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DOCUMENT CHANGE NOTICE (DCN)

DCN No. E010171-00-D
SHEET 1 OF 1
9/17/01

DOCUMENT No. (DOC-REV-GP. ID)	TITLE	NEW REV.
LIGO-E970037-C-D	Small Optic Suspension Assembly Specification	D

CHANGE DESCRIPTION (FROM/TO):

Section 3.1: Added a note about the orientation of the Wire Clamp attachment to the Top Suspension Block. This is an important step that was left out of the document.

REASON FOR CHANGE: Updated for Detector Installation

ACTION: ☒ Incorporate change ☐ Attach DCN to drawing(s) ☐ Other action (specify):

DISPOSITION OF HARDWARE (IDENTIFY SERIAL NUMBERS)

- ☒ No hardware affected (record change only)
- ☐ List S/Ns which comply already:
- ☐ List S/Ns to be reworked or scrapped:
- ☐ List S/Ns to be built with this change:
- ☐ List S/Ns to be retested per this change:
- ☐
- ☐
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X J. Hazel Romie
X D. Ottaway

SAFETY, COST, SCHEDULE, REQUIREMENTS IMPACT? ☒ No ☐ Yes (If yes, enter Change Request number)

APPROVALS:		DATE	OTHER APPROVALS (specify)	DATE
ORIGINATOR:	J. Hazel/Romie	9-24-01		
TASK LEADER:	B. Weaver	9/18/01		
GROUP LEADER:	S. Whitcomb	9/19/01		
DCC RELEASE:		9/25/01		

TITLE

SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

APPROVALS:		DATE
DRAWN:	J. Hazel Romie	8-21-98
CHECKED:	J. Hazel Romie	1-4-01
APPROVED:		
DCC RELEASE:		

REV	DCN NO	BY	CHK	DCC	DATE
A	E980228-00-D	n/a	n/a	n/a	n/a
B	E010004-00-W	n/a	n/a	n/a	1/4/01
C	E010071-00-D	JHR			4/18/01
D	E010171-00-D	BW			9/

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 Optic 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 Version History

8/21/98: Rev A by J. Hazel Romie.
8/28/00: Rev B&C by D. Ottaway and B. Weaver.
8/12/01: Rev D by D. Ottaway and B. Weaver.

1.3 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
LIGO-E980034	Small Optic Cleaning Procedures
LIGO-M990034	LIGO Hanford Observatory Contamination Plan
LIGO-E990196	Magnet/Standoff Assembly Preparation Specification
LIGO-E990197	Magetn/Standoff Assembly Quality Control Worksheet
LIGO-E000388	Sensor/Actuator Assembly Specification
LIGO-T980009	Input Optics Final Design
LIGO-E000460	LIGO Small Optic Process Traveler Form

1.4 Cleaning and Baking

All procedures in this document must be performed while suited up in clean room clothing including, but

not limited to: frock, bouffant cap, overshoe covers, gloves, and face mask. The assembly is 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
D000035	Magnet and Dumbell Sanding Fixture
D000036	Magnet-to-Dumbbell Assembly Fixture
D000335	Small Optic Guide Rod Gluing Fixture
	Multi-axis Traveling Microscope
D000342	Magnet/Standoff Assembly Fixture
38427	Edmund Scientific, Pocket Measuring Microscope
D960016	Microscope Bushing
	PZT Buzzer
D970181	Bracket, SOS Optic Cleaning
D970180	Winch Fixture
D970314	Winch Adapter Plate, SOS

F. W. Bell Model 9200 Portable Gaussmeter
Gaussmeter Probe, P/N HTB92-0608
Magnet Strength Fixture, P/N D970169

Set Screw Tool Used in the installation of the spring plungers in the Sensor/Actuator Plates.
Magnet/Dumbell Sanding Fixture Used to sand the ends of the magnets and dumbell standoffs. See LIGO-E990196.
Magnet-to-Dumbbell Gluing Fixture Used to configure and bond the magnets to the dumbbell shaped aluminum standoffs. See LIGO-E990196.
Guide Rod/Wirestandoff Gluing Fixture Used to accurately position and bond a guide rod and a wire standoff to the side of the optic. This is used in conjunction with the Multi-axis traveling microscope.
Multi-axis Traveling Microscope Used to measure and guide the position of the wire-standoff and the guide rod on the side of the optic prior to gluing.
SOS Gripper Magnet Standoff Fixture Used to locate all magnet/dumbells when gluing to the face and sides of the optics. See LIGO-D000342.
Measuring Microscope Used to align the sensor/actuator plates to the magnet/standoff assemblies glued on the optic.
Microscope Bushing Mounted on the bore of the measuring microscope and used to fit the shaft 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.

3. Assembly Procedure

3.1 Suspension Structure Assembly

Assemble the Small Optic Suspension Tower as per D960001-A-D.
Notes to keep in mind during this assembly:

- Press in the large and small dowel pins into the top plate using an auger press. Lubricate liberally with isopropanol.
- Silver plated hardware should be used in stainless threads and stainless steel hardware should be used in aluminum threads.
- Install the spring plungers 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.
- Check Side Plates and Sensor/Actuator Plates for dowel pins. If dowel pins are used instead of machined rails, replace these parts with the ones that have machined rails. It is best to phase out the parts with dowel pins as they cause sensor/actuator misalignment.
- Assemble the Top Block, Side plates, Stiffener Plate, and Base Plate and torque all fasteners to 100 in/lbs.
- Insert a spring into the counterbore of the Safety Stop Screws and install all four Bottom Safety Stop Screws into the Lower Clamps until the springs protrude above the clamps by about 6mm.
- Insert an SOS Flourel Tip into the counterbores of two Lower Front Safety Stop Screws and install the two into the Lower Clamps so the tips also protrude beyond the bracket by about 6mm.
- Position the two Sensor/Actuator Plates in place and torque the screws finger tight.
- Insert a spring into the counterbores of the two Back Safety Stop Screwsand screw them into the Sensor/Actuator Plates until they protrude past the plates by about 12.5mm.
- Install the two Upper Front Safety Stop Screw into the Upper Mirror Clamp, but do not attach the clamp unit to the tower yet. Insert a spring in the top screw's counterbore and an SOS Flourel Tip into the counterbore of the face screw.
- Attach all Suspension Block and Wire Clamps to the Suspension Top Block, loosely. ***Note: The Suspension Wire Clamp (1205308) must be oriented such that it's lower edge is flush with the lower edge of the Supsension Top Block (D960003).**
- Set the whole assembly aside until the mirror is ready to be suspended.

3.2 Optic Preparation

3.2.1 Applying Guide Rod and Wire Standoff

Materials:
SOS Optic
D970188 Guide Rod
D970187 Wire Standoff
Perkin Elmer Vac-Seal epoxy resin

D000335 Small Optic Guide Rod Gluing Fixture

solvents; isopropanol, acetone
4" length of clean copper wire
UHV aluminum foil
lint-free wipes

1. Clean optic: Clean optic thoroughly to remove contamination per LIGO Small Optics Cleaning Procedure document, LIGO-E980034. Care must be taken to clean the outside diameter of the optic.
2. Prepare fixture and parts: Clean the parts of the Guide Rod/Wire Standoff Gluing Fixture thorougly as CLASS B per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022. Clean and bake the guide rod and wire standoffs as Class A per the same specification.
3. Align optic in fixture: Unscrew and remove the Optic End holder (see diagram below). Place the optic HR surface down on the fixture base plate, between the three Optic Mount Holders. The optic will rest on the teflon pads around the bottom of each Optic Holder. The scribed arrow on the side of the optic should be near one of the side arms, pointing down. Push the optic against the two Optic Mount Holders at the center of the fixture. Reattach the end Optic Mount Holder and screw it down so that it clamps the optic by its bevel. Adjust the tension of the Side Arms of the fixture, so that they just touch the sides of the optic (use the 6 screws that attach each arm to the fixture to make this adjustment). Insert the guide rod and the wire standoff into the slot holder of the appropriate arms. The guide rod slot is smaller in diameter.

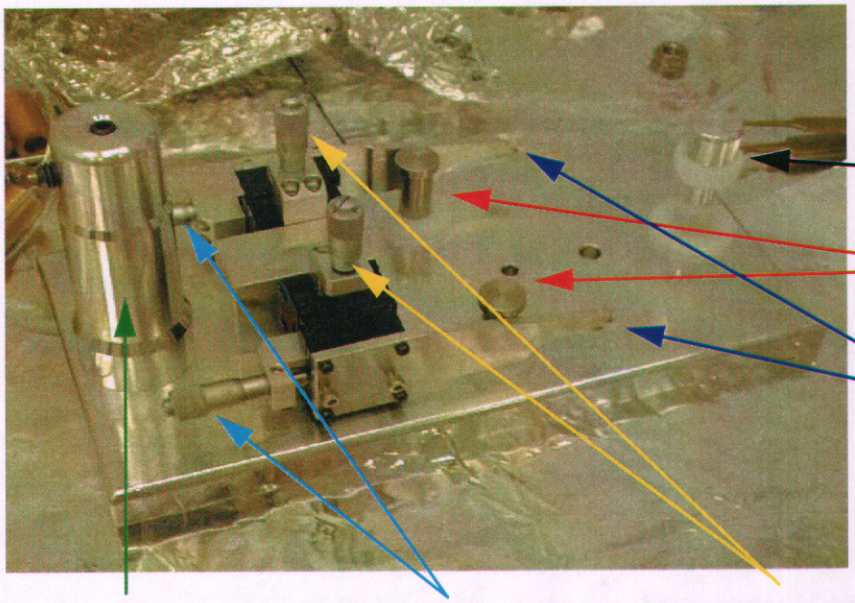
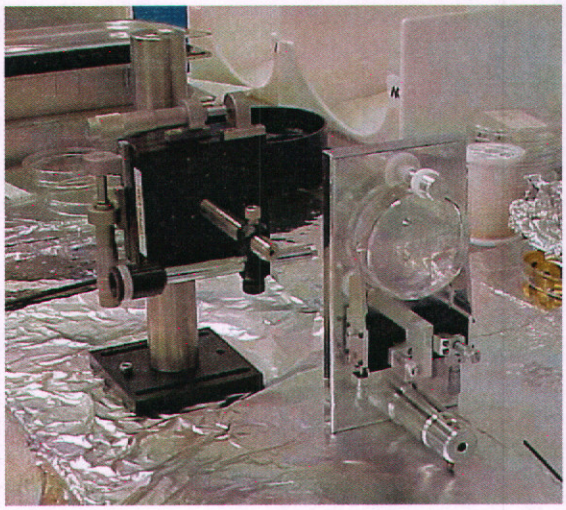


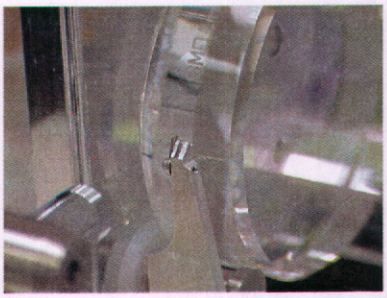
Figure 1. SOS Guide Rod and Wire Standoff Gluing Fixture.

4. Align the Guide Rod and the Wire Standoff Tangentially with Optic: With the Fixture Handle, tip the whole fixture with the optic up on end vertically, so that it rests on the handle and edge of the base plate. Have the side of the optic with the guide rod positioned towards you. Position the traveling microscope so

that it is centered and focused on the side scribe line of optic near the guide rod. Record this number. Subtract 1.73 mm from the recorded number. This offset number is where the center of the guide rod should be positioned. Adjust the height of the traveling microscope to the offset number. While looking through the microscope, adjust the Side Arm location so that the guide rod is centered in the microscope. Make the Side Arm adjustment with the Tangential Adjustment micrometers. Turn the fixture around 180 degrees to repeat this step for the wire standoff on the other side of the optic. For the wire standoff, use 0.94mm as the subtracting offset instead of 1.73mm.



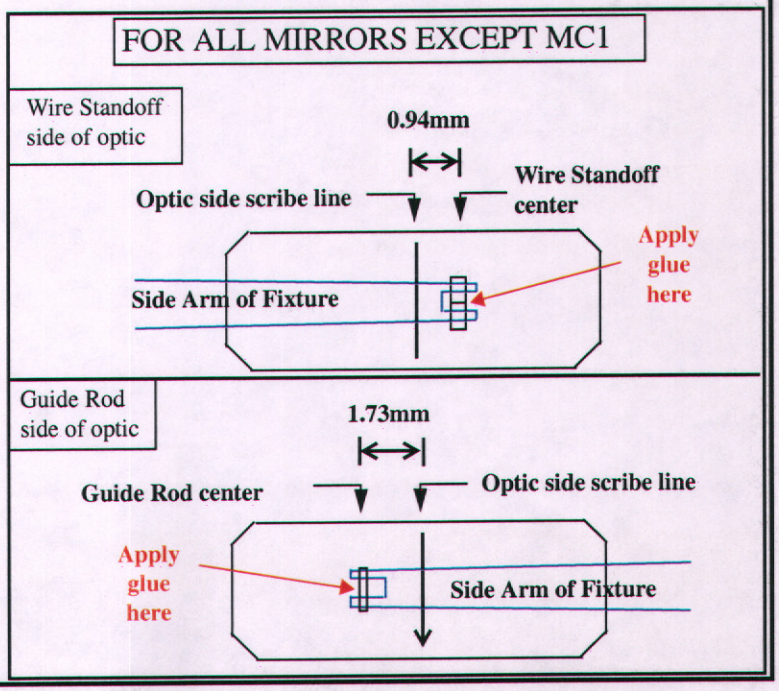
Gluing fixture/optic assembly and traveling microscope.



Close-up view of Guide Rod in Side Arm holder

Traveling microscope, mount, and vernier adjustments

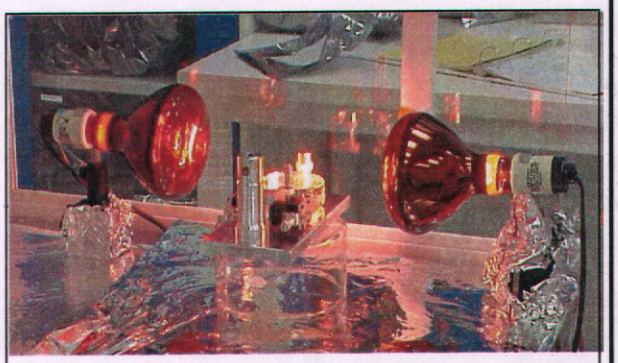
5. Align the Guide Rod and the Wire Standoff Axially with Optic: Set the fixture back down horizontal. Position the fixture and optic so that the side with the wire standoff is towards you (and the microscope). Coarsely adjust the traveling microscope so that you sight on the edge of the top surface of the optic. Center and focus the traveling microscope on this edge line. Record this number as measurement 1. Scroll the traveling microscope down and center and focus on the bottom edge of the optic. Record this number as measurement 2. Find the center of the thickness of the optic, by averaging measurement 1 and 2. This number is the height at which the v-groove line of the wire standoff should be set to. Adjust the traveling micro-



scope to this centerline number. Use the microscope to adjust the Side Arm position so that the v-groove of the wire standoff is centered in the microscope cross hairs. Make this adjustment with the Axial Adjustment micrometers. Turn the fixture around 180 degrees so that the guide rod is towards you. Repeat this step for the axial positioning of the guide rod.

NOTE: The guide rod does not a have a v-groove line to use as a centering reference therefore, you must use the end of the guide rod as a reference. So, once you find the coordinate of the center of the optic thickness, subtract 1.5mm (half of the length of the guide rod) to get this reference number. After you adjust the microscope to that number, adjust the Side Arms so that the upper end of the guide rod is what is centered in the microscope.

6. Prepare adhesive applicator: Cut a 4" section of thin (32 ga) copper wire and wipe it down with acetone. Wind it around the handle end of a cleanroom q-tip for support, leaving a 1/2" end unwound for use as a glue applicator.
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 UHV aluminum foil boat. Outgass the epoxy in a small vacuum pump for approx. 3 minutes.
8. Glue the wire standoff and guide rod: Set the fixture vertical, resting on the base plate edge and Fixture Handle. Dip the copper wire end into the epoxy and withdraw it, leaving a tiny amount of epoxy on the wire. Apply epoxy to the end and top of the wire standoff joint touching the optic edge. Apply epoxy to the top center of the guide rod.
9. Check adhesive joints: Look through the optic at the two glue joints and make sure that the contact areas are visible.
10. Cure epoxy: Set up a heat lamp on either side of the optic in the gluing fixture such that there is a light heating the guide rod glue joint and a light heating the wire standoff glue joint. Let the assembly sit under the heat lamps for 6 to 12 hours. Vertical or horizontal orientation is acceptable.
11. Remove the guide rod fixture: Loosen the tension on the Side Arms, so that the arm holders come away from the glued on wire standoff and guide rod. Unscrew and remove the end Optic Mount Holder. Carefully, remove the optic from the fixture.



Heat Lamp Setup

3.2.2 Magnet-to-Dumbbell Standoffs

Make sure that there are a matched set of 2 North and 4 South magnet/standoff assemblies. If not, make them up according to the instructions in Magnet/Standoff Assembly Preparation Specification, E990196. Record the magnet strengths on the appropriate Small Optic log for each optic.

3.2.3 Applying Magnet/Standoff Assemblies

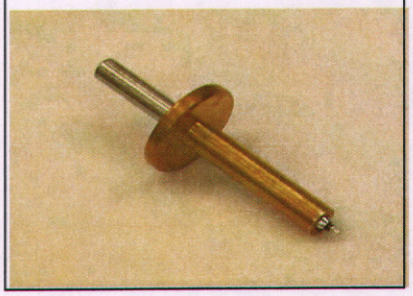
Materials

TITLE

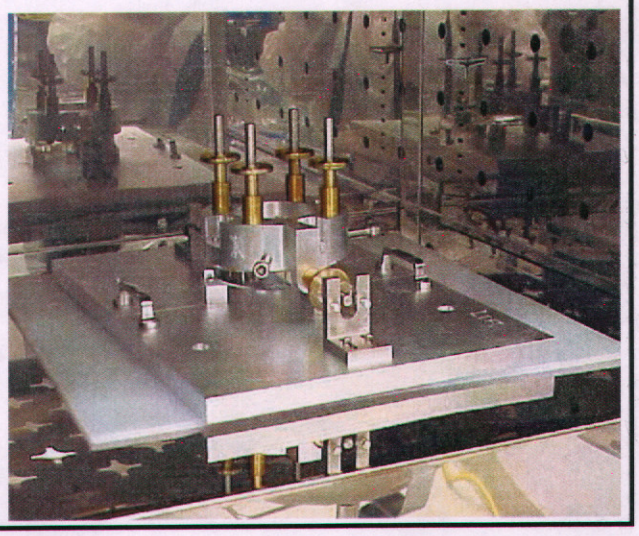
SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

6 magnet/dumbbell standoff assemblies
Perkin Elmer Vac-Seal epoxy resin
D000342 Magnet/Standoff Assembly Fixture
6 Gripper Assemblies (part of D000342 fixture assembly)
SOS Optic
solvents; isopropanol, acetone
4" lengths of clean copper wire
UHV aluminum foil
lint-free wipes

Gripper



12. Clean the gluing fixture: Clean all parts of the gluing fixture thoroughly as CLASS B, per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022.
13. Mount the magnet/standoff fixture: With the top ring fixture upside-down, place the optic into the ring fixture with the AR surface down. Align the lines on the outside diameter of the fixture with the etched lines on the side of the optic. Use the three side set screws to position the optic wthin the fixture such that it is centered within the fixture. That is, make sure that there is an equal distance between the optic and the ring fixture around the circumference of the optic. *Also,* ***make sure that the fixture doesn't slip from its alignment with the lines on the optic.***
14. Prepare the Grippers with Magnets: Insert the magnets into the grippers, magnet first, leaving the dumbell standoff protruding from the end. Lay the grippers out in such a way so that you keep track of which gripper holds which type of magnet (N or S). Make sure that each magnet /dumbell standoff are inserted into the grippers equal amounts. (In other words, don't have one magnet /dumbell standoff sticking out of the gripper further than another set.) See Figure 1 below for polarity layout. 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.
15. 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 UHV aluminum foil boat. Outgass the epoxy in a small vacuum pump for approx. 3 minutes.
16. Prepare adhesive applicator: Cut a 4" section of thin (32 ga) copper wire and wipe it down with acetone. Wind it around the end of a cleanroom q-tip for support, leaving a 1/2" end unwound for use as a glue applicator.
17. Apply epoxy: Dip the glue applicator in epoxy and withdraw it, leaving a tiny amount of epoxy on the wire. Apply epoxy to the end of a standoff. Epoxy should only cover a diameter of about 0.5mm with a height of 0.3mm. Insert the gripper with that dumbell standoff carefully into the appropriate brass bushing of the top ring fixture, making sure not to get adhesive on fixture. Verify that the dumbell standoff makes contact with the optic surface and that the glue has formed a ring around the joint. Repeat this for the five remaining magnet/standoff assemblies. Attach the side gripper spring pressure brackets and springs to the fixture base plate. These will help insure that the side



grippers are pushing the dumbell standoffs against the side of the optic.

18. Cure epoxy: Put the whole gluing fixture with the optic into the airbake oven. Turn the oven on, with it set to ramp to 100 deg. C. Leave the assembly in the oven for 2 hours. Turn the oven off after the 2 hours and let the assembly slowly cool in the oven.
19. Remove the magnet/standoff fixture: *Once cool, remove the six grippers by pressing down on the plungers* first to disengage the grippers grip on the magnet, and then sliding out. After all of the grippers are out of the top ring fixture, remove the ring. Incrementally loosen the set screws of the three 1/4-20 screws. When the positioning ring has cleared the magnet/standoff assemblies, carefully set it aside.

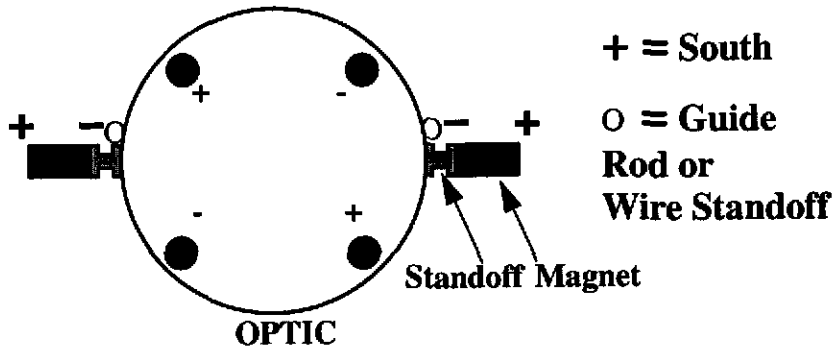


Fig. 1. Configuration of the magnet/standoff assembly as viewed from the back side (AR surface).

3.3 Optic Hanging and Balancing

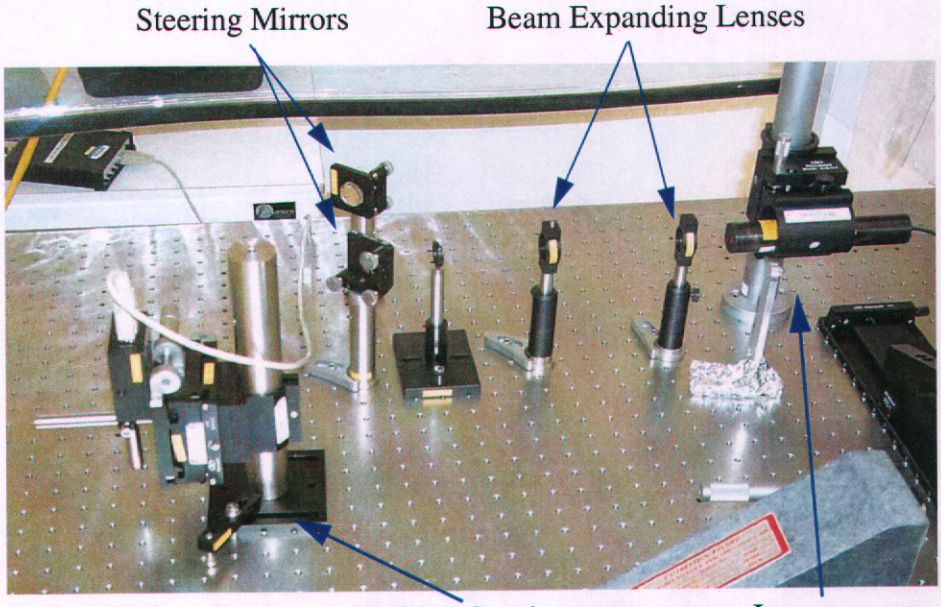
Materials

Optic with 6 magnet/standoff assemblies, 1 guide rod, and 1 wire standoff glued to it
SOS suspension structure
.0017" diameter suspension wire (steel piano wire/California Fine Wire Company)
D970187 Wire standoff
D970180 Winch fixture
D970314 Winch adapter plate
HeNe laser
Position Sensing photodiode
Function Generator
2 Oscilloscopes
"Octopus" Cables
Table level
38427 Edmund Scientific, Pocket Measuring Microscope
Height Gauge
D960016 Microscope Bushing
PZT Buzzer, Driver, and Power Supply

TITLE
SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

solvents: isopropanol, acetone
Perkin Elmer Vac-Seal epoxy resin
4" length of clean copper wire
UHV aluminum foil
lint-free wipes

1. Prepare the wire standoff and suspension wire: Clean and bake a wire standoff as Class A per LIGO Vacuum Compatibility, Cleaning Methods and Qualifications Procedures document, LIGO-E960022.
2. Prepare the suspension wire: Cut a piece of the wire to be approximately 1m and free from kinks. The suspension wire should not be baked. Clean the wire thoroughly by wrapping an acetone soaked lint-free wipe around the wire and gently pulling the wire through the wipe. Be careful not to put any kinks in the wire. Wiping should be done a minimum of three times to remove any rust and contaminants. Examine the wire under a microscope.
3. Make an optical lever: Level the optical table that is being used for this suspension work, using a mechanical bubble type level, to within +/- 0.05 mrad. Set up an optical lever, using a small HeNe laser and a quad position sensing photodiode. Level the HeNe beam to within +/- 0.05 mrad. This is done by first setting the height of the laser to the height of the hole in the beam height target. Then place the photodiode near the output of the laser and move it down the table to measure the angular displacement of the beam. Use an expanding telescope to produce a minimum spot size on the photodiode. Make the lever arm as long as possible to increase the accuracy of the alignment (by setting the laser and steering mirrors as far from the SOS tower as possible). Use an oscilloscope to monitor the voltage of the position sensing photodiode. Zero voltage corresponds to a beam hitting directly on the center of the diode. If the balance angle of the optic you are suspending is different than zero, you will need to reset the height of the position sensing photodiode, based on the distance between the suspended optic and the position sensing photodiode.



Optical Lever Assy.

Beam Height Target

TITLE

SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

4. Prepare the winch fixture: Screw the Winch Adapter Plate to the top of the Suspension Block using 2 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 towards the front of the structure. Line up the front of the suspension block with the front of the adapter plate. Using oversize washers and two 1/4-20x1.25" long screws, attach two winches to the threaded holes in the adapter plate with the rocker of the winch closest to the front of the suspension block (the outer most holes on the adaptor plate have proven to work best). Loosely attach Suspension Block Clamps to the winches.
5. Prepare the height gauge: Attach a microscope perpendicular to the direction of travel on a height gauge. Focusing on the beam height target, adjust the height of the gauge so that the microscope is centered on the center of the hole in the target. This height represents where the center of the optic should be when positioning it. When setting this height, make sure that both the height gauge and the target are on the same height surface (i.e. on the same table with a single piece of foil underneath them).
6. Position the optic in the structure on the stops: With the Upper Front Safety Stop Clamp removed from the suspension structure, carefully place the optic onto the Lower Safety Stops in the structure. Attach the Upper Front Safety Stop Clamp to the structure above the optic. Set all front and back safety stops 1 mm away from the optic. Adjust the height of the optic in the structure by eye, making the scribe lines look centered in the sensor/actuator mounting holes in the side plates. Fine tune this adjustment with the height gauge microscope, positioning the optic so that the scribe lines on the side of the optic are at the correct height. Utilize the lower safety stops to get the optic to the right height.
7. Thread the wire around the optic: Loosely string each end of the wire up one side of the optic from below, as shown in D960001. Minimize the amount of drag of the wire across any edges around the top block to avoid breakage. Once both ends are clamped in the winches, make sure that the wire sits in the v-groove of the wire standoff.
8. Suspend the optic: Position the wire such that it is slightly taunt by threading in or backing off of the winch's 1/4-20 screw. It may be necessary to support the optic with the Lower Safety Stops when adjusting the winches, so that there is not too much tension on the wire (it breaks easily during winch adjustments). 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. Recheck the position of the optic with the height gauge microscope. If the optic has sagged, put the lower stops back up to support the optic and take some more tension up with the winches. These adjustments may need to be repeated numerous times so that the optic is at the right height when suspended.
9. Coarsely balance the optic: With the safety stops backed off, determine which direction the wire standoff needs to be slid along the guide rod to balance the optic. Use a foil covered q-tip to micro-position the wire standoff so that the optic will hang correctly. In other words, balance the optic so that the HeNe beam is hitting somewhere on the position sensing photodiode. When repositioning the wire standoff, be sure to clamp the optic with the face safety stops. Check often that the wire is still in the grooves of both wire standoffs.
10. Install the Sensor/Actuators: Choose 5 sensor/actuator heads by matching their unblocked (open light) voltages as closely as possible. Install the sensor/actuators into the holes in the brackets such that they are about 1cm from the optic. Connect the 5 balancing sensor/actuator pin connectors to their appropriate pinouts on the satellite module stand on the corner of the optics table.
11. Discharge the optic: Lightly clamp the optic with the front and back safety stops. Blow both sides of the optic with the N2 ionizing gun for a few minutes. Unclamp the optic. Verify that the optic has been dis-

charged by measuring the electric field strength using the ion meter.

12. Optimally position the heads: Using an oscilloscope and the "octopus" cables connected directly to the satellite box, 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 50% of the unblocked voltage. Typical unblocked voltage is 2.2V. Rejection criteria for sensor/actuator heads is found in LIGO-E000388.
13. Damp the optic: Enable the damping on the suspension controller screen in the lab. Default settings on the suspension controller screen should be as follows: The sliders in the POS Input matrices should be set at 25 and the sliders in the PIT and YAW Input matrices should be set at 63, all of the gain sliders in the center of the screen should be set at 10, the POS, PIT, YAW, and SIDE should all be in RUN mode, and all Output matrices sliders should set at 75. Verify that the optic is damped using the output from the optical lever.
14. Balance the optic: Turn the Hepa filters of the flow bench off. Use the PZT Buzzer (with function generator set to a triangular waveform with an amplitude of 5.00 Vrms and frequency of 1000 Hz) to fine tune the balance. With the optic clamped, gently touch the end of the buzzer rod against the wire standoff to make small movements. Unclamp the optic and observe the voltage of the photodiode on the oscilloscope. Repeat the last two steps until the voltage approaches zero and the optic is well within tolerances. Using the optical lever, balance the optic such that the balance is **within +/-.5 mrad**. NOTE: This is a time-consuming step. Patience is important here.
15. Discharge test: Unscrew the safety stops so that they are away from the optic by 3mm. Check the balance angle of the optic. If it has changed, repeat steps 11, 14, and 15.
16. Prepare adhesive applicator: Cut a 4" section of thin copper wire and wipe it down with acetone. Wind it around the end of a cleanroom q-tip for support, leaving a 1/2" end unwound for use as a glue applicator.
17. 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 UHV aluminum foil boat. Outgass the "boat" of epoxy in a small vacuum chamber for 3 minutes.
18. Apply epoxy: Dip the wire in epoxy and withdraw it, leaving a tiny amount of epoxy on the wire. Apply epoxy to the top side and ends of the wire standoff.
19. Cure epoxy: Set a heat lamp next to the suspension tower so that it will direct heat onto the new glue joint, but do not turn them on, yet. DISABLE the damping. While making as little movement near the optic as possible, turn the heat lamps on and leave the area. Let the suspension sit under the heat for 6 to 12 hours. Note the final balance angle of the optic.
20. Final balance check: ENABLE the damping. Note the final balance angle.
21. Inspect, bake and clean optic: Set the back safety stops to just touch the optic. This will save the front/back position of the optic for later. Turn the damping off. Remove the sensor/actuators from the structure. Remove the Upper Front Safety Stop Clamp from the structure. Gripping the front of the optic at the top and bottom (with index finger and thumb) lift the optic straight up and then out of the structure. Be careful not to pull the wire with the optic or break off the magnet/standoff assemblies. Carefully inspect the surface of the optic for cleanliness. Clean the optic with the CO2 gun and then discharge the optic with the N2 ionizing gun.
22. Re-install the optic: With another person gently holding the suspended loop of wire open (i.e. with 2 wooden dowels wrapper in UHV foil), set the optic back into the structure on the lower stops and in the wire loop. Adjust the wire around the sides of the optic, back into the v-grooves of both wire standoffs.

Adjust the rotation of the optic by eye. Set the rest of the stops to 1mm from the optic. Adjust the position of the optic by lining up the side scribe lines on the optic with the height gauge microscope as in Step 6 above. Drop the lower stops. Verify that no stops are touching the optic. Recheck the position of the optic with the height gauge.

23. 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 sensor/actuator plates are aligned with the magnet/standoff assemblies. Compomise on the positioning if required.Remember that the image in the microscope is an inverted image. Perform this same operation for the other sensor/actuator plate.
24. Tighten suspension block clamps: Tighten the screws of the wire clamp. Tighten the screws of the other suspension clamps. Remove the winch and the winch adapter plate.

3.4 Sensor/Actuator Head Installation

Materials

Suspension Tower with Suspended Optic
D960011 Sensor/Actuator Assembly
D970073 Sensor/Actuator Pin Plate
Kapton sensor/actuator cables
D970084 Connector Bracket Assembly
E000388 Sensor/Actuator Assembly Specification

Assembly

1. Prepare the sensor/actuator heads: Assemble and test the sensor/actuator heads per E000388.
2. Mount the sensor/actuator heads: Mount the sensor/actuator assemblies in the proper configuration, making sure that the optic is clamped with the front and back stops. Slowly, slide the sensor/actuator assemblies into the holes in the plate until just about 2mm of sensor/actuator assembly protrudes beyond the front of the sensor/actuator plates. Verify that the magnet is located in the center of the sensor/actuator head to as much occurrence as visual inspection will allow from the front of the optic. Adjust the position of the sensor/actuator mounting plates if necessary.
3. Optimally position the heads: Using an oscilloscope, optimally position the sensor/actuator assemblies with respect to the magnet/standoff assemblies on the optic. Repeat Steps 10,11, and 12 above. Tighten the sensor/actuator down with the spring plungers, taking care to maintain the 50% unblocked (open light) volatage readings.
4. Check for 14.7 Hz spike: The vertical bounce mode of the suspended optic has a frequency of around 14.7 Hz. The orientation of the LED/photodiode pair in each sensor/actuator head affects the magnitude of this resonance's coupling into the photodiode horizontal position readout. While moving the sensor/actuator head assemblies near the magnets on the optic, check the rotation of the sensor/actuator head assemblies. Generally, the optimum position is such that the photodiode is directly over the LED. If the oscilloscope

shows a sharp spike around 14.7 Hz., slowly rotate the sensor/actuator 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 0.5mm 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 is achieved.

3.5 Preparing SOS for Installation

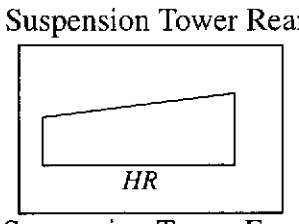
1. Clamp the optic firmly in place, while preserving the optic's pointing. Do this by watching the optical lever beam as you clamp the optic. This will help in rough aligning the optic during installation.
2. Wrap the structure in clean UHV foil and Ameristat.
3. The procedure for installation of a large optic into a HAM chamber is given in E000061. No procedure currently exists for Small Optic installations, so adopt this procedure for the meantime.

TITLE

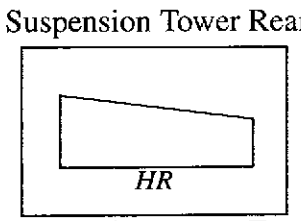
SMALL OPTICS SUSPENSION ASSEMBLY SPECIFICATION

3.6 Appendix - Suspension Wedge Angle Orientation

All small optics suspensions have their mirrors mounted with the wedges oriented in the horizontal direction. The table below lists the wedge orientation for each suspension. *The convention is defined such that the left and right refer to the orientation of the thick side of the optic when viewed looking towards the front face of the tower. Viewed from above:*



RIGHT



LEFT

Table 1: Small Optics Suspension Wedge Orientation

Suspension	*Wedge Orientation*
Mode Cleaner Flat Mirror 1	Thick side right
Mode Cleaner Flat Mirror 2	Thick side left
Mode Cleaner Curved Mirror	Thick side left
Steering Mirror 1	Thick side left
Steering Mirror 2	Thick side left
MMT1	Thick side left
MMT2	Thick side left