CALIFORNIA INSTITUTE OF TECHNOLOGY
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COMPONENT SPECIFICATION

TITLE

LARGE OPTICS SUSPENSION BALANCING

APPROVALS:		DATE	REV	DCN NO	BY	CHK	DCC	DATE
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1 INTRODUCTION

1.1. Objectives and Scope

The scope of this document is to specify how to clean and assemble a Large Optic Suspension. It also details how to prepare an optic for installation into the suspension structure and how to hang and balance that optic.

1.2. Version History

8/21/98: Rev A by J. Hazel Romie.

6/28/99: Rev B first draft by M. Barton - near-complete rewrite.

7/13/99: Rev B final draft. Extensive revision of procedure for installing the wire.More detailed description of autocollimator usage.

1/28/00: Rev C. Major update.

4/18/00: Rev D. Add use of deionizing gun for static charge, extra precautions to identify autocollimator HR surface reflection, non-reuse of clamps.

1.3. Applicable Documents

LIGO-D960132: Large Optic Suspension Assembly, LOS1a
LIGO-D970560: Large Optic Suspension Assembly, LOS1b
LIGO-D970564: Large Optic Suspension Assembly, LOS1c
LIGO-D970572: Large Optic Suspension Assembly, LOS1d
LIGO-D970577: Large Optic Suspension Assembly, LOS1e
LIGO-D970561: Large Optic Suspension Assembly, MMT3, 4k
LIGO-D970578: Large Optic Suspension Assembly, MMT3, 2k
LIGO-D970505: Large Optic Suspension Assembly, LOS2a
LIGO-D970539: Large Optic Suspension Assembly, LOS2b
LIGO-D970507: Large Optic Suspension Assembly, LOS3

LIGO-D960133: LOS Structure Assembly, LOS1
LIGO-D970551: Recycling Mirror Structure Assembly
LIGO-D970506: LOS Structure Assembly, Beamsplitter
LIGO-D970508: LOS Structure Assembly, Folding Mirror

LIGO-D960145: LOS Height Adapter Assembly
LIGO-D970571: LOS1c Height Adapter, Recycling Mirror 4k
LIGO-D970579: LOS1e Height Adapter, Recycling Mirror 2k
LIGO-D970554: LOS2a Height Adapter, Beamsplitter 4k
LIGO-D970555: LOS2b Height Adapter, Beamsplitter 2k
LIGO-D970569: LOS3 Height Adapter, Folding Mirror

LIGO-E960022: LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures
LIGO-M990034: LIGO Hanford Observatory Contamination Control Plan
LIGO-E970153: Large Optics Suspension Quality Conformance Worksheet
LIGO-E990196: Magnet/Standoff Assembly Preparation Specification
LIGO-E990197: Magnet/Standoff Assembly Quality Control Worksheet
LIGO-T960074: Suspension Preliminary Design
LIGO-T950011: Suspension Design Requirements
LIGO-T970158: Large Optics Suspension Final Design (Mechanical System)
LIGO-L970196: Part Numbers and Serialization of Detector Hardware
LIGO-E000029: LIGO Large Optic Process Traveler Form
LIGO-E000028: Core Optics Tilt Angles
LIGO-E000033: Large Optics Suspension Table
LIGO-E990035: Large Optics and COC Cleaning Procedures
LIGO-E000061: LOS Installation Procedures for HAM Chambers
LIGO-E000062: LOS Installation Procedures for BSC Chambers

2 VACUUM COMPATIBILITY REQUIREMENTS

2.1. General Handling

All procedures listed under this specification for assembly and balancing must be performed in a clean room environment while suited up in clean room clothing including, but not limited to: frock, shoe covers, bouffant cap, LIGO-approved latex gloves, and facial mask. This applies to anyone handling or near clean pieces or pieces being cleaned.

For further detailed handling requirements see M990034, LIGO Hanford Observatory Contamination Control Plan. In the terminology of that document, the optic, suspension structure and associated parts are Class A hardware (i.e., destined to be installed in vacuum) and once cleaned and baked should not come into contact with anything but Class A and B hardware.

2.2. Preparation of the Suspension Structure

2.2.1. Cleaning and Baking

The structure assembly is to be cleaned and baked in preparation for installation according to LIGO-E960022, LIGO Vacuum Compatibility, Cleaning Methods and Qualifications. Information on vendors and part numbers for C.P. Stat foil and other clean room supplies is given in that document.

Cleaning is to be performed in a “clean manufacturing area” separated from all other operations. This space should have non-shedding floors, walls and ceiling. In addition, the atmosphere for this “clean manufacturing area” must not exchange directly with the shop floor area; the air must be carbon and HEPA filtered and monitored with a hydrocarbon meter.

After cleaning and baking, suspension component surfaces shall not be touched by skin or other contaminants. Only C.P. Stat plastic sheet, UHV Al foil and LIGO-approved swabs and latex gloves are acceptable. All suspension parts shall be double bagged (C.P.Stat plastic) or protected by a Class 100 cleanroom atmosphere. Small components can be bagged together with other small pieces.

2.2.2. Cleaning Inspection and Testing

Sample check the cleanliness of blind tapped and through tapped holes with a clean swab dampened with alcohol for a minimum of 10% of the holes. If any discoloration of the swab is evident, then the part must go through at least one more wash before repeating a check of the cleanliness. If any machining chips are found:
(a) a HEPA filtered vacuum cleaner may be used to remove the chips from the holes, and
(b) the holes must be cleaned with a solvent dampened swab.

After inspection and testing, double bag the component in C.P. Stat plastic film. Tie or band the inner bag(s) closed. Do not use tape or heat sealing on the inner bag.The outer bag should be sealed.

A log of the cleaning procedure shall be kept and form part of the component traveler.

2.2.3. Baking Inspection

After baking, sample check the cleanliness of blind tapped and through tapped holes with a clean swab dampened with alcohol for a minimum of 10% of the holes in case any material has leached out during baking. If any discoloration of the swab is evident, then the part must go through at least one more wash cycle before repeating the bake.

After inspection, double bag the component in C.P.Stat plastic film. Tie or band the inner bag(s) shut. Do not use tape or heat sealing. The outer bag should be sealed.

3 QUALITY ASSURANCE/CONTROL

3.1. Documentation

For each optic, make a copy of the LIGO Large Optic Process Traveler form, E000029. Obtain an E-series document number for the copy, using as a title “Process Traveler for <name of optic>”, e.g., “Process Traveler for ETM4K, LLO”.

3.2. Quality Assurance Provisions for Sensor/Actuator Heads

Collect five sensor/actuator head assemblies which pass the following tests and record serial numbers and test data in the process traveler for the optic.

1. Measure the photodiode output voltage in each sensor/actuator head with the standard current applied to the LED. (This can be done using the suspension controller test stand.) Reject sensor/actuator heads for which the voltage is below 1.5 V.
2. Test for continuity of the plating by measuring the resistance from the face to the side of each OSEM.
3. Check for shorts between turns of the coil by measuring the resistance between the ends of the wires. Reject coils whose resistance is not approximately 13 ohms.

4 FIXTURES

4.1. Drawing Numbers

D000256 Large Optic Holder, Part A
D000257 Large Optic Holder, Part B

D000035: Magnet and Dumbbell Sanding Fixture

D000036: Magnet-to-Dumbbell Assembly Fixture

D990158: Magnet/Standoff Assembly Fixture
D990186: “Ears” for use with ETM, MMT3, FM, Dummy Mass
D990187: “Ears” for use with ITM4k
D990189: “Ears” for use with ITM2k
D990188: “Ears” for use with RM

D990190: LOS2 Magnet/Standoff Assembly Fixture (for use with BS)

D960147: Base Plate of Guide Rod Fixture Assembly and blocks for use with ETM, MMT3, FM and Dummy Mass
D970574: Guide rod blocks for use with ITM4k
D970573: Guide rod blocks for use with ITM2k

D970568: Guide rod blocks for use with RM
D970550: LOS2 Guide Rod Fixture for use with BS-4k, BS-2k

D960763: Fixture, Test Mass (a.k.a. the Dummy Mass)
D970553: LOS2 Test Mass Fixture (an Al blank the size of the BS)

Microscope, Edmund Scientific, p/n J39-110
D000013: Microscope-OSEM Bushing
PZT Buzzer
D970180: Winch Fixture
D960753: Fixture, Wire and Optics (Cradle Fixture)

D960145: Height Adapter for ETM, ITM4k, ITM2k
D970571: Height Adapter for MMT3-4k, RM-4k
D970579: Height Adapter for MMT3-2k, RM-2k
D970554: Height Adapter for BS4k
D970555: Height Adapter for BS2k
D970569: Height Adapter for FM

4.2. Descriptions

- **Magnet-to-Dumbbell Standoff Fixture**

Used to configure and bond the magnets to the dumbbell shaped aluminum standoffs.

- **Magnet/Standoff Assembly Fixture**

Used to position and epoxy the magnet/standoff assemblies to the face and sides of the optic.

- **Guide Rod Fixture**

Used to position and bond a guide rod and a wire standoff to the side of the optic.

- **Fixture, Test Mass and LOS2 Test mass Fixture**

Used for the prototype test. These aluminum dummy optics have the same size, wedge, chamfer and approximate mass as the ETM and BS.

- **Measuring Microscope**

Used to align the sensor/actuator plates to the magnet/standoff assemblies glued on the optic or dummy mass.

- **Microscope Bushing**

Mounted on the measuring microscope and used to adapt the microscope to the bore of the holes for the sensor/actuator head assemblies in the sensor/actuator plates.

- **PZT Buzzer**

Used for sliding the wire standoff along the side of the optic to change the pitch balance of the optic. It is a rod or tube to which a PZT is attached. The PZT is driven while the vibrating rod is placed against the end of the standoff to produce small displacements of the standoff.

- **Winch Fixture**

Used to microposition the suspension wire vertically.

- **Height Adapter**

Used to adapt suspension to its correct vertical position relative to the laser beam.

- **Fixture, Wire and Optics (Cradle Fixture)**

Used to position the wire and to protect and move the optic into position in the suspension support structure.

5 ASSEMBLY/BALANCING SPECIFICATION

5.1. Magnet Preparation

Make sure there are (i) a matched set of 2 north and 2 south magnet/standoff assemblies for use on the face of the optic, (ii) a matched set of 2 south magnet/standoff assemblies for use on the side of the optic, (iii) a matched set of PAM screws. If not make them up according to the instructions in Magnet/Standoff Assembly Preparation Specification, E990196. Record the magnet strengths in the Process Traveler.

5.2. Optic (or Dummy Mass) Preparation

5.2.1. Wire Standoff and Guide Rod (With Guide Rod Fixture)

5.2.1.1 Materials

Optic or Dummy Mass
D960755 LOS Large Wire Standoff or appropriate
D960146: Guide Rod
Perkin Elmer Vac-Seal epoxy resin
D960147: Base Plate of Guide Rod Fixture Assembly and blocks for use with ETM, MMT3, FM
D970574: Guide rod blocks for use with ITM4k
D970573: Guide rod blocks for use with ITM2k
D970568: Guide rod blocks for use with RM
D970550: Guide Rod Fixture Assembly and Blocks for use with BS4k, BS2k
solvents; isopropanol or methanol, and acetone
6” length of clean copper wire (never having had insulation)
UHV aluminum foil
lint-free wipes
small vacuum chamber with backing pump
Mylar or Kapton film, 0.0075”, **with no adhesive** (note: thickness is critical for precise placement of guide rod)

5.2.1.2 Fixture Assembly

1. Clean optic per E990035.

2. Clean fixtures: Clean the base plate and the side blocks of the guide rod fixture thoroughly per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022. Clean and bake the guide rod and wire standoff per the same specification.
3. Prepare baseplate: Put the baseplate on a clean work surface with the serial number the right way up as viewed from the position of the worker. (NOTE: subsequent instructions assume this orientation. Engage the two side blocks with the dovetail slides on the guide rod fixture, taking care to match left and right. It is important to do this step before placing the optic, because the blocks foul on the optic when it is in position. Slide the blocks to their lowest position to give plenty of space for bringing in the optic. Cut three small strips (.50” x 1.00”) of Mylar film and place on the etched circle in the base plate. This Mylar is used to protect the bottom face (the high reflective surface) of the optic.
4. Position optic on baseplate: Note that one of the four etched lines on the sides of the optic has an arrowhead. For all large optics, this arrow is at the thinnest point of the wedge and points towards the high-reflectance or beam-splitting surface. Note also that all large optics except for the recycling mirror are suspended with the thin part of the wedge at the bottom. The optic should be laid on the baseplate such that (i) the face of the optic is concentric with the etched circle, (ii) the HR or BS surface down is down and (iii) what will be the bottom when the optic is later hung is towards the worker. That is, in all cases, the arrow should point towards the floor. Also, with one exception (the recycling mirror), the arrow should be on the side nearest the worker. (For the recycling mirror it should be on the side opposite the worker.) Make fine adjustments to the position and angle of the optic until the four etched lines on the side of the optic line up with those on the base plate. Be careful to allow for parallax. Before sighting on the line on the baseplate, position your eye so that the line on the near side of the optic lines up through the body of the optic with the one on the far side.
5. Clean the sides of the optic. Wipe over the sides of the optic with a lint-free wipe dampened with acetone. Repeat with isopropanol or methanol.
6. Position left and right blocks: Snug them up against the side of the optic and tighten the screws that hold the top blocks to the base plate to finger tightness.
7. Prepare adhesive applicator: Clean the copper wire with acetone and alcohol with lint-free wipe.
8. Prepare epoxy: Mix the two epoxy components of a Vac Seal “bipax” together thoroughly, approximately 2 minutes. Dispense from the middle of the container into a boat made of clean UHV aluminum foil. Degas the epoxy for 2 minutes at 10 torr (or the vacuum from any typical backing pump).
9. Position and glue the wire standoff and guide rod: Position the guide rod in the smaller vertical v-groove. If there is difficulty inserting the guide rod into the v-groove, move the top block down a bit, along the wedge, insert the guide rod, and then cinch the block back into position, holding the guide rod in the v-groove securely. Dip applicator wire in epoxy and withdraw it, leaving a tiny amount of epoxy on the wire. Apply epoxy on the wire to the vertical line of contact between the guide rod and the optic that is furthest away from the worker. Be sparing in epoxy at this point as more glue will be used later to secure this guide rod. Take care not to get epoxy on the fixture. Insert the wire standoff in the other vertical v-groove and apply epoxy in the same way. Be sure to apply epoxy to the vertical line of contact between the wire standoff and the optic that is furthest away from the magnet/standoff assembly.
10. Check the adhesive joints: If preparing an optic rather than a metal dummy mass, look through the optic at the two glue joints and make sure that the glue has spread over the whole area of the joint.
11. Cure epoxy: Leave the assembly for 24 hours or more. Vac Seal cures fully in 72 hours so if that time is available, it should be used to allow the assemblies to fully cure. Note that the side blocks which existed as

of this version of the balancing procedure are **not** rated for an oven cure (as used for the magnet standoff assemblies in the following section).

12. Remove the guide rod fixture: After curing, unscrew the fasteners that hold the top blocks to the base plate, one side at a time, and slowly, carefully, move the top blocks down the wedges.

5.2.2. Applying Magnets (With Magnet/Standoff Assembly Fixture)

5.2.2.1 Materials

1 set of magnet/dumbbell standoff assemblies for LOS
Perkin Elmer Vac-Seal epoxy resin
D990192: Large Optic Holder
D990158: Gripper Assembly
D990190: BS Gripper Assembly
D990186: “Ears” for use with ETM, MMT3, FM
D990187: “Ears” for use with ITM4k
D990189: “Ears” for use with ITM2k
D990188: “Ears” for use with RM
D960763: Fixture, Test Mass (Dummy Mass) or Optic or appropriate

solvents: acetone, and isopropanol or methanol
6” length of clean copper wire (never having had insulation)
small vacuum chamber with backing pump
UHV aluminum foil
lint-free wipes
oven mitts
Teflon or PFA440HP, approx 400 mm x 400 mm x 3 mm (note: only PFA440 is approved for use in the airbake oven)
air bake oven
lab jack Newport Corp. p/n 281
plate, Newport Corp, p/n 290-TP
extensions to bring plate level with oven rack when mounted on the lab jack

5.2.2.2 Fixture Assembly

1. Preheat bake oven: Turn on the air bake oven and set the thermostat for 100°C.
2. Clean fixtures: Clean the Large Optic Holder and top ring of the magnet/standoff assembly fixture thoroughly per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022.
3. Prepare holder: Put the Large Optic Holder on a clean work surface with the two handles at front and back as viewed from the position of the worker.
4. Position optic on holder in roughly the same orientation as for gluing the wire standoff and guide rod (see 5.2.1.2). The precise orientation is not critical.
5. Prepare the magnet/standoff fixture: Back off the three 1/4-20 set screws in the top ring until the PFA440HP tips are flush with the the inner surface of the ring.

6. Mount the magnet/standoff fixture: Carefully lower the ring onto the face of the optic with the “top” part of the ring away from the worker. Align the lines on the “top” and “bottom” of the ring with the etched lines on the side of the optic. Advance the set screws by small, equal increments (e.g., 1/4 turn) until they grip the sides of the optic. Recheck the alignment of the etched lines. If there is misalignment, back off all the set screws a small amount, rotate the ring as appropriate and retighten the screws. Using the depth gauge of a clean set of vernier calipers, check that the distances to the side of the optic from the reference flats on the outside of the ring are equal. If the calipers foul on one of the handles of the Large Optic Holder, rotate the optic slightly or remove the handle temporarily.
7. Move the optic into the oven: Open the oven door. Working quickly, set up a lab jack in front of the door, with the top level with the floor or a suitable rack of the oven. A sheet of PFA440HP may be laid on the rack of the oven rack to reduce friction when sliding the optic in. A sheet of either Teflon or PFA440HP may be laid on the top of the jack. Teflon, although similar, is not approved for use in the oven - it gives off fluorine gas when heated which may damage the optic. Move the optic holder with the optic on it onto the lab jack, being careful to keep it level so that the optic and top ring do not slide around. Slide the whole assembly into the oven and close the door. Wait for the temperature to return to 100C (approximately 1 hour).
8. Prepare the plungers: Lay out a clean piece of UHV foil in a convenient position near the oven. Lay out the plungers on the foil in an arrangement similar to the magnet positions in Figure 1. The magnets are placed so that polarities of the magnets alternate; this is to minimize coupling of the optic to time-varying ambient magnetic fields. For each magnet/standoff assembly, double-check the magnet polarity and standoff type and install it into the corresponding plunger, with the standoff end outwards and with only about 1 mm of the magnet visible. (A magnetic compass is convenient for checking the polartity.) Gently press on the end of the standoff to ensure that the magnet/standoff assembly is gripped firmly and will not slide into the plunger.
9. Prepare the adhesive applicator: Clean the copper wire with with lint-free wipes dampened with first acetone and then isopropanol or methanol .
10. Prepare the epoxy: Mix the two epoxy components of a Vac Seal “bipax” together thoroughly, approximately 2 minutes. Dispense from the middle of the container into a boat made of clean UHV aluminum foil. Degas the epoxy for 2 minutes at 10 torr (or the vacuum from any typical backing pump).
11. Slide the optic out of the oven: Have an assistant available to spot. Open the oven door and set up the lab jack in front of the oven. A Teflon or PFA440HP sheet may be laid on top to reduce friction. Using oven mitts, slide the optic far enough out that the “ears” on the side of the Magnet/Standoff Assembly Fixture are readily accessible.
12. Apply the epoxy and insert the plungers in the fixture, starting with the sides. Dip applicator wire in epoxy and withdraw it, leaving a tiny amount of epoxy on the wire. Apply a bead of epoxy with a diameter of about .02” [.5mm] and a height of .01”[.3mm]. Spread out the bead of adhesive to cover the entire end of the standoff evenly. Insert the plunger holding the magnet/standoff assembly into fixture. (The optimum adhesive thickness is .003” [.08mm] or a volume of 3.9×10^{-6} in^3 [$.06 mm^3$].) Have an assistant apply gentle pressure to the side plungers for about 30 s after they have been inserted while you are working on the face plungers. Make sure to preserve the configuration of magnets established in Step 8. Apply more epoxy to the wire standoff and guide rod if necessary.
13. Cure epoxy: Slide the optic back into the oven and close the door. Allow to bake for 2 hours.
14. Remove the plungers: Using several lint-free wipes to protect your hand from the hot metal, squeeze each

plunger so that it releases the magnet/standoff assembly and withdraw it. NOTE: The plungers must be removed before the optic is allowed to cool, or differential themal expansion will cause joint failures.

15. Let the optic cool: Where possible, just slide the optic back into the oven, turn the oven off and allow the optic to cool in situ. If the oven is required again immediately, use extreme caution in removing the optic to avoid burns to workers and damage to the optic.
16. Remove magnet/standoff fixture: An assistant to act as a spotter is recommended for this step. Loosen the three 1/4-20 set screws that hold the Magnet/Standoff Assembly Fixture to the optic. Slide the ring off straight upwards, using extreme care to ensure that the ears maintain safe clearance from the side magnets.
17. Test the strength of the bonds: For each magnet in turn, allow the flat surface of a clean razorblade to stick to the flat end. Pull the razorblade straight off along the axis of the magnet. If the magnet/standoff assembly survives the bond is adequate. Note the results of the test in the Process Traveler (Appendix A of this document).

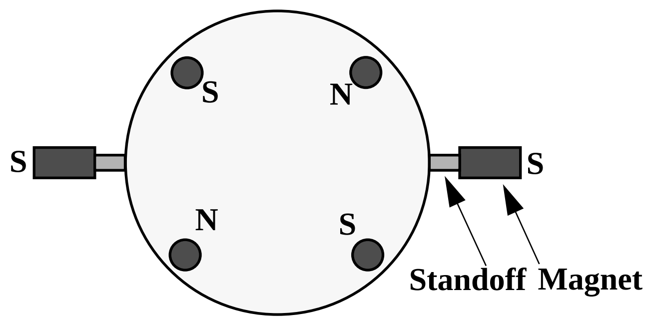

Figure 1: Polarities of the magnet/standoff assemblies.

5.3. Suspension Assembly

5.3.1. Materials

D960144: suspension block
D970540: LOS2 Suspension Block (for BS)
#4 flat washer, stainless
#4 lock washer, stainless
#4-40x1/2, silver-plated stainless SHCS
1/4 flat washer, stainless
1/4 lock washer, stainless
D960134: LOS Clamp, Suspension Block
D970180: Winch fixture (2 of)
4 silver-plated 1/4-20 x 1.0” socket head screws
D990690: LOS Safety Stop

D960499: LOS Chamfer Stop
D000040: Teflon Screw Tip, Small
D000041: Teflon Screw Tip, Large
D970563: Beamsplitter Safety Stop
D970562: Beamsplitter Chamfer Stop
D990691: LOS3 Chamfer Stop
deionizing gun

5.3.2. Procedure

1. Clean and bake all components of the suspension assembly, except the suspension wire, per LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures, LIGO-E960022.
2. Prepare the suspension block and winch fixtures: Set the suspension block on top of the LOS structure, and insert the attachment screws with their washers. Before tightening the screws, use a clean set of vernier calipers to ensure that the edge of the suspension block is parallel to the top front edge of the structure. Using oversize washers and 1/4-20x1.5” long screws, attach a winch to each of the threaded holes on the top of the suspension block, with the rocker of the winch closest to the front of the suspension block. Fit suspension block clamps (6 in all) to the suspension block and the winch fixtures, leaving all screws very loose.
3. Screw in the 8 chamfer stop screws and the 8 safety stop screws into their respective brackets until they protrude past the inside of the bracket by about .25”.
4. Replace the Fluorel tips of the lower safety stop screws with the Teflon caps. Wrap the Fluorel tips in clean UHV foil and save. (The tips will be changed back again at the end of installation in the chamber.)
5. Install the socket head set screws, into the Sensor/Actuator Brackets in preparation for the installation of the Sensor/Actuator Assemblies.

Note: Do not install the height adapter yet. Although it is part of the suspension assembly, if it is installed before the optic is suspended, access to the suspension block is awkward at best and impossible at worst.

5.4. Optic Installation

5.4.1. Suspension Structure Assembly and Optic Hanging

5.4.1.1 Materials

Optic or dummy mass with magnet/standoff assemblies, guide rod and wire standoff from above.
D960132: Structure for ETM (LOS1a), ITM4k (LOS1b), ITM2k (LOS1d), MMT-4k, MMT3-2k
D970551: Structure for RM4k (LOS1c), RM2k (LOS1e)
D970506: Structure for BS4k (LOS2a), BS2k (LOS2b)
D970508: Structure for FM (LOS3)
0.012” diameter steel music suspension wire (0.008” for BS)
D960755: Large Wire Standoff or appropriate
Bubble level
Perkin Elmer Vac-Seal epoxy resins
6” length of clean copper wire (never having had insulation)

UHV aluminum foil, C.P. Stat
lint-free wipes
solvents: acetone and isopropanol or methanol
Microscope, Edmund Scientific p/n J39-110
D960013: Microscope-OSEM Bushing
PZT Buzzer
D960753: Fixture, Wire and Optics

5.4.2. Assembly

NOTE: It is absolutely essential to have two people for this section of the procedure.

1. Prepare the wire standoff: Select a wire standoff cleaned and baked per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022.
2. Prepare work surface: Level an optical bench using a bubble level to 0.3 mrad (1 minute) or better. Place the LOS structure on a sheet of C.P. Stat on the table and align it square to the hole pattern as closely as possible by eye. If at all possible, have the structure facing such that when the optic is installed, the side of the optic with the guide rod will be in a convenient position towards the edge of the table (the guide rod is not on the same side for all optics). Make sure there is a clear space for at least 0.5 m behind the structure (on the side with the sensor-actuator brackets) and 1 m in front.
3. Level the structure: Optics to go in BSC chambers (all but MMT3 and RM) will hang from the downtube, so the reference surface is the top. Check that the top surface of the structure is level to 0.3 mrad (1 minute) or better. If necessary shim the base with sheets of UHV Al foil. For optics which will stand on the optical table in a HAM (MMT3 and RM), the reference surface is the bottom. Just ensure the optical table is level and that the base of the structure sits snugly on it.
4. Prepare the suspension wire: Cut a length of wire about 2 m long. Note that the BS uses thinner wire (0.008”). The wire should not be baked - only cleaned. Clean the wire thoroughly by wrapping an acetone-soaked lint-free wipe around the wire and gently pulling the wire through the wipe. This should be done a minimum of three times to remove any rust and contaminants. Repeat with isopropanol or methanol.
5. Install the suspension wire: Thread one end of the wire up through the gap between the side sensor/actuator bracket and the optic, then up to the suspension block, through the jaws of the lower suspension block clamp, around the inside of the dowel pin, and through the jaws of the other suspension block clamp and the winch fixture clamp. Repeat with the other end of the wire, ensuring that the wire is free of twist and kinks. (In the case of the LOS2 structure, ensure that the wire encircles the strut that runs between the front and back reinforcing box-beams.) Tighten the upper and lower suspension block clamps so that they locate the wire against the face of the block, but apply negligible force. Leave a very large amount of slack - enough that the loop can be formed into a large triangle with its corners outside and below the safety stop screw brackets. Tuck the bottom of the loop below the rear brackets and move all the wire as far to the rear as possible.

NOTE: Steps 7 - 9 do not apply to the BS because the cradle of the Wire and Optics Fixture does not fit into LOS2. The BS should be picked up with hands at 6 o’clock and 12 o’clock and inserted into the structure manually.

6. Place the aluminum cradle baseplate near the LOS structure on the front side (opposite the sensor actuator

brackets) and put the cradle on top. Adjust the height of the top of the baseplate by placing one or more lint-free wipes under it so that it is level with the bottom plate of the LOS structure and the cradle can slide smoothly from one to the other.

7. Move the optic onto the cradle: This step assumes the optic starts lying HR (or BS) side down on the baseplate of the gluing fixture. Standing the optic up is possibly the most risky part of the procedure and should be carefully rehearsed. The side magnets are at the 3 o'clock and 9 o'clock positions around the edge and are extremely easy to knock off. The sequence of holds described below keeps hands away from the magnets and eliminates awkward wrist angles, thus minimising the risk of injury to personnel and damage to the optic. One person should pick up the optic with hands placed at 6 o'clock and 12 o'clock. The stronger hand (i.e., typically the right hand) should be at 6 o'clock and the fingers should be horizontal, i.e., tangentially around the edge of the optic. The first person should then rotate the optic so that it is standing up, with the weight on the hand at 6 o'clock. A second person should then take the optic, using hands at 4:30 and 7:30 and with fingers pointing parallel to the cylinder axis. The second person should have the face magnets towards them so they are easy to see and cannot be knocked off if their fingers curl behind the optic. The second person should place the optic on the cradle with the arrow exactly at the bottom (or exactly at the top in the case of the RM).
8. Move optic into place: A person to act as a spotter is recommended for this step. Rotate the cradle on its baseplate until the face magnets on the optic point towards the back of the structure. Slide the baseplate up to the bottom plate of the structure. Carefully slide the cradle off the baseplate, onto the bottom plate and into the structure, checking continually that the optic does not bump into any of the brackets, until it is symmetrically located both left-to-right and front-to-rear relative to the safety stop brackets. Screw in the lower safety stops until they touch the optic. Then screw each stop in one turn further so that they lift the optic about 1 mm above the cradle. Push the cradle out from underneath the optic towards the front of the structure (not the back as in previous versions of this procedure) and remove it. Screw in the chamfer stops and the upper safety stops so that there is a 1-2mm gap between the optic and the end of the stop.
9. Post a person to safeguard the side magnets: Have a second person watching throughout the next few steps to make sure the wire does not come too close to the side magnets. This requires a lot of care because the wire is magnetic. The assemblies should withstand the wire being pulled off straight in any direction against the force of the magnetic attraction. However the assemblies are no match for a taut wire trapped on one side and wanting to be on the other side. Be especially careful to avoid the wire getting hooked in the waist of the dumbbell standoff.
10. Take up the slack in the wire: Move the bottom of the wire loop forward into the gap between the front and rear safety stop brackets. Pull the ends of the wire so that the loop tightens around the optic. On the side of the optic with the wire standoff, let the wire drop into the groove in the standoff. On the other side, let the wire rest on the guide rod, a few mm to one side of the magnet standoff assembly. Tighten one upper suspension block clamp, taking care to keep the wire centered between the screws. Apply moderate tension with fingertips to the end of the wire on the other side and tighten the other upper suspension block clamps, again taking care to center the wire between the screws. It should be possible to pull the wire a few millimetres away from the optic using only tweezers.
11. Insert the second wire standoff: Hold the wire away from the side of the optic (and the magnet!) with a pair of tweezers and insert the second wire standoff below the guide rod but snugged up against it, using a second pair of tweezers. Position the wire standoff so that its central groove is directly below the centre of the guide rod, and make sure the wire drops into the groove. If the standoff is difficult to insert or if it will not

hold its position beneath the guide rod, adjust the tension in the wire slightly with the winch fixture and try again.

12. Suspend the optic: Slowly, lower the safety stops that support the bottom of the optic and suspend the mass. Try backing off the chamfer stops and note which direction the optic tends to tip. Use the PZT buzzer to micro-position the wire standoff so that the optic/dummy mass will hang stably at very roughly the desired angle (as judged by eye). An alternative technique is to emulate a diamond cutter and to use the handle of a screwdriver (or similar) as a mallet and a long pointed (clean) tool to transmit the force to the optic. Use the de-ionizing gun on the optic to make sure stray static charges have not affected the balance.
13. Check the line of the wire underneath the optic: Check that the part of the loop below the standoff lies in the same plane as the part above, as nearly as possible as judged by eye. If the wire bends at the standoff when viewed from the side, it will cause a substantial pitch of the optic which is likely to change over time as the wire relaxes. A bend of the wire sufficient to displace the bottom of the loop about 5 mm from the centreline is equivalent to about 3 mrad of pitch. If the wire is bent, raise the lower safety stops to take most of the tension off the wire, and push it into line using the PZT buzzer. Even if the wire is not out of place, gently apply the PZT buzzer to the entire length of the wire against the glass so as release any tension.
14. Set up the winch fixtures: The cradle leaves the optic slightly higher than its working position so it is convenient to set the initial position of the winches so there is plenty of scope for lowering. (This may not apply for the BS, which is inserted manually.) For each winch fixture in turn, hold the back of the lever up under the head of the main screw (it tends to fall under its own weight) and adjust the main screw until the the lever is slightly nose up. Still holding the lever in position, put tension on the end of the wire and tighten the wire clamp on the nose of the winch.
15. Do a preliminary adjustment of the position of the optic in roll and vertical using the winches. Put sensor-actuator head assemblies (without PAM screws) in the brackets. Rock them back and forward on the rails in the brackets until they settle snugly. Check visually that there is a full line of contact between the rails and the body of the assembly. Do not bring them close to the magnets at this point - the risk of damage is too great. Leave several mm clearance - somewhat more than the chamfer stop to optic distance. Sight through the sensor-actuator heads, controlling for parallax by positioning your eye so that the aperture at the far end of the sensor-actuator head is centred in the aperture on the closer side. Adjust the lengths of the wires on each side until the magnets on the face of the optic line are centered in the square holes for the sensor/actuator head assemblies. At this stage, concentrate on roll, that is, make sure that the magnets on opposite sides are in the same relative vertical positions with respect to the corresponding sensor/actuator heads. The final absolute adjustment in vertical can only be done after the final pitch adjustment, because the lever arm of half the thickness of the optic times a typical pitch angle amounts to a non-negligible vertical displacement of the magnets.

5.4.3. Optic Balancing

5.4.3.1 Materials

Optic suspended in Large Optic Suspension Structure
Perkin Elmer Vac-Seal epoxy resins
6” length of clean copper wire (never having had insulation)
UHV aluminum foil

lint-free wipes
PZT Buzzer
D960753: Fixture, Wire and Optics
solvents: acetone, and isopropanol or methanol

autocollimator and power supply, Davidson Optronics p/n D-416
breadboard, Newport Corp p/n SA11 (2 of)
HeNe laser: Uniphase Model 1108P (1 mW)
HeNe/Autocollimator mount: Newport UML-TILT (2 of)
optical lever quad photodiode: On-Trac Photonics Inc. Model PSM2-100 & controller.
corner cube reference for autocollimator, Edmund Scientific, p/n F-45190
goniometer stage, Newport Corp. p/n VTR160
bubble level (1' precision, Method 1 only))
precision right angle, McMaster-Carr p/n 5230A63 or Newport Corp., p/n 360-90 (Method 1 only)
beamsplitter holder or similar tilt/rotation stage (Method 1 only)
Starrett Granite 3 Face TriSquare: model 81961 or 81962 (Method 2 only)
precision optical flat, CVI Laser Corp., p/n PW1-2025-UV
assorted posts, brackets, dogs, 1/4-20 screws, hex wrench
M6 screws and metric wrench

5.4.3.2 Setup of Autocollimator and Balancing

NOTE: most of the alignment operations in the following procedure are there to eliminate trivial second-order errors and to avoid hunting for the autocollimator image in a large multidimensional parameter space. The alignments that are critical to the final result are indicated specially.

The following instructions allow for two different methods of making a vertical reference to zero the autocollimator position. Method 2 uses a granite corner block and is intended for the granite work table at the Livingston observatory.

1. <u>Set the goniometer up on brackets</u> at a convenient height and position about 0.8 m from the LOS structure. Note that the threaded holes in the base of the goniometer are metric. Ensure (i) the rotation axis is horizontal and parallel to the face of the optic, (ii) the scale is uppermost and set roughly to zero, (iii) the autocollimator, when fitted, will point very roughly at the centre of the optic (this is not at all critical - the optic is effectively perfectly flat for the purposes), and (iv) the fine adjustment screw is set to the appropriate end of its range such that it has room to move in the direction that will take the autocollimator from horizontal to the desired angle for the particular optic.
2. <u>Setup and roughly align the autocollimator:</u> Attach the autocollimator holder and autocollimator. Using the adjustment on the holder, set the autocollimator to be square on the optical table as close as possible when viewed by eye from above (ignore vertical for the moment). Connect the autocollimator power supply and turn it on.
3. <u>Check zeroing of the autocollimator:</u> Put the corner cube reference over the end of the autocollimator. Focus the crosshairs using the black knurled eyepiece surround, and then focus the calibrated scale using the metallic knurned ring at the back of the autocollimator. Check that the scale disappears when the corner cube is removed and the autocollimator aperture is blocked (if not, the autocollimator is actually focussed

on an internal surface and is ten or twenty turns from the proper focus). With the corner cube back in place, check that the crosshairs are aligned with the dot in the centre of the scale. (If not, get the autocollimator realigned/repaired.) Remove the corner cube.

4. Find a reflection from the optic in the autocollimator. Let the optic hang freely. Rotate the goniometer until a scale due to reflection from the optic is visible in the eyepiece. (Because of the by-eye horizontal alignment of the structure and autocollimator specified above, you should only have to search vertically.) If you need to rotate by a large angle, undo the goniometer lock screw and rotate the goniometer stage with your hands - don't use up the limited range of the fine adjustment screw. Refocus the autocollimator (it should only take a turn or two).
5. Identify whether the reflection is from the HR or AR surface. Get a rough idea of whether the scale is from the front (HR) surface or the back (AR) surface by looking by eye from the side and noting which surface is more nearly orthogonal to the body of the autocollimator. Confirm the identification by moving the autocollimator to bring the other scale into view. For the usual case of a thick-side-up wedge (all optics but RM), to go from the HR reflection to the AR one the nose of the autocollimator has to be lowered by an amount equal to the wedge angle times the refractive index (1.46). Identifying the HR reflection correctly is particularly important for ITMx2K, which has a very small wedge angle. The two reflections are normally different colours, e.g., orange and pink. Note the colour of the HR refection for future reference.
6. Align the autocollimator and optic horizontally: As well as the scale from the HR face, there will be one from the AR face. Use the adjustment on the holder to improve the alignment of the autocollimator with the optic horizontally (still ignore vertical).
7. Set up the reference: Method 1 (for standard metal optical table) - Clamp the optical flat to one of the reference surfaces of the right-angle block. Set up the beamsplitter holder on a post in front of the autocollimator. Set the right-angle block on the holder with the optical flat towards the autocollimator and the other reference surface uppermost. Level the reference surface in both directions with the bubble level (not critical). Method 2 (for granite table) - make sure the granite TRIsquare is sitting snugly on the table. Clamp the optical flat to one of the reference surfaces.
8. Align the reference horizontally: Rotate the reference in yaw until the optical flat is facing the autocollimator as accurately as can be judged by eye. Rotate the autocollimator in pitch until it is as accurately horizontal as can be judged by eye. Look in the autocollimator and continue adjustments in yaw of the reference and pitch of the autocollimator until the scale from reflection of the optical flat on the reference can be seen. (Because of the by-eye alignment in the previous two steps, this should be close in both directions.) Refocus the autocollimator. Continue fine rotation in yaw until the scale is centred horizontally (not critical).
9. (Method 1 only) Level the upper surface of the right-angle block as accurately as possible in pitch with the bubble level. The zeroing of the bubble level should be checked independently beforehand by the usual method of measuring a flat surface and then repeating with the level reversed. Do not reverse the level while it is on the right-angle block - the resulting mechnical perturbation will undo any benefits of the check. Leave the bubble level in place for the next step.
10. Decide the autocollimator angle and check the sense of goniometer adjustment screw: Check the sign of the desired angle of the HR surface in E000028. If the HR surface of the optic is to face upwards, the nose of the autocollimator must dip to point directly at it. Conversely, if the HR surface must point down, the autocollimator must tilt up. Check the sense (clockwise or anticlockwise) of the rotation of the goniometer adjustment screw that is required to tilt the autocollimator by an easily visible amount (a degree or more) in the desired direction.

NOTE: there are two versions of the next step depending on the magnitude of the desired tilt. The autocollimator scale is somewhat more accurate than the goniometer scale and should be used where possible, but the goniometer scale has a larger range and is needed in some cases.

11. Set the autocollimator to the desired angle: CASE I - the magnitude of the desired tilt is within the range of the autocollimator scale (30 minutes). Ignore the scale on the goniometer. Using the goniometer adjustment screw, first centre the autocollimator scale vertically (not critical for Case I). Then, turn the goniometer adjustment screw in the direction established in step 7 until the crosshair indicates the correct magnitude as given in E000028 (critical). CASE II - the magnitude of the desired tilt is outside the range of the autocollimator scale. Set the goniometer stage to exactly zero as indicated on the goniometer scale. Using the vertical adjustment screw on the autocollimator holder, centre the autocollimator scale vertically (critical for Case II). Turn the goniometer adjustment screw in the direction established in Step 7 until the goniometer scale indicates the magnitude of the desired tilt (if the rotation takes the goniometer scale to the positive side of zero, or 360 degrees minus the magnitude of the desired tilt if it moves to the negative side of zero and so wraps around).
12. Remove the reference block.
13. Find the HR scale again: The initial position of the optic will typically put the scale outside the viewfinder. Have an assistant gently touch the optic on the chamfer at top and/or bottom with a gloved finger until the scale from the HR reflection enters the viewfinder. Refocus the autocollimator. Note the direction that the optic needed to be pushed.
14. Adjust the position of the wire standoff to tip the optic in the same direction as above until the scale is visible with the optic hanging freely.
15. Double check the right reflection is being used. Check that the colour is right for the HR reflection. View the optic from the side and double check that the relative tilts of the two faces are correct as near as can be judged by eye (have the correct sign, etc). Have an assistant press with a gloved finger on the face of the optic at the top or bottom to ensure that the AR reflection is where it is supposed to be. For the usual case of a thick-side-up wedge (all optics except RM), the HR face of the optic has to be tilted down to bring the AR reflection into view.
16. Continue fine adjustments until the scale is centred to 0.5 minutes or better (critical).

5.4.3.3 Cementing Wire Standoff

1. Prepare adhesive applicator: Clean copper wire with acetone and isopropanol using a lint-free wipe.
2. Prepare epoxy: Mix the two epoxy components of a Vac Seal “bipax” together thoroughly, approximately 2 minutes. Dispense from the middle of the container into a boat of UHV aluminum foil. Degas the epoxy for 2 minutes.
3. Apply epoxy: Dip conductor wire in epoxy and withdraw it, leaving a tiny amount of epoxy on the wire. Apply epoxy on the wire to the top side and ends of the wire standoff. Apply epoxy to the unglued end of the opposite wire standoff to secure it better.
4. Gently clamp optic: When the optic is balanced, gently move the chamfer stops near the face of the optic, just until contact is made. Make sure that the alignment doesn’t change. (If the optic is fully clamped, the alignment will change upon the adhesive curing.)
5. Cure epoxy: Let the suspension sit for at least 24 hours (72 hours or more if possible).
6. Remove optic: Raise the lower safety stops until they support the optic and take the tension off the wire. Cut

the suspension wire in several places and remove it, taking care not to let it touch the side magnets. Bring in the cradle and back off the lower safety stops so as to lower the optic onto the cradle. Continue removing the optic by the reverse of the above procedure.

7. Inspect, bake and clean optic: Carefully inspect the surface of the optic for cleanliness. Blow the optic with dry, filtered nitrogen. Bake the optic per LIGO-E960022. After baking, clean the optic per E990035, Large Optic and COC cleaning procedures.

5.4.4. Final Preparation

1. Reinstall the optic: Take the clamps off the suspension block and reinstall them backwards so that a fresh surface faces the suspension block. Rehang the optic, using a new length of suspension wire that has been cleaned according to the instructions in 5.4.2 step 5. Use the microscope and bushing to ensure that the magnets line up precisely with the holes in the sensor/actuator brackets. Vertical and roll adjustments are made with the winches. If necessary, large roll adjustments can be made by lifting the optic by hand and rotating it. (Make sure the sensor/actuator heads are well out of the way.) If necessary a small horizontal adjustment can be made by loosening the suspension block and sliding it sideways. The optic may have to be rotated a number of times to position the wire in the same way it was before baking the optic. Check that the wire loop lies in a plane and use the PZT buzzer to reposition it. Even if the wire is not out of place, gently apply the PZT buzzer to the entire length of the wire against the glass so as release any tension.Use the de-ionizing gun on the optic to reduce any influence of static charge on the balance.
2. Check balance using the autocollimator. Double-check using the optical lever. If the pitch has changed by more than about 5 minutes, the side standoffs will need to be soaked off with water and the balancing procedure restarted from section 5.2.1 (skipping the attachment of the magnet/standoff assemblies).
3. Tighten suspension block clamps: Tighten the screws for the bottom suspension block clamps. (This is the first and only time this step should be done. The quality of the clamping at this interface is critical to the mechanical Q of the pendulum and thus the thermal noise. If for some reason it becomes necessary to make further adjustments, the optic should be rehung with fresh wire and fresh clamp pieces.) Tighten the top suspension block clamps. Remove the winches and clip short the excess suspension wire above the clamps. Recheck all clamp screws to make sure the wire is secure.

5.5. Sensor/Actuator Head Installation

- **Materials**

suspension
D960138: Sensor/Actuator Assembly
D970615 PAM Screws
D970501 Magnets
Perkin Elmer Vac-Seal epoxy resin
D990675: Sensor/actuator Pigtail, Long
D990676: Sensor/actuator Pigtail, Short
solvents: acetone, and isopropanol or methanol

NOTE: BSC chamber installations use long (3’) pigtails, HAM chamber intallations use short (2’) pigtails.

- **Assembly**

1. Prepare the sensor/actuator heads and cables: Clean the assemblies along with the cables per LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures, LIGO-E960022.
2. **Check the position of the safety and chamfer stops. A gap of 1mm must be maintained to protect the magnet/standoff assemblies during this procedure**.
3. Mount the sensor/actuator heads: Check that #10-32 set screws in the threaded holes that will hold the sensor/actuator assemblies in place are flush with the inside diameter of the sensor/actuator assembly mounting hole in the sensor/actuator bracket. Make sure that the optic/dummy mass is fully clamped. Mount the sensor/actuator assemblies in the proper configuration. Slowly, slide the sensor/actuator assemblies into the holes in the bracket until about 2mm of sensor/actuator assembly protrudes beyond the back of the sensor/actuator brackets. The pigtails should be at the top side of the upper OSEMS and the lower sides of the lower OSEMS.
4. Connect the sensor/actuator assemblies to the test stand. The orientation and order for plugging the pigtail connectors into the DB25 connectors is given in Fig. 2.

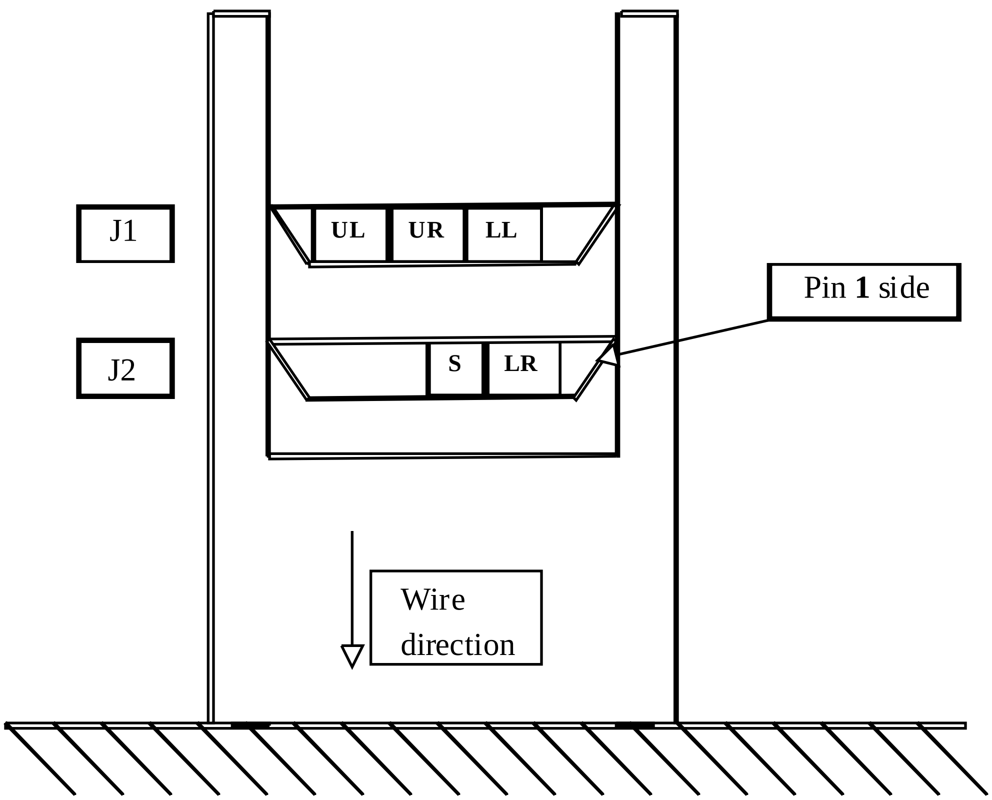

Figure 2: Sensor/actuator connections for the test stand, looking into the DB25 connectors. The small connectors are oriented so that the pigtail wires leave from the bottom.

5. Position the sensor/actuator assemblies: Using an oscilloscope, position each sensor/actuator assembly with respect to the magnet/standoff assembly on the optic such that the magnet shadows the photodiode and pro-

duces 60% of the unblocked voltage (measured earlier). Make fine adjustments in roll of the assembly until the screws in the back of the assembly are level in height, as nearly as can be judged by eye. After each adjustment in either position or roll, rock the assembly back and forward on the rails in the brackets until it settles snugly. Check visually that there is a full line of contact between the rails and the body of the assembly. Use the set screws to clamp the sensor/actuator assemblies in their optimum positions.

6. Install the PAM screws: Check that the sensor/actuator assemblies damp properly and that critical damping may be achieved. Screw the assembled PAM screws into the back of the sensor/actuator assemblies until the distance from the ceramic body of the assembly to the underside of the PAM screw head is 0.85”.
7. Adjust the PAM screws to correct for any pitch error shown by the autocollimator and optical lever.
8. Iterate: Correcting a pitch error with the PAM screws will move the optic magnets away from their optimal positions relative to the sensor/actuator assemblies. However moving the sensor/actuator assemblies to correct for this will move the PAM magnets and perturb the position of the optic. Repeat steps 5 and 7 at least once or until convergence is adequate. Note the final photodiode voltages and pitch angle in the Process Traveler.

5.5.1. Measure resonant frequencies

5.5.1.1 Materials

spectrum analyzer, e.g., Stanford Research Systems, SRS785

5.5.1.2 Measurement

1. Connect the spectrum analyser to the satellite box test output for a face sensor/analyzer assembly.
2. Turn off the damping.
3. Do a power spectrum with a start frequency of approximately 0.4 Hz and a stop frequency of 1.0 Hz. There should be three peaks corresponding to the pitch, yaw and pendulum modes at roughly the frequencies given for the optic in the table in T970158. Record the frequencies in the Process Traveler. If there are any major discrepancies, especially in the pitch frequency, investigate the position of the wire standoff and guide rod.
4. Do a power spectrum with a start frequency of around 10 Hz and a stop frequency of around 14 Hz. Look for a peak corresponding to the vertical mode at the frequency given in T970158. Record the vertical mode frequency in the Process Traveler.
5. Do a power spectrum with a start frequency of around 15 Hz and a stop frequency of around 19 Hz. Look for a peak corresponding to the roll mode at a frequency approximately sqrt(2) times that of the vertical mode. Record the roll mode frequency in the Process Traveler.
6. Connect the PZT buzzer to the source of the spectrum analyser.
7. Do a swept sign measurement from around 300 to 350 Hz with the tip of the PZT buzzer pressed gently against one of the wire locating pins of the suspension block. Look for a peak (or a cluster of very closely spaced peaks) due to the violin mode of the wires. Ignore peaks at multiples of 60 Hz. Record the violin mode frequency in the Process Traveler.

5.6. Prepare for installation in chamber

5.6.1. Materials

HeNe laser: Uniphase Model 1108P (1 mW)
HeNe/Autocollimator mount: Newport UML-TILT
optical lever quad photodiode: On-Trac Photonics Inc. Model PSM2-100 & controller.
oscilloscope with XT mode

5.6.2. Immobilize optic

1. Damp the optic using the SUS controller.
2. Set up an optical lever using the HeNe laser and quad photodiode. Using a single bounce off of the front HR surface of the optic with the HeNe beam, center the reflected beam onto the quad diode receiver.
3. Set up the oscilloscope in XY mode so that pitch of the optic is vertical on the screen and yaw is horizontal. Use a scale setting of <500mV sensitivity for accuracy. Place the oscilloscope where it is easily viewed by the person adjusting the safety stops.

NOTE: When performing the next steps, be sure to watch that the magnets do not make contact with the OSEM interior walls.

4. Screw in the bottom safety stops so as to make light contact with the optic. (As these have large diameter Teflon tips they will have a lot of influence on steering the optic, but it is necessary that they give adequate optic support for transportation and placement.)
5. Screw in the eight chamfer stops to touch the optic. While viewing the screen, maintain the optic alignment by adding or reducing small amounts of pressure from the chamfer stops.
6. Clamp the top safety stops.
7. Continue to tighten all the stops by tiny increments, maintining the alignment, until the optic is held firmly.
8. Verify the final position has not changed using the autocollimator.

5.6.3. Wrapping

1. Wrap the structure in UHV foil. Keep it in a laminar flow hood until it is ready to be installed.

5.7. Installation

The procedure for the installation of the optic in the chamber is given in E000061 (for HAM chambers) or E000062 (for BSC chambers).