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LOS Installation Procedures for HAM Chambers

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This is an internal working note
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1 PURPOSE AND SCOPE

This document is the standard guideline for properly handling and installing the Large Optic Suspension (LOS) assemblies into the **HAM** chambers at the LIGO Hanford Observatory. It contains a step by step check list to aid in the installation process (see Appendix 1). This is done to prevent over-looking important installation details, which when omitted, have in the past, proven to damage suspended optics. This procedure picks up at the point where the optic has had its post bake cleaning, inspection, the magnets checked for bond integrity, and is re-hung in its structure. The LOS balance and tilt measurements should have been confirmed and logged. The OSEM open-light voltages recorded and the OSEMs set at 60% of the open light voltage. PAM magnets should be set to length and damping checked and readings recorded. The optics table on which the LOS is destined, should contain the counter weight payload and be level and sitting at the proper elevation.

2 HAZARDS

The LOS assemblies are heavy and awkward to maneuver, and require two persons coordinating their movements carefully, to prevent personnel from becoming injured or damaging property. The LOS assembles have under gone several expensive, time consuming operations, prior to this point of installation, and the optic itself, being a very expensive, long lead time component, requires personnel to be alert and diligent when handling them.

3 CONTAMINATION AND CONTROLS

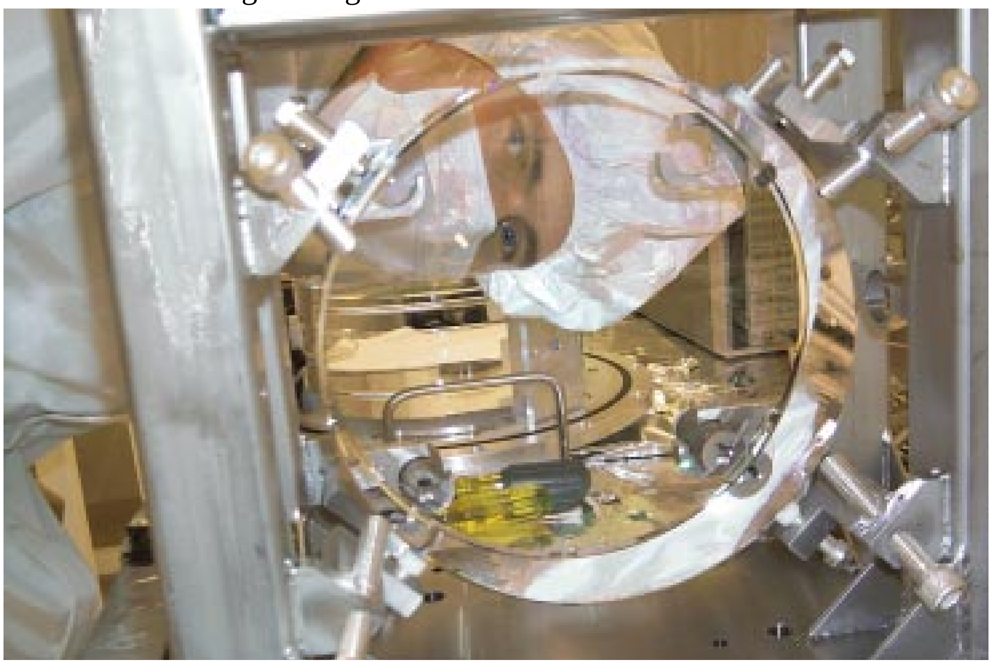
To provide reasonable assurance against the inadvertent introduction of contaminants to the optic, fixturing and/or the vacuum envelope, all personnel assisting with LOS installations, should be familiar with the LIGO Hanford Observatory Contamination Control Plan, LIGO-M990034-A-W and the LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures, LIGO-E960022-05-E. It is important that proper clean room attire is worn in the appropriate areas, while handling the LOS assemblies and their related fixtures.

4 REQUIREMENTS

The minimum gowning requirements for working in close proximity to an LOS assembly in the Optics Labs are: *Bouffant Cap, Frock, Overshoe Covers, Face Mask and UHV Gloves*, all from the approved supply. When doing the actual installation into an open chamber, while working under the soft wall enclosure, the minimum garment requirements are: *Full Hood, Face Mask, Clean Room Coveralls, Clean Room Knee High Boots, and UHV Gloves*, all from the approved supply. If you are going to be entering into the chamber, *Inside Chamber Overshoe Covers* are to be worn over the *Cleanroom Knee High Boots*, donning them at the time you transition to the chamber interior, making sure the *Inside Chamber Overshoe Covers* do not come in contact with surfaces on the exterior of the chamber. The forgoing is just part of the protocols required when working with contamination-sensitive hardware. It is a must that the Contamination Control Plan be followed in it's entirety.

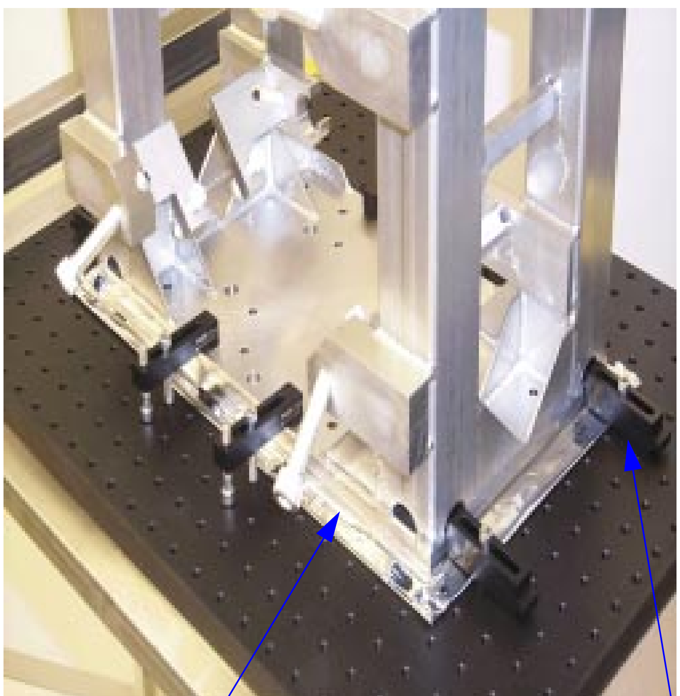
APPENDIX 1 INSTALLATION PROCEDURES

1. Check the alignment between the magnets and the OSEMs. Magnets should still be centered in the OSEM openings.
2. Using a low power HeNe laser for an optic lever transmitter and a quad diode receiver, clamp the optic in its balanced position. Check that the 4 Teflon capped silver plated bottom support screws are *lightly touching* the optic. Next contact the optic with the 8 chamfer stop screws while maintaining the alignment. Next clamp the optic with the 4 top Viton tipped safety stop screws while maintaining the alignment.



3. Position the LOS near the edge of the optics table, in close proximity to the *transport cart*. Place clean UHV foil on the top of the transport cart. Wrap the OSEM "pig tails" in a UHV foil pouch to prevent them from dangling free or wrap them through the structure.
4. One person should man the transport cart to prevent it from moving, pushing it against the optics table.
5. With a second and third person facing each other, keeping hands clear of critical components, grip the LOS structure in a comfortable, balanced position, and upon a "count down", lift the LOS onto the transport cart.

Shows the Stainless Steel LOS *Transport Cart* with its shock absorbing casters. There is an optical bread board fastened to the cart to enable the structure to be clamped down during transport. There are four nylon slings for craning purposes. Use eight "dog clamps" to secure the structure



UHV Aluminum Foil

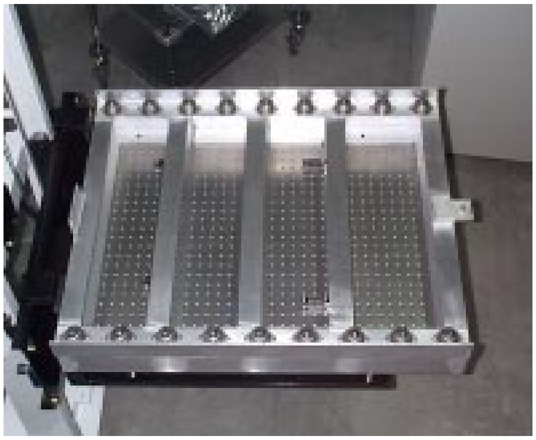
"Dog" Clamps

2 styles from Thor Labs

6. Clean the optic with the CO2 *"snow-gun"* and ion N2 gun to remove dust particles and foreign matter, and wrap the structure with UHV foil before transporting it from the optics lab. Roll the optic to the HAM chamber and into the soft wall enclosure. If craning is required, use the dedicated straps and tag lines.

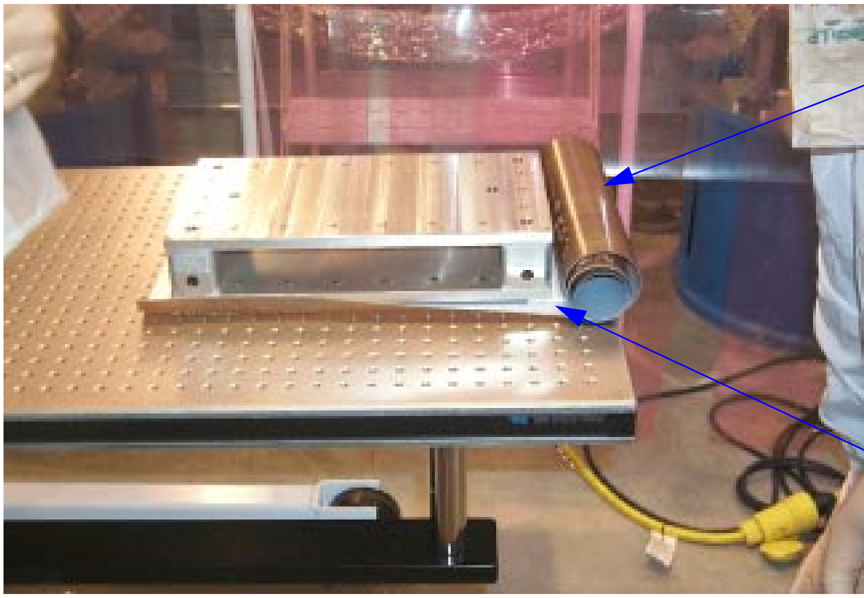
7. Bolt the *optical breadboard and posts* to the forks of the *straddle*.
8. Position the straddle and the transport cart in close proximately to each other to facilitate easy transferring of the LOS onto the bread board.

Straddle with roller truck installed in place. (this set up is only used to install the lift table into BSC chambers).



Bread Board and Posts

9. Place the *Teflon strip* on the center of the bread board
10. Place the *Teflon step blocks* onto the *Teflon strips*.

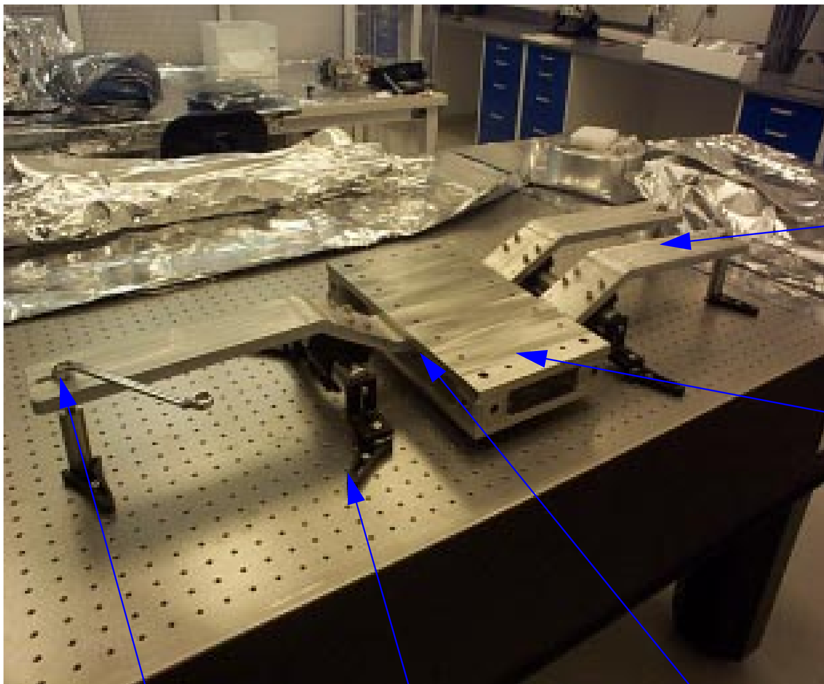


11. Place the LOS Height Adapter onto the *Teflon blocks*.
12. One person should secure the transport cart, while a second and third person facing each other, keeping their hands clear of critical areas, grip the LOS structure in a comfortable, balanced position, and upon a "count down", lift the LOS from the transport cart onto the Height Adaptor.
13. Fasten the LOS to its height adaptor with 1/4-20 X 1 1/4 SST cap screws and lock washers and silver plated SST nuts. (18 each).
14. Steer the straddle with the LOS to the opening of the chamber and raise the bread board height up to the optic table height. Push the straddle forward, gently to meet the HAM optic table.

.Note: The optics table should have its counter weights in place and be level at its proper elevation. Check using a Starrett model 98 level.005" / foot rated accuracy or equivalent spirit level.

15. Roll out a *"Teflon Highway"*, using more of the Teflon strip toward the final location where the LOS will be installed.
16. Install the "Belly Bars" across chamber opening.
17. Slide the LOS structure along the Teflon highway to its location. Reference the optic table hole patterns.
18. Recheck table level especially if counterweights have been moved.

19. Install the LOS *3 point lifting hardware* onto the HAM optic table. The single arm on one side of the structure and the double arm on the other. The step on the short end of the arm sits under the top plate of the height adaptor. Clamp down the 7 posts. Carefully tighten down on the 3 bolts located in the top of the posts at the long end of the lever arms. This will raise the structure allowing the removal of the Teflon blocks and highway. After removing the teflon lower the structure by loosening the three 3/8” screws.



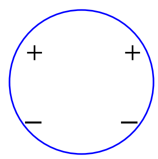
20. Remove the 3pt. lifting fixture.
21. Attach the *prism mount, and prism* to the Height Adapter.
22. Check the initial transverse and axial positions with Theodolite.
23. Install the *brass pusher bars* using optical table mounting holes and or clean class B dog clamps to secure them. Translate to correct location using theodolite readings of prism position, orient angle using laser autocollimator. Position should be ~ 1/2mm or better in location.
24. Connect the OSEM cabling and verify sensor signals.(see below)
25. CHECK TABLE LEVELNESS.
26. Back off stop screws: top-> bottom-> chamfer.
27. Turn on *SUS controller* and verify damping of optic
28. Recheck orientation using laser autocollimator with optic suspended.
29. SNUG CHAMFER STOPS
30. Remove *pushers*.
31. Attach LOS to table using class A dog clamps (longs and shorts as needed).
32. Remove LOS compensation counter weights.
33. CHECK TABLE LEVELNESS.
34. Release Chamfer Stops adjust alignment using PAM magnets.(<10 micro radians in Pitch & YAW))
35. SNUG CHAMFER STOPS.
36. Change bottom safety Teflon capped screws to *Viton tips*.
37. Secure the OSEM pig tail wires to the structure so not to obscure the beam path using class Aclean stainless steel wire.
38. Release chamfer stops, set-up *optical lever*.
39. SNUG CHAMFER STOPS.
40. Clean optic with CO2 gun.
41. Final chamber check.
42. Release chamfer stops and exit.

OSEM Sensor Consistency Check *by Bill Kells*

When an LOS is installed we assume that the tower package, including OSEMs and their wiring, has been properly tested to identify and route the OSEM signals. Once installed this is again "checked" by verifying damping for pitch, yaw, position, and side motion. However this verification via damping might be ambiguous, since it is often found that the degrees of freedom are sufficiently coupled to allow induced [anti]damping. Motivated by at least one situation where the as installed OSEM wiring identification was called into doubt due to such ambiguities, this more explicit check of the as installed OSEM response was developed. It is based on comparing a known mirror motion, as established by the LOS' optical lever, with direct individual OSEM shadow sensor photo-diode levels. Therefore this test is restricted to suspended optics with optical lever monitors, i.e. the LOS. However this could be extended to any suspended optic if an auxiliary optical lever monitoring its motion could be set up. As described here the check assumes that the OSEM actuation is correctly wired, and only the shadow sensing readout is tested. A similar procedure might be developed to test the actuation, but would not be so straight forward since control of individual OSEM actutation is not accessible leads to coupled motions. A distinct feature of this check is that it requires no perturbation of the fully operational LOS. For instance it can be performed once the optic is inaccessible, under vacuum.

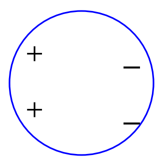
First I describe the generic procedure (subsequently a specific, quantitative example is summarized). Two steps may be distinguished:

STEP 1. The correlation between LOS pitch and yaw bias setting and optical lever pitch and yaw readings are established. One anticipates that variation of LOS pitch bias changes only lever pitch to some good approximation, and similarly for yaw. In general there will be some degree of pitch/yaw cross coupling. The level of this which can be tolerated for unambiguous OSEM verification will have to be decided on an individual basis. Then for a significant pitch bias shift one expects the 4 OSEM shadow sensor voltage levels to change:



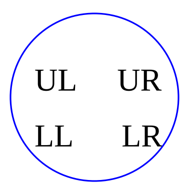
with overall sign ambiguity.

and for a significant yaw bias shift:



with overall sign ambiguity.

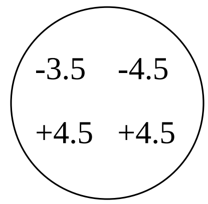
where the convention here is a view looking at the optic from the back:



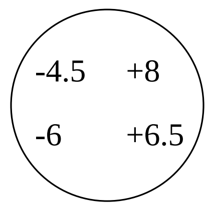
STEP 2. Now the above expected shadow sensor voltage change patterns are determined by measuring the (~DC) analog voltages extracted at the “J3” test point connection on the LOS controller satellite box. If both pitch and yaw expected voltage change patterns are confirmed, then the OSEM sensors must be routed correctly through to the satellite box.

As an example, this procedure was actually applied to the LHO 2K interferometer Y arm ITM. For both pitch and yaw, the bias was changed by +19.0 slider units (nearly full scale, with the not being tested degree of freedom bias set to 0 slider units). The measured J3 voltage changes were:

for pitch:



and for yaw:



where all numbers refer to milli-volts of level change. Note that the typical OSEM sensor voltage at this test point is ~1.6 volts, so that the difference measured here is quite small. However it is unambiguously determined by using a digital oscilloscope with a large number of traces averaged and the scale greatly expanded. The relative signs of the above pitch compared to the yaw data, is not relevant for the basic OSEM routing determination. However it does reveal the relative sense of the pitch vs. yaw slider bias actuation and drive matricies.

5 TESTING THE DAMPING OPTIC D.O.F.

by Jay Heefner

1. Disable all d.o.f. and set the polarity and gains to the nominal (anticipated) values for the optic under test.
2. Monitor the side channel with a scope and enable the side damping. Make certain that the optic is damping.
3. Monitor the pitch d.o.f. using a scope and enable the pitch d.o.f. Convince yourself that the optic is damping. Invert the polarity and ring up the pitch. Flip the polarity back and observe how many cycles it takes for the optic to damp. I believe it should be between 5 and 10 for "optimal" damping.
4. Monitor yaw and repeat step 3.
5. Monitor position and repeat step 3.
6. Monitor side again and repeat step 3.
7. Now all d.o.f. should be damped. Individually monitor each coil output. The observed waveform should not be a "rail to rail" waveform. This is usually easy to see since the extremes of the waveform will be flat tops (i.e. noticeable clipping). If this is observed begin the debug procedure by first checking that all of the coils can be "seen" be the controller. This is done by measuring the coil resistance and the appropriate pins on the cable coming from the controller.

This is a brief synopsis of what we used to do. The procedure that you use may be slightly different, but is probably equivalent.