TITLE
SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

APPROVALS:	DATE	REV	DCN NO	BY	CHK	DCC	DATE
DRAWN: J. Hazel Romie	8-21-98	A	E980228-00-D	n/a	n/a	n/a	n/a
CHECKED:							
APPROVED:							
DCC RELEASE:							

1. Introduction

1.1 Objectives and Scope

The objectives and scope of this document is to specify how to identify, prepare and assemble a Small Optics Suspension. This document also details how to prepare an optic for installation into the suspension structure and how to hang and balance that optic.

1.2 Applicable Documents

LIGO-D960001	Small Optics Suspension Assembly
LIGO-E960022	LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures
LIGO-T960074	Suspension Preliminary Design
LIGO-T950011	Suspension Design Requirements
LIGO-T970135	Small Optics Suspension Final Design (Mechanical System)
LIGO-L970196	Part Numbers and Serialization of Detector Hardware
LIGO-E970080	Small Optic Suspension Assembly Quality Conformance Worksheet

1.3 Requirements

1.3.1 Physical Configuration

According to LIGO-D960001 Small Optics Suspension Assembly

1.3.2 Identification

Assembly part number and serial number to be marked on the top of the base of the assembly, [detail part name, Tower Base, P/N D960004] with laser marking or acid etch techniques. The marked area shall be cleaned thoroughly after marking with the appropriate solvents listed in the LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022.
Machined piece parts of the assembly shall be marked and serialized according to the document titled Part Numbers and Serialization of Detector Hardware, LIGO-L970196. This document allows for “bag-and-tag” type of identification.

Serial Number
The Serial number shall be of the format:
Dxxxxxx-x S/N *nnn* Where
Dxxxxxx-x is the LIGO piece part or assembly drawing number, including the revision letter to which the

hardware item was built, and
nnn is the sequential serial number, 001 through 999 in the order produced.

1.3.3 Quality Assurance Provisions

A first article fabrication and assembly shall be inspected for form and fit and workmanship. An inspection report shall be issued using JPL inspection report form, U.S. Government Printing Office 1995-680-304. These forms may be provided by LIGO.
Measure the strength of the magnets using an F. W. Bell Model 9200 Portable Gaussmeter with a Gaussmeter Probe, P/N HTB92-0608 and the Magnet Strength Fixture, P/N D970169, -1 for magnet testing. Collect 8 magnets that have comparable strengths, to within +/- 5%, record the manuf. name, P.O. number, serial/lot number, magnet strength of each magnet and set them aside for one suspension.
Inspect the mechanical parts of the Small Optic Suspension to their respective drawings for the following dimensions, detailed in Appendix A.
Inspect the mechanical parts of the fixtures for the Small Optic Suspension to their respective drawings for the following dimensions, detailed in Appendix B.
To ensure Quality Conformance for the assembly, complete and file the Small Optic Suspension Assembly Quality Conformance Worksheet, E970080-00-D, and keep it with the traveler record for the assembly.

1.3.4 Cleaning and Baking

All procedures in this document must be performed while suited up in clean room clothing including, but not limited to: coat, booties, bonnet, gloves, facial mask. The assembly to be cleaned and baked in preparation for installation according to LIGO-E960022, LIGO Vacuum Compatibility, Cleaning Methods and Qualifications.

2. Fixtures

D961412	Set Screw Tool
D970074	Magnet-to-Dumbbell Standoff Fixture
D960020	Magnet/Standoff Assembly Fixture
D960022	Guide Rod Fixture Assembly
D960017	Base Plate
D970066	Right Block, Top
D960018	Left Block, Top
D960159	SOS Dummy Mass
38427	Edmund Scientific, Pocket Measuring Microscope
D960016	Microscope Bushing
	PZT Buzzer
D950126	LED Fixture
D970181	Bracket, SOS Optic Cleaning
D970180	Winch Fixture

D970314 Winch Adapter Plate, SOS

Set Screw Tool Used to ease in the installation of the spring plungers in the Sensor/Actuator Plates.
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 of the optic.
Guide Rod Fixture Used to position and bond a guide rod, a wire standoff and side magnet/standoff assemblies to the side of the optic. This fixture is made up of three separate parts, listed above.
SOS Dummy Mass Used for the prototype test. This aluminum "optic" has the same size, wedge, chamfer and approximate mass as the fused silica optic.
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 bore of the measuring microscope and used to adapt the bore of the microscope to the bore of the holes for the sensor/actuator head assemblies in the sensor/actuator plates. This bushing is also used to align the centerline of the microscope (crosshairs) to the centerline of the outside diameter of the bushing.
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.
LED Fixture Used to position and mount the LED relative to the photodiode in the sensor/actuator head. Use of this fixture will be covered in another document
Bracket, SOS Optic Cleaning Used as a replacement to the Upper Mirror Clamp. It is used when cleaning the optic because it allows for drag wiping. Use of this fixture will be covered in another document.
Winch Fixture Used to microposition the suspension wire vertically.
Winch Adapter Plate, SOS Allows for use of the winch fixture by bolting onto the top of the suspension block

3. Assembly Procedure

3.1 Suspension Structure Assembly

Screw together the Tower Base, Left Side Plate, Right Side Plate, Stiffener Plate and the Suspension Block using the hardware specified on the assembly drawing and to the torques specified in the notes. Screw the Lower Clamp and Lower Clamp, Opposite into place. Mount the four Safety Stop, Conductive, Small into the Clamps until they protrude above the clamps by about .25"[6.4mm]. Install the Safety Stop, Conductive screws into the Clamps so they also protrude beyond the bracket by about .25"[6.4mm].
Position the two Sensor/Actuator Plates in place and torque the screws finger tight. Screw in the two Safety Stop, Conductive, Long into the Sensor/Actuator Plates until they protrude past the plates by about .50"[12.7mm]. Install the spring plungers, or the alternate socket head set screws, into the Sensor/Actuator Plates in preparation for the installation of the Sensor/Actuator Assemblies. The Set Screw Tool may be used with the cross head spring plungers instead of a regular screw driver. Install the Safety Stop, Conductive screws

into the Upper Mirror Clamp then set it aside until the mirror is suspended.

3.2 Optic Preparation

3.2.1 Magnet-to-Dumbbell Standoff

Materials:
D960501 Magnet
D970075 Dumbbell Standoff
Perkin Elmer Vac-Seal epoxy resin
D970074 Magnet-to-Dumbbell Standoff Fixture
solvents; methanol, acetone, isopropyl alcohol
6" length of 20 to 30 ga insulated wire
800 grit sandpaper
cellophane tape
oil-free aluminum foil
lint-free wipes
microscope
ultrasonic agitator

Adhesive Procedure

1. Prepare magnets and standoffs: Clean 8 magnets and 8 standoffs, separately, per LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures, LIGO-E960022. Lightly sand both ends of each magnet with 800 grit sandpaper. Use cellophane tape to remove the grit. Using a microscope, examine the sanded magnet ends to make sure that all grit has been removed. Clean the magnets in an ultrasonic agitator with acetone. Check the ends of the standoffs under the microscope to make sure that each surface is clean, flat and without burrs. If a surface looks unsatisfactory, follow the magnet sanding instructions for both ends of the standoffs.
2. Prepare applicator: Strip off about 0.5"[12mm] of insulation from the wire. Splay conductors and clip off all but one. Clean conductor with acetone and alcohol using a lint-free wipe.
3. Prepare epoxy:Mix the two epoxy components of a Vac Seal "bipax" together thoroughly, approximately 2 minutes. Dispense from the middle of the container onto clean oil-free aluminum foil.
4. Install magnets in fixture: Insert eight magnets into the magnet-to-dumbbell standoff fixture after it has been cleaned thoroughly with methanol and acetone. The magnets have to be positioned on the optic so that their polarities are alternated. Make five magnet/standoff assemblies of one polarity and three of the other polarity. The easy way to do this is to line up the eight magnets to be used with this fixture. Insert five magnets in five holes and then turn the magnets in your hand 180 degrees, and then insert the last three in the remaining holes. Using Table 1 in the QC Worksheet, D970080, note which magnets are which polarity. A "Master Magnet" may be used to determine polarity. Simply mark the ends of a magnet with a "+" on one end and a "-" on the other end using paint or nail polish.
5. 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 end of a standoff. Optimum adhesive thickness is 0.003" [.08mm] or a volume of 3.9×10^{-6} in^3 [$.06mm^3$]. Epoxy should only cover a diameter of about .02" [.5mm] with a height of

.01"[.3mm]. Insert standoff carefully into fixture, making sure not to get adhesive on fixture. Repeat this for seven remaining standoffs. Lightly tap the standoffs against the magnets.

6. Cure epoxy: Leave the assembly for 24 hours or more. Vac Seal cures in 72 hours so if that time is available, it should be used to allow the assemblies to fully cure.
7. Remove from fixture: Use a blunt, clean instrument to tap the magnets and remove the assemblies. Take care to move each assembly away from the fixture after loosening. Move the assemblies onto a clean, flat plate. **Take great care when handling these glued assemblies as they are extremely fragile.**
8. Ultrasonic clean assemblies: Place plate with assemblies into an ultrasonic agitator filled with isopropyl alcohol for 10 minutes.

3.2.2 Magnet/Standoff Assembly Fixture

Materials:

8 magnet/dumbbell standoff assemblies, from instructions above.
Perkin Elmer Vac-Seal exoxy resin
D970020 Magnet/Standoff Assembly Fixture
D960017 Base Plate of Guide Rod Fixture Assembly
D960159 SOS Dummy Mass or Optic
Kapton film, 0.0075" thick
solvents; methanol, acetone, isopropyl alcohol
6" length of 20 to 30 ga insulated wire
oil-free aluminum foil
lint-free wipes

Fixture Assembly

1. Clean guide rod fixture: Clean base plate and magnet/standoff assembly fixture thoroughly per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022.
2. Clean optic: Clean optic thoroughly to remove heavy contamination per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022. Care must be taken to clean the outside diameter of the optic.
3. Position optic on fixture:Make sure that the Kapton strips on the base plate are securely in place to protect the bottom face of the optic. If Kapton film is missing, cut three small strips (.25 x .50") and place on the etched circle in the base plate. Place the optic or dummy mass onto the base plate with the side up that will have the magnet/standoff assemblies epoxied to it. Configure the optic such that its outer diameter lines up evenly with the circle etched onto the base plate. This fixture is appropriate for an optic with a horizontally configured wedge of 30 minutes or less as the center of mass shift is not included in the guide rod fixture positioning calculations. Using the arrow on the side of the optic, rotate the optic until the arrow lines up with the horizontal and/or vertical lines of the base plate, whichever is appropriate for the positioning of the optic with respect to the face magnets.
4. Prepare the magnet/standoff fixture: Clean the magnet/standoff assembly fixture per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022. Make sure the two #4-40 screws that hold the two pieces of the fixture together are in place and tightened. Install the three #10-32 set screws on the side of the bottom piece of the fixture (called the holding ring) until the tips are flush

with the inside diameter of the holding ring. Position the two screws with knobs so that the tip of the screws just touch the holding ring. Mark a line on the top of each knob from the centerline to the outside diameter to determine initial rotation position. The lines on the knobs should be parallel to each other.

5. Mount the magnet/standoff fixture: Carefully lower the magnet/standoff assembly fixture onto the face of the optic such that the top piece of the fixture (called the positioning ring) registers onto the top surface of the optic. Align the lines on the outside diameter of the fixture with the etched lines on the side of the optic. Using the three side set screws, position the fixture such that its centerline is coincident with the centerline of the optic as close as possible. This is done by incrementally advancing the set screws. Make sure that the fixture doesn't slip from its alignment with the lines on the optic. Using 4-40x1.25 socket head cap screws, replace the shorter 4-40 screws and attach the magnet standoff assembly to the base plate of the guide rod fixture.
6. Prepare adhesive applicator: Strip off about.5"[12mm] of insulation from the wire. Splay conductors and clip off all but one. Clean conductor with acetone and alcohol using a lint-free wipe.
7. Prepare epoxy: Mix the two epoxy components of a Vac Seal "bipax" together thoroughly, approximately 2 minutes. Dispense from the middle of the container onto clean oil-free aluminum foil.
8. 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 end of a standoff. Optimum adhesive thickness is.003" [.08mm] or a volume of 3.9×10^{-6} in^3 [$.06mm^3$]. Epoxy should only cover a diameter of about .02" [.5mm] with a height of .01"[.3mm]. Insert standoff carefully into fixture, making sure not to get adhesive on fixture. Repeat this for three more magnet/standoff assemblies. Make sure that the magnet's poles are in opposite configuration to the magnet next to it in the circle. For example, see Figure 1 below. Lightly tap the top of the magnets. The magnets are placed so that polarities of the magnets alternate; this is to prevent the mass from being shaken in position and orientation, by time-varying ambient magnetic fields.
9. Cure epoxy: Leave the assembly for 24 hours or more. Vac Seal cures in 72 hours so if that time is available, it should be used to allow the assemblies to fully cure.
10. Remove the magnet/standoff fixture: After curing, remove the two #4-40 screws that hold the positioning ring to the holding ring. Incrementally turn the knobs of the two #10-32 screws, at the same time, so that the positioning ring slowly rises above the holding ring without tilting. When the positioning ring has cleared the magnet/standoff assemblies, carefully set it aside and again, carefully, remove the holding ring from the optic. Maintain the position of the optic on the base plate as it will need to be in this position for the guide rod fixture assembly procedures, below.

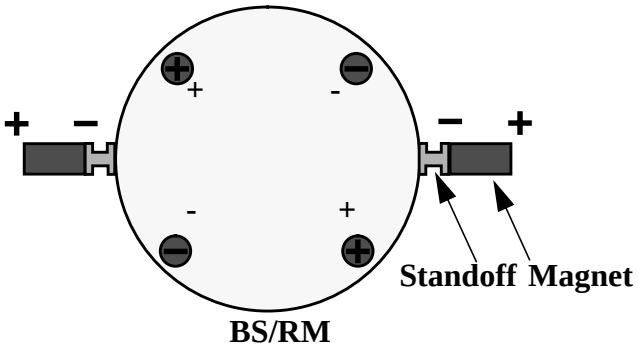

Fig. 1. Configuration of the magnet/standoff Assembly.

3.2.3 Guide Rod Fixture

Materials:
SOS Dummy Mass or Optic with four magnet/standoff assemblies glued to its face
2 or more magnet/standoff assemblies of the same pole configuration
D970188 Guide Rod
D970187 Wire Standoff
Perkin Elmer Vac-Seal exoxy resin
D960022 Guide Rod Fixture Assembly - which includes:
D960017 Base Plate
D960018 Left Block, Top
D970066 Right Block, Top
solvents; methanol, acetone, isopropyl alcohol
6” length of 20 to 30 ga insulated wire
oil-free aluminum foil
lint-free wipes

Fixture Assembly

1. Check optic alignment: Check to make sure that the optic or dummy mass is centered in the etched circle on the base plate of the guide rod fixture. If the parts are separate, review step #2 of the magnet/standoff fixture assembly, above. Check the outside diameter of the optic for cleanliness. If marks are apparent, clean it with the appropriate solvent and lint-free wipes. Take care to keep solvent away from the epoxied magnet/ standoff assemblies.
2. Prepare fixture and parts: Clean the blocks of the guide rod fixture thorougly per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022. Clean and bake the guide rod and wire standoffs per the same specification.
3. Align optic in fixture: Carefully slide the two top pieces; left block, top and right block, top along the wedges of the base plate. Snug them up against the side of the optic. Notice the step in the top blocks. The

wall that denotes that change in height (the step) should be aligned with the etched arrows on the side of the optic or dummy mass. Do not use the v-grooves for alignment, only the vertical wall. Once this alignment is made, tighten the screws that hold the top blocks to the base plate. Tighten down all the screws to finger tightness.

4. Check polarity of magnets: Check that the magnet/standoff assemblies that will be used with this fixture are of the same pole configuration (i.e. the positive pole is glued to the standoff) as shown in Figure 1.
5. Prepare adhesive applicator: Strip off about.5" [12mm] of insulation from the wire. Splay conductors and clip off all but one. Clean conductor with acetone and alcohol using a lint-free wipe. If using an adhesive applicator that was previously used, be sure to clean off all old, cured adhesive.
6. Prepare epoxy: Mix the two epoxy components of a Vac Seal "bipax" together thoroughly, approximately 2 minutes. Dispense from the middle of the container onto clean oil-free aluminum foil.
7. 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 conductor 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 magnet/standoff assembly. Be sparing in epoxy at this point as more glue will be used later to secure these guide rod. Take care in not getting epoxy on the fixture. Position a wire standoff in the vertical v-groove on the other block. Dip conductor 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 wire standoff and the optic that is furthest away from the magnet/standoff assembly. Be sparing in epoxy at this point as more glue will be used later to secure this guide rod. Take care in not getting 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.
8. Glue the magnet/standoff assemblies: Dip conductor wire in epoxy and withdraw it, leaving a tiny amount of epoxy on the wire. Apply epoxy on the wire to the standoff end of a magnet/standoff assembly. Optimum adhesive thickness is.003" [.08mm] or a volume of 3.9×10^{-6} in^3 [$.06mm^3$]. Epoxy should only cover a diameter of about .02" [.5mm] with a height of .01"[.3mm]. Push magnet/standoff assembly slowly and carefully along the larger horizontal v-groove, making sure not to get adhesive on fixture. Repeat this for the magnet/standoff assembly on the other side of the optic. Lightly tap the end of the magnets.
9. Check adhesive joints: Look through the optic at the four glue joints and make sure that the contact areas are visible.
10. Cure epoxy: Leave the assembly for 48 hours or more. Vac Seal cures in 72 hours so if that time is available, it should be used to allow the assemblies to fully cure.
11. 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 and out of the way of the magnet/standoff assemblies and the guide rod and wire standoff.

3.3 Optic Hanging and Balancing

Materials

Optic or dummy mass with 6 magnet/standoff assemblies and 1 guide rod and 1 wire standoff glued to it.

TITLE
SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

SOS suspension structure
.0017" diameter suspension wire
D970187 wire standoff
D970180 Winch fixture
D970314 Winch adapter plate, SOS
HeNe laser
Quad photodiode
Table level
Perkin Elmer Vac-Seal epoxy resin
6" length of 20 to 30 ga insulated wire
oil-free aluminum foil
lint-free wipes
38427 Edmund Scientific, Pocket Measuring Microscope
D960016 Microscope Bushing
PZT Buzzer
solvents: methanol, acetone

Assembly

1. Prepare the wire standoff and suspension wire: Clean and bake the other wire standoff per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022. The suspension wire should not be baked - only cleaned. Be sure to clean the wire thoroughly by wrapping a solvent 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 contaminents.
2. Make an optical lever: Level the optical table that's being used for this suspension work, using a mechanical bubble type level, within +/- 0.05 mrad. Set up an optical lever, using a small HeNe laser and a quad cell photodiode, and level the beam within +/- 0.05 mrad. This is done by placing the photodiode near the output of the laser and then moving the photodiode down the table and measuring the angular displacement of the beam. Make the lever arm as long as possible to increase the accuracy of the alignment.
3. Prepare the winch fixture: Screw the winch adapter plate, SOS to the top of the suspension block using 2 clean 1/4-20x.50 screws and 1/4-20 washers in the through holes of the adapter plate. The threaded holes of the adapter plate should be farthest from the dowel pins of the suspension block. Line up the front of the suspension block with the front of the adapter plate. Using oversize washers and a 1/4-20x1.25" long screw, attach the winch to one of the threaded holes in the adapter plate with the rocker of the winch closest to the front of the suspension block. Attach one suspension block clamp to the suspension block with its screws tightened finger tight. Attach the other suspension block clamp to the face of the winch, tightening the screw finger tight. Attach the wire clamp to the suspension block with its screws, leaving the clamp loose.
4. Thread the wire around the optic: Carefully place the optic or dummy mass on the conductive teflon safety stops in the suspension structure. Screw the Upper Mirror Clamp, with its safety stops, into position. Clean the suspension wire again if it has not been done within an hour or so beforehand. String the wire from the suspension block down and around the optic and then back up to the suspension block. Clamp one wire end under the wire clamp and then under the suspension block clamp. Tighten the screws of the suspension block clamp. Thread the wire such that they are touching the inside of the dowel pins on the front of the sus-

pension block. In the process of threading the wire, be sure to keep the wire clear of the magnets as the wire is magnetic. Make sure that the wire sits in the v-groove of the wire standoff. Thread the other side under the wire clamp and then against the dowel pin and then clamp the end under the winch's clamp. The purpose of the wire clamp at this point is only to keep the wire against the face of the suspension block. Again, check to make sure that the wire is being aligned by the dowel pins.

5. Suspend the optic: Position the wire such that it is slightly taut by threading in or backing off of the winch's 1/4-20 screw. By eye, align the centerline of the magnets with the centerline of the holes in the sensor/actuator plates. Insert a wire standoff below the guide rod, making sure that the wire sits in the v-groove of the wire standoff. Slowly, lower the safety stops that support the bottom of the optic and suspend the mass. Try backing off the face safety stops to determine which direction the wire standoff needs to be slid along the guide rod to balance the optic/dummy mass. Use the PZT buzzer to micro-position the wire standoff so that the optic/dummy mass will hang stationary. When repositioning the wire standoff, be sure to clamp the optic/dummy mass with the safety stops. Again check the position of the optic making sure that the centerlines of the magnet/standoffs on the face of the optic line up with the centerline of the holes for the sensor/actuator head assemblies in the sensor/actuator plates. Adjust the height of the optic with the winch if necessary. Check often that the wire is still in the grooves of the wire standoffs
6. Balance the optic:Using the optical lever, balance the optic such that the unbalance is **within +/- .5 mrad**. Test the balance by rotating the mass around the optical axis. Before rotating the optic, be sure to move the safety stops below the optic into position such that the optic is lightly supported by these stops. This will allow the wire to loosen a bit when the optic is rotated. After rotating the optic a number of times to check the balance, gently move the face safety 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.
7. Prepare adhesive applicator: Strip off about .5" [12mm] of insulation from the wire. Splay conductors and clip off all but one. Clean conductor with acetone and alcohol using a 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 onto clean oil-free aluminum foil.
9. 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.
10. Cure epoxy: Let the suspension sit for 72 hours or more.
11. Inspect, bake and clean optic:If balancing an optic (rather than a dummy mass) for installation into an interferometer, remove the optic from the suspension being careful not to break off the magnet/standoff assemblies or the guide rods or wire standoffs in handling. Try not to break the suspension wire upon removal of the optic. Carefully inspect the surface of the optic for cleanliness. If the optic exhibit contaminents, clean for light contamination per LIGO-E960022. Care should be taken to keep the solvents away from all glue joints as acetone will dissolve Vac Seal. Bake the optic per that same specification. After baking, clean the optic for light contamination per LIGO-E960022 to remove outgassing contaminents from the epoxy.
12. Re-install the optic: Rehang the optic, with the same suspension wire, and make sure it is has maintained its balance using the optical lever.
13. Mount microscope bushing to microscope: Align the centerline of the microscope to the centerline of the microscope bushing. To do this, start by mounting the bushing onto the microscope bore as evenly as pos-

sible, using one row of set screw holes. Position the bushing in an optical mount so that the other row of set screws is accessible. Mount a fiber optic beam delivery cable, connected to a high intensity lamp, into another optical mount and position it so that the light passes through the microscope and illuminates the cross hairs at the focal length. Remember that this type of microscope will show an inverted image. Use a piece of paper, mounted on a flat vertical plate, to image the cross hairs at the focal length. Slowly rotate the microscope to determine the magnitude of the displacement between the centerline of the microscope cross hairs and the centerline of the bushing outer diameter. Using the accessible set screws, reduce the displacement as much as possible between the two centerlines. Use a treadlocker or tape on/around the adjustment set screws to indicate that this alignment has been performed.

14. Use microscope to position sensor/actuator plates: Mount the bushing/microscope assembly into one of the holes for the sensor/actuator head assembly in the sensor/actuator plate and view the position of the magnet relative to the position of the sensor/actuator plate. Insert the bushing/microscope in the hole next to it and determine the position of the magnet/standoff assembly relative to the sensor/actuator plate. Adjust the position of the plate, by unscrewing the mounting hardware, if required, so that the magnet/standoff assemblies are aligned as much as possible with the sensor/actuator plates. Remember that the image in the microscope is an inverted image. Perform this same operation for the other sensor/actuator plate.
15. Check balance: Determine if this alignment is satisfactory by assuming a maximum vertical positional offset is 500 microns and the maximum horizontal offset is 300 microns. These offset assumptions are valid for a sensor/actuator head assembly that has the LED and photodiode oriented vertically. If the optic is still misaligned vertically from the sensor/actuator plates, use the winch to adjust its vertical position. If the optic is misaligned rotationally, prop it up with the safety stops under it, and gently rotate. 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.
16. Tighten suspension block clamps: Tighten the screws of the wire clamp. Install the second suspension clamp and tighten its screws. Tighten the screws of the other suspension clamp. Remove the winch and the winch adapter plate.

3.4 Sensor/Actuator Head Installation

Materials:

Suspension
D960011 Sensor/Actuator Assembly
D970073 Sensor/Actuator Pin Plate
Kapton sensor/actuator cables
D970084 Connector Bracket Assembly
solvents; methanol, acetone, isopropyl alcohol
solder and flux
deflux spray

Assembly

1. Prepare the sensor/actuator heads:Install the sensor/actuator pin plates on the back side of the sensor/actuator heads. Clean the assemblies along with the cables per LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures, LIGO-E960022.
2. Mount the sensor/actuator heads: Install the 4 cleaned and baked #10-32 set screws or spring plungers in the threaded holes that will hold the sensor/actuator assemblies in place until they are flush with the inside

diameter of the sensor/actuator assembly mounting hole in the sensor/actuator plate. Mount the sensor/actuator assemblies in the proper configuration, making sure that the optic/dummy mass is fully clamped. Slowly, slide the sensor/actuator assemblies into the holes in the plate until about 2mm of sensor/actuator assembly protrudes beyond the back of the sensor/actuator plates.

3. Optimally position the heads: Using an oscilloscope, optimally position the sensor/actuator assemblies with respect to the magnet/standoff assemblies on the optic. This is done by measuring the voltage of the unblocked photodiode and then positioning the sensor/actuator head such that the magnet shadows the photodiode and produces half of the unblocked voltage.
4. Check for 12 Hz spike:The vertical resonant frequency of the wire is about 12 Hz. The orientation of the LED/photodiode pair in each sensor/actuator head affects the magnitude of this resonance's coupling into the pitch and yaw resonant frequencies. While moving the sensor/actuator head assemblies near the magnets on the optic, check the orientation of the sensor/actuator head assemblies. Generally, the optimum position is near to vertical, in that the photodiode is directly over the LED in a vertical orientation, as shown in Figure 2 below. If the oscilliscope shows a sharp spike around 12 Hz., slowly rotate the head assembly until the spike is at a minimum. Generally this is within 20 degrees of the vertical.
5. Clamp the heads and check safety stop gap:Use the set screws to clamp the sensor/actuator assemblies in their optimum positions. **Always check the position of the safety stops as a gap of 1mm must be maintained to protect the magnet/standoff assemblies during this procedure**.
6. Check sensor/actuator head electronics: Check that the sensor/actuator assemblies damp properly and that critical damping may be achieved.

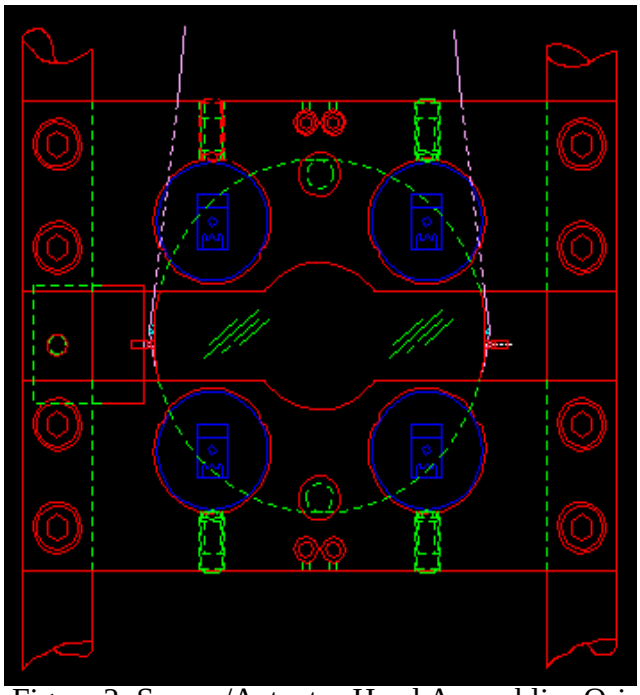

Figure 2: Sensor/Actuator Head Assemblies Orientation

APPENDIX A

D960002 Sensor/Actuator Plate	
zone	dimension (in)
C1	2X,.375
C1	2X,1.25
D2	1.715
D2/3	3.66
C3	2X,1.028
check for all vent holes	

D960003 Suspension Block	
zone	dimension (in)
A1	2X,1.080
B1	2X,.360
B1	4X,.375
B2	(2X) .348
C/D2	(2X).219
C/D3	(2X).406
C/D3	(2X)2.062+/-.002
check for all vent holes	

D960004 Tower Base	
zone	dimension (in)
B2	2X,1.313
B2	2X,.812
C2	2X,1.624
C2	6X,.562
C1	4.125+/-.002
D2	.375

D960005 Right Side Plate	
zone	dimension (in)
A2	6.750
A3	5.875
A3	4.375
A3	3.500
A4	4X,.312
B4	5X,.438
B/C4	1.125
C4	1.250
C4	5X,2.062
C1	1.420
C1	2.140
C1	15.280
check for all vent holes	

D960006 Left Side Plate	
zone	dimension (in)
D3	6.750
D3	5.875
D3	4.375
D3	3.500
C4	4X,.312

D960006 Left Side Plate	
zone	dimension (in)
B4	5X,.438
B4	1.125
B4	1.250
B4	5X,2.062
B1	1.420
B1	2.140
A/B2	15.280
check for all vent holes	

APPENDIX B

D970074 Magnet-to-Dumbbell Standoff Fixture	
zone	dimension (in)
B3	25X,DIA.077+.002/-.000

D960020 Magnet/Standoff Assembly Fixture, Sheet 2, Positioning Ring Detail	
zone	dimension (in)
A1	3.500 DIA BOLT CIRCLE

TITLE
SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

D960020 Magnet/Standoff Assembly Fixture, Sheet 2, Positioning Ring Detail	
zone	dimension (in)
B1	1.945 +/-.001
C2	1.945 +/-.001
A3	90 DEG. APART
A4	.077 DIA +.004/-.000,4PL
B4	3.000 DIA +.005/-.000

D960020 Magnet/Standoff Assembly Fixture, Sheet 3, Holding Ring Detail	
zone	dimension (in)
A2	3.500 DIA BOLT CIRCLE
A3	90 DEG. APART

D960017 Base Plate	
zone	dimension (in)
D1	.105
D2	2X,.094 DIA
C2/3	.885 +.000/-.001
D3	1.500
D6	1.500
D/E6	.885 +.000/-.001
D6	2X,.094 DIA

TITLE
SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

D960017 Base Plate	
zone	dimension (in)
D7	.105

D970066 Right Block, Top	
zone	dimension (in)
B1	2X, 60 DEG
B1	1.500
C2	.125
C1	2X,.094 DIA
C1	.518 +.001/-.000
A/B2	.750
B3	.112
B3	.075
A4	.095
A4	.108
C4	.047

D960018 Left Block, Top	
zone	dimension (in)
C1	1.500
C2	2X,.094 DIA
C2	.518 +.001/-.000

D960018 Left Block, Top	
zone	dimension (in)
D1	.125
B3	.750
B4	.068
B4	2X,.054
B4	.143
A4	.065
C4	.025 +/-.002