISM	1	MIRROR PRISM		

2-013	6	ORING, VITON, DIA 7/16"ID x 1/16"C/S (0.070")	PARKER	
2-010	2	ORING, VITON, DIA 1/4"ID x 1/16"C/S (0.070")	PARKER	
0065038	1	FINAL MACHINING, CRADLE STAND	FAB	
0065039	1	CRADLE STAND ASSEMBLY	FAB	
0065040	1	CRADLE STAND BASE PLATE	FAB	INVAR 36 PLATE
0065041-1	1	CRADLE STAND UPRIGHT PLATE	FAB	INVAR 36 PLATE
0065041-2	1	CRADLE STAND UPRIGHT PLATE	FAB	INVAR 36 PLATE
0065042	2	CRADLE STAND GUSSET PLATE	FAB	INVAR 36 PLATE
SCREW	14	SOC. HD. CAP SCREW, 3/8-16UNC x 25.4LG. VENTED, SILVER PLATED		
SCREW	2	SOC. HD. CAP SCREW, 3/8-16UNC x 19.05LG. VENTED, SILVER PLATED		
0065089	1	INTERFEROMETER MIRROR MOUNT	FAB	AL 6061-T6
0065043	2	CRADLE STAND CAM ADJUSTER AIR GUARD TUBE, MIRROR COOLANT	FAB	AMPCO 18
0065062	2	SUPPLY/RETURN LINE	FAB	
103-55-1-EE	1	BELLOWS WELDMENT, S.S.	SBC	
TUBING	A/R	TUBING, S.S.-304, DIA 5/8"O.D. x .065"WALL		
110003	1	CF FLANGE, DIA 1.33" NON-ROT.	MDC	
100003	1	CF FLANGE, DIA 1.33" ROTATABLE	MDC	
0065072	4	COOLING PROBE WELDMENT ASSEMBLY	FAB	
0065073	1	GUARD VACUUM CAP	FAB	S.S. 304
0065074	1	COOLANT PROBE TUBE	FAB	S.S. 304
TUBING	A/R	TUBE, STAINLESS STEEL-304. 1/2" x .095" WALL		
0065001-3	1	HALF UNION		
715105	1	ISO KF HALF NIPPLE, NW16	MDC	
T-404-NA	2	SOC. SET SCR., 4-40UNCx6.4 LG., S.S., SILVER PL.	UC-COMP	
0065068-1	2	FEED THRU ACTUATOR TUBE WELDMENT ASSY	FAB	

0065060-01	1	SINEBAR MANIFOLD, GRATING/MIRROR	FAB	S.S. 304L
C-1010-A	2	SOC. HD. CAP SCREW, 10-32UNF x 15.8 LG. SILVER PLATED, VENTED	UC-COMP	TUBE, SEAMLESS S.S.-304, .75"Odx.065"WALL
0065070	1	ACTUATOR AIR GUARD TUBE, MIRROR/GRATING	FAB	
0065069	1	MODIFIED DIA 3.37" CF FLANGE		
100015	1	CONFLAT FLANGE, ROTATABLE DIA 3.38", THRU HOLES	MDC	
0065071	1	BELLOWS CUFF ADAPTER	FAB	S.S. 304
0065061	1	SINEBAR CLAMP, GRATING/MIRROR	FAB	S.S. 304L
C-1010-A	4	SOC. HD. CAP SCREW, 10-32UNF x 15.8 LG. SILVER PLATED, VENTED	UC-COMP	
150-96-13-EE	1	BELLOWS, 1.5"OD x .96ID, 13 SEGMENTS LONG, STYLE 'E'	SBC	
0065068-2	2	FEED THRU ACTUATOR TUBE WELDMENT ASSY	FAB	
0065060-02	1	SINEBAR MANIFOLD, GRATING/MIRROR	FAB	S.S. 304L
C-1010-A	2	SOC. HD. CAP SCREW, 10-32UNF x 15.8 LG. SILVER PLATED, VENTED	UC-COMP	TUBE, SEAMLESS S.S.-304, .75"Odx.065"WALL
0065070	1	ACTUATOR AIR GUARD TUBE, MIRROR/GRATING	FAB	
0065069	1	MODIFIED DIA 3.37" CF FLANGE		
100015	1	CONFLAT FLANGE, ROTATABLE DIA 3.38", THRU HOLES	MDC	
0065071	1	BELLOWS CUFF ADAPTER	FAB	S.S. 304
0065061	1	SINEBAR CLAMP, GRATING/MIRROR	FAB	S.S. 304L
C-1010-A	4	SOC. HD. CAP SCREW, 10-32UNF x 15.8 LG. SILVER PLATED, VENTED	UC-COMP	
150-96-13-EE	1	BELLOWS, 1.5"OD x .96ID, 13 SEGMENTS LONG, STYLE 'E'	SBC	
0065045	2	FEED THRU YOKE	FAB	AL 6061-T6

1191-3CN380	1	THREAD INSERT, 10-32UNF x 50.8LG., S.S.	EMHART
0065064	1	AIR GUARD TUBE, GRATING COOLANT SUPPLY LINE	FAB
103-55-1-EE	1	BELLOWS WELDMENT, S.S.	SBC
TUBING	A/R	TUBING, S.S.-304, DIA 5/8"O.D. x .065"WALL	
110003	1	CF FLANGE, DIA 1.33" NON-ROT.	MDC
100003	1	CF FLANGE, DIA 1.33" ROTATABLE	MDC
0065065	1	AIR GUARD TUBE, GRATING COOLANT RETURN LINE	FAB
103-55-1-EE	1	BELLOWS WELDMENT, S.S.	SBC
TUBING	A/R	TUBING, S.S.-304, DIA 5/8"O.D. x .065"WALL	
110003	1	CF FLANGE, DIA 1.33" NON-ROT.	MDC
100003	1	CF FLANGE, DIA 1.33" ROTATABLE	MDC
0065099	1	INTERFEROMETER: NOT PART OF PROCUREMENT	FAB
5016400	12	FLEXURAL PIVOT	LUCE
TUBE	A/R	TUBE, TEFLON 7/16" x .065"WALL	
SCREW		SOC. HD. CAP SCR., 10-32UNF x 3.25"LG., S.S., SILVER PLATED	
2-018	4	O-RING VITON, .75"ID x 1/16	PARKER
T-404-NA	8	SET SCREW, 4-40UNC x .25"LG., S.S., SILVER PLATED	UC-COMP
2-012	8	O-RING VITON, .375"ID x 1/16	PARKER
C-3120-NA	32	SOC. HD. CAP SCR., 5/16-24UNF x 1.25"LG., S.S., SILVER PLATED	UC-COMP
AN960-C516	40	FLAT WASHER, AN STYLE, 5/16"ID, S.S.	UC-COMP
191007	4	GASKET, COPPER, DIA 3.37" CONFLAT	MDC
C-1824-NA	4	SOC. HD. CAP SCR., 5/16-18UNC x 1.5"LG., S.S., SILVER PLATED	UC-COMP
N-3118	4	NUT, HEX, 5/16UNC, S.S.	UC-COMP
DOWEL PIN	2	DOWEL PIN, DIA .25" x 1.0"LG., VENTED, S.S.	
C-1612-A	4	SOC. HD. CAP SCR., 3/8-16UNC x 0.75"LG., S.S., SILVER PLATED	UC-COMP

MIRROR	2	INTERFEROMETER MIRROR		
C-2032-NA	8	SOC. HD. CAP SCR., 1/4-20UNC x 2.0"LG., S.S., SILVER PLATED	UC-COMP	
0065097	2	MONOCHROMATOR STAGE MODIFICATIONS	FAB	
LINEAR STAGE	1	LINEAR STAGE MODEL#: 8010006CTEPD1L2C7M1E1	DAEDAL	
191000	8	GASKET, COPPER, DIA 1.33" CONFLAT SOC. HD. CAP SCR., 8-32UNC x 0.62"LG., S.S., SILVER PLATED	MDC	
C-810-A	48		UC-COMP	
2-015	8	O-RING VITON, DIA .43"ID x 1/16 SOC. HD. CAP SCR., 1/4-20UNC x 1.5"LG., S.S., SILVER PLATED	PARKER	
C-2024-A	4		UC-COMP	
C-2008-NA	10	SOC. HD. CAP SCR., 1/4-20UNC x 0.5"LG., S.S., SILVER PLATED	UC-COMP	
C-2012-NA	8	SOC. HD. CAP SCR., 1/4-20UNC x 0.75"LG., S.S., SILVER PLATED	UC-COMP	
0065028	1	CHAMBER LID ASSEMBLY	FAB	
0065027	1	CHAMBER LID	FAB	AL 6061-T651
WN 130018-Nrus	2	114MM, DN63 CF, WELD NECK, BIMETAL, NON ROT.	ATLAS	
WN 130025-Nrus	4	152MM, DN100 CF, WELD NECK, BIMETAL, NON ROT.	ATLAS	
WN 130030-Nrus	3	203MM, DN160 CF, WELDNECK, BIMETAL, NON ROT. 152MM, DN100CF, WELD NECK, BIMETAL, NON ROT.	ATLAS	
152MM FLANGE	2	CUSTOM 114MM, DN 63 CF, WELD NECK, BIMETAL, NON ROT., CUSTOM	ATLAS	
114MM FLANGE	1		ATLAS	
0065020	1	CHAMBER BASE ASSEMBLY	FAB	
0065019	1	CHAMBER BASE	FAB	AL 6061-T651
FM 8.93X3.125 SS	2	RECTANGULAR FLANGE, 8.93"X3.125", BIMETAL	ATLAS	
WN 130030- Nrus	1	203MM, DN160 CF, WELDNECK BIMETAL, NON ROT.	ATLAS	
WN 130008-	4	70MM, DN40 CR, WELDNECK, BIMETAL, NON ROT.	ATLAS	

Nrus				
WN 130017-				
Nrus	4	87MM, WELDNECK, BIMETAL, NON ROT.	ATLAS	
0065085	2	CHAMBER PORT COVER	FAB	AL 6061-T6
0065100	1	CHAMBER ASSEMBLY		
0065024	1	CHAMBER RAIL MOUNT	FAB	STEEL 4140 ANNEALED
0065029	1	BELLOWS END PLATE	FAB	S.S. 304
0065030	1	ROTARY STAGE MOUNT	FAB	AL 6061-T651
0065031	1	ROTARY STAGE ADAPTER	FAB	AL 6061-T651
0065032-1	1	ROTARY STAGE STOP	FAB	S.S. 304
0065032-2	1	ROTARY STAGE STOP	FAB	S.S. 304
BELLOWS	1	BELLOWS		
BALL SCREW	1	BALL SCREW		
BALL SCREW NUT	1	BALL SCREW NUT		
SCREW	50	SOC. HD. CAP SCR., 1/4-20UNC x 25.4LG., S.S.		
SCREW	4	SOC. HD. CAP SCR., 10-32UNF x 57.2LG., S.S.		
HEX NUT	4	HEX NUT, 10-32UNF, S.S.		
WASHER	8	FLAT WASHER, #10, S.S.		
SCREW	20	SOC. HD. CAP SCR., 1/4-20UNC x 19.0LG., S.S.		
LRWH25C2R66				
0	2	RAIL, LINEAR	IKO	
JRH525-				
02/12	4	RAIL BELLOWS END COVER	IKO	
LRWH25	4	TRUCK, LINEAR BEARING	IKO	
JRHS25-210LM	2	RAIL BELLOWS, CENTER	IKO	
HEX NUT	1	HEX NUT		
0065023	1	OPTICAL TABLE	FAB	
OPTICAL TABLE	1	MELLES GRIOT "PERFORMANCE" GRADE OPTICAL		

		TABLE			
0065092	1	STAND ASSEMBLY	FAB		
0065093	1	STAND TOP	FAB	STEEL ASTM A36	PLATE
0065094	1	STAND BASE	FAB	STEEL ASTM A36	PLATE
TUBING	A/R	RECTANGULAR TUBING, 8"x6"x3/8"WALL, A500, GRADE B			
0065033	12	STRUT CLEVIS	FAB	AL 6061-T651	
0065034-1	3	STRUT	FAB		
SLEEVE	1	SLEEVE (STEEL)			
CUFF-RH	1	CUFF-RH			
CUFF-LH	1	CUFF-LH			
0065034-2	3	STRUT			
SLEEVE	1	SLEEVE (STEEL)			
CUFF-RH	1	CUFF-RH			
CUFF-LH	1	CUFF-LH			
0065095	2	ION PUMP STRAP	FAB	STEEL ASTM A36	PLATE
0065026	2	OPTICAL TABLE PADS-US	FAB	STEEL 1015-1020	PLATE
0065025	1	OPTICAL TABLE PADS-DS	FAB	STEEL 1015-1020	PLATE
0071530	1	UHV SWITCH ASSEMBLY	FAB		
0071502	1	UHV SWITCH BODY	FAB	BISQUE-FIRED	ALUMINA
0071500	1	UHV SWITCH CRADLE	FAB	C172 BERYLIUM	
0071501	1	UHV SWITCH NC CONTACT MOUNT	FAB	C172 BERYLIUM	
0071512	1	UHV SWITCH CONNECTOR POST	FAB	C172 BERYLIUM	

00715 03	1	UHV SWITCH BUTTON	FAB	BISQUE-FIRED ALUMINA
00715 04-1	1	UHV SWITCH THREADED BUS-LINE	FAB	C172 BERYLIUM
00715 04-2	1	UHV SWITCH THREADED BUS-NO	FAB	C172 BERYLIUM
00715 04-3	1	UHV SWITCH THREADED BUS-NC	FAB	C172 BERYLIUM
00715 05	1	UHV SWITCH ACTUATOR	FAB	SS
0065297	1	BELLOWS COVER-C	FAB	POLYCARBONATE
0065298	1	BELLOWS COVER-B	FAB	POLYCARBONATE
0065299	1	BELLOWS COVER-A	FAB	POLYCARBONATE
0071506	1	TARGET MIRROR LOWER CLAMP	FAB	S.S. 304
0071507	1	TARGET MIRROR UPPER CLAMP	FAB	S.S. 304
0071508	1	TARGET MIRROR MOUNT	FAB	S.S. 304
SCREW	96	SOC. HD. CAP SCR., 5/16-24UNF x 1.25"LG., S.S.		
GASKET SEAL	1	GASKET SEAL		
405034	1	4 WAY CROSS	MDC	
110030	1	FLANGE, BLANK OFF, 8"CFF	MDC	
ION PUMP	1	ION PUMP		
SCREW	48	SOC. HD. CAP SCR., 3/8-16UNC x 0.75"LG., S.S.		
SCREW	12	CAP SCR., 3/8-16UNC x 2.5"LG., ZN. PL.		
HEX NUT	12	HEX. NUT 3/4-10UNC, ZN. PL.		
AN960-1216	24	3/4"ID WASHER-ZN.	McMST. CARR.	
SCREW	4	SOC. HD. CAP SCR., 3/8-16UNC x 1.5"LG., S.S.		
T1 PUMP	1	T1 SUBLIMATION PUMP		
0065004	6	3/4" STRUT ROD END LH FINE THREAD		

MB-12D-27	1	STEEL-MALE ROD END, 3/4" BORE 3/4-16UNF-3A-LH	AURORA	
7L100	12	CLAMP COLLAR 1"IDx1.75"OD	STAFFORD	
0065003	6	3/4" STRUT ROD END RH FINE THREAD		
MM-12D-27	1	STEEL-MALE ROD END, 3/4" BORE 3/4-16UNF-3A	AURORA	
SCREW	21	SOC. HD. CAP SCR., 1/4-20UNC x 1.25"LG., S.S.		
SCREW	88	SOC. HD. CAP SCR., 6-32UNC x .75"LG., S.S.		
GASKET	2	GASKET, TIN SEAL MATERIAL		
98296A183	12	SPRG. PIN 1/8"x1"LG.	McMST. CARR.	
450008	1	VIEWPORT 8"CFF-ZERO PROFILE	MDC	
BELLOWS	1	BELLOWS 8"CFF x 12.5"LG.		
450004	1	VIEWPORT, 4.5"CFF	MDC	
0071509	1	PRISM, MOUNT, LEFT	FAB	S.S. 304
0071510	1	PRISM, MOUNT, RIGHT	FAB	S.S. 304
0071513	1	TAPER PIN	FAB	
0071514	1	HELICOFLEX SEAL		