

LASER INTERFEROMETER GRAVITATIONAL WAVE  
OBSERVATORY

- LIGO -

CALIFORNIA INSTITUTE OF TECHNOLOGY  
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# LIGO Contamination Control Plan

Authors...

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This is an internal working note  
of the LIGO Project.

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# 1 ABSTRACT

The LIGO interferometers are extremely sensitive to optical scattering or absorption losses induced by both particulate and hydrocarbon contamination. In order to minimize the likelihood of contamination of optical surfaces, numerous operational practices have been implemented at the LIGO Observatories. The purpose of this document is to describe the operational practices that have been implemented so that it can serve as a reference for observatory staff and visitors. It is expected that this document will be continuously updated as practices evolve as we gain experience with the interferometer hardware.

## 2 CONTAMINATION-SENSITIVE HARDWARE

**CLASS A** hardware is defined as any item that will be temporarily or permanently mounted inside of or on the inner surfaces of the interferometer vacuum equipment and will be exposed to vacuum.

**CLASS B** hardware is defined as any item that will come into contact with **CLASS A** hardware or the surfaces of the interferometer vacuum equipment that will be exposed to vacuum (including the o-rings).

### 2.1. CLASS A Hardware

Included in this category are the interferometer optics and suspensions and all in-vacuo interferometer hardware that has been prepared for installation. All **CLASS A** hardware is to be manufactured, cleaned, baked, and packaged in accordance with the specifications detailed in LIGO-E960022 *LIGO Vacuum Compatibility, Cleaning Methods, and Qualification Procedures*.

### 2.2. CLASS B Hardware

Included in this category are tools and fixtures that will come into contact with **CLASS A** hardware **OR** be used inside the interferometer vacuum envelope. Follow cleaning and baking procedures dictated in LIGO-E960022 *LIGO Vacuum Compatibility, Cleaning Methods, and Qualification Procedures*, but substitute the airbake oven for the vacuum bake oven.

Please do not bring Class B tools to the sites. There are standard Class B tool sets on site that can be used for most Class A assembly work. Below is a list of Class B tools available at the sites. If you have a special tool or fixture that you will need, please coordinate with your site liaison to arrange for the tool to be properly prepared as Class B in advance. Your site liaison should be able to arrange for a specific subset of tools to be placed in a kit for you.

Ratchets

#### Site Supplied Class B Tools:

Allen Key Sets

T-Handled Allen Key Sets

Metric Allen Key sets

Flat head screw driver (all metal, S-shaped)  
Scissors  
Wire cutters  
Metal Rulers  
Open end wrench sets (Imperial)  
Dental Mirrors  
Tweezers – various sizes  
Helicoil insertion tools (various sizes)  
Helicoil removal tools (various sizes)

## 2.3. Washer and Oven Use

Parts washers and ultrasonic cleaners are maintained by site staff. Cleaning requests should be coordinated with this staff.

The vacuum bake ovens and large air bake ovens are maintained by site staff. Class A bake requests should be coordinated with this staff.

Small countertop Air bake ovens are for general use, provided the user is familiar with the equipment and Class B cleaning and handling. See *LIGO-E960022 Vacuum Compatibility, Cleaning Methods, and Qualification Procedures*.

There are two air bake ovens located in the Vacuum Prep. and Assembly Area at LHO.(LLO?) One is only to be used for curing epoxy on IFO parts. It is clearly labeled and is not to be used for baking **CLASS B** hardware.

## 2.4. Handling

**CLASS A** and **CLASS B** hardware should never come into contact with anything except other **CLASS A** or **CLASS B** hardware, *UHV Gloves*, *UHV Aluminum Foil*, *Lint-free Wipes*, or the in-vacuo surfaces of the interferometer vacuum equipment. **CLASS A** and **CLASS B** hardware are to be unwrapped and handled only in a contamination sensitive area (see Section 6). All persons handling or working in the vicinity of **CLASS A** and **CLASS B** hardware shall at all times wear contamination control garb, see chart below for details. While working with **CLASS A** and **CLASS B** hardware, *UHV Gloves* should contact only **CLASS A** or **CLASS B** hardware; they must be changed immediately after contacting any other surfaces.

Note: When the white clean room fabric similar to that used for the chamber door soft covers (Burlington C3, white static-dissipative, clean room fabric) is contacting or will come into contact with Class A or Class B hardware, it should be handled as Class B hardware.

# 3 CONTAMINATION-SENSITIVE AREAS AND ACCESS PROTOCOL

Contamination sensitive areas are locations where personnel will be working in the vicinity of exposed Class A or Class B hardware. The contamination-sensitive areas in the corner station are the Optics Laboratory, the Vacuum Prep. and Assembly Area, the Vacuum Bake Oven Room, the Active Storage Area, the Laser and Vacuum Equipment Area (LVEA), and the Portable Clean Room Enclosures in the LVEA. The contamination-sensitive areas in the mid and end stations are the Cleaning Areas, the Vacuum Equipment Areas (VEA), and the Portable Clean Room Enclosures in the VEAs. All of these areas have HEPA-filtered air supplies. Access to all of these areas is restricted. Each person entering any of these areas must wear the required clean area clothing described below and follow the required procedures for handling and working in the vicinity of contamination-sensitive hardware as described in Section 2.

**TABLE 1 - GARB**

Where	Over shoe covers	Frock	Bouff. Cap	Mask	Hood	Suit	Over shoe boots
LSB Labs (LHO)	X	X	X	X			
OSB Optics Labs	X	X	X	X			
Clean and Bake Facilities	X	X	X				
ADVLIGO labs				X	X	X	X
ADVLIGO assembly cleanrooms				X	X	X	X
ADVLIGO Staging Building	X	X	X				
L/VEAs	X						
L/VEAs staging clean rooms	X	X	X	X			
L/VEA clean rooms with exposed vacuum chamber				X	X	X	X
L/VEA clean rooms with cloth covered vacuum openings	X	X	X	X			

*UHV Gloves* are required when handling or working in the immediate vicinity of contamination-sensitive hardware.

Whenever **CLASS A** or **CLASS B** hardware is left unattended, the area will be clearly marked. Exposed items will be covered with *UHV Aluminum Foil*.

There is an advisable method of donning the clean room garb. Always put garb on from top to bottom. Start with gloves, then mask, then hood (or cap), then suit (or frock), and finally boots (or clean room shoe covers). Change gloves, or put on a second clean outer pair, before touching Class A and B equipment.

Dedicated clean-area shoes can be worn instead of the *Overshoe Covers*. It is the responsibility of the wearer to ensure that the dedicated clean-area shoes are kept clean. These shoes should be kept in the garb rooms.

Garb rooms are anterior to all lab spaces, VEAs, and assembly cleanrooms. Utilize hangers and racks for reuseable items. Users are responsible for getting fresh garb at appropriate intervals. Rough cumulative durations for use before laundering are as follows:

- Frocks – 16 hours (less if working in dirty or strenuous conditions)
- Bouffant Caps – 8 hours
- Overshoe covers - 16 hours (unless inspection shows particulates or soiling)
- Suit/Hood – 4-8 hours depending on work conditions
- Cleanroom Boots - 4-8 hours depending on work conditions
- In-Chamber Boots - 4-8 hours depending on work conditions

Paper products are prohibited in all Contamination-Sensitive Area. Laptops should be utilized for note taking, etc. Drawings should be laminated before brought into the areas. Items that will be transported into the areas should be unpacked outside the area and particulates should be removed by vacuuming (either with a HEPA filtered vacuum cleaner or one that exhausts to the outside of the building) or other suitable method. Plastic baskets and carts are available on site and should be used to transport items into the contamination sensitive areas.

### **3.1. Portable Staging Clean Room Enclosures**

Portable clean rooms are utilized to stage CLASS A and B equipment outside of chambers for installation preparation. Once portable clean rooms are positioned over work areas, but before contamination sensitive equipment is loaded into the room, the room should be cleaned and inspected top to bottom. If the room is positioned such that vacuum equipment is inside of the room, the equipment must also be cleaned top to bottom. Any missing softwall curtains or broken HEPA filters should be replaced. The HEPA filter fan units must run continuously from 24 hours before work starts through the completion of the task.

During periods of work inside the portable clean room enclosures, an “outside helper” is usually utilized to avoid the need for gowned workers to exit the enclosure to retrieve supplies or perform other functions outside the enclosure. Portable radios also facilitate communication between portable clean rooms and reduce the need to physically transition between them.

### **3.2. Working Inside Interferometer Vacuum Chambers**

Many times, a worker must get fully into the chamber to gain access to equipment. In these cases, aside from the standard garb shown in Table 1, an additional Inside-chamber Overshoe Cover is required. These *Inside-chamber Overshoe Covers* must not contact any surface outside the vacuum chambers.

## **4 SPECIFIC WORK PRACTICES**

### **4.1. UHV Gloves**

Maintaining the cleanliness of *UHV gloves* is particularly challenging. First, it takes care and practice to get the *UHV gloves* on without touching the outside surfaces of them except at the very top of the cuff. Second, it is often difficult to avoid accidentally touching surfaces that are

neither Class A nor Class B when wearing *UHV gloves* intended for handling of contamination sensitive hardware. *UHV gloves* must be changed after such incidents.

## 4.2. Wipes

The sites supply a few types of wipes which can be used for a variety of purposes. See the chart below to identify which wipe to use for what task.

**TABLE 2 - WIPES**

Wipe	Use	Example
Contec Polyester wipe	General purpose – most widely used	Cleaning equipment, work surfaces, Class A or Class B Lint free
LensX 90 wipe	Optics	iLIGO wet cleaning of optics NOT lint free
Berkshire Polysorb wipes	Optics	iLIGO wet cleaning of optics NOT lint free

## 4.3. Solvents

Copies of Material Safety Data Sheets (MSDS) for all chemicals on site are available in the site MSDS notebooks.

Acetone, Isopropanol and Methanol are available and stored in yellow cabinets marked “FLAMMABLE”. These cabinets are located throughout the VEAs and labs.

It is best to use a fresh bottle of solvent for many applications. If you need a solvent bottle for Class A or Class B use, please fill your own. At LHO, there is a “filling station” just outside of the main entrance to the LVEA. The station is equipped with empty dispenser bottles, wipes for spillage, a flammable cabinet full of larger solvent bottles, disposable solvent bins, and gloves. Please bring bottles back to fill station when finished. The bottles will eventually get emptied and recycled for use.

If you need solvents for optic cleaning purposes, please see the site optics liaison. There are special cleaning procedures for optics.

Site usage for solvents can be categorized in the following table:

**TABLE 3 - SOLVENTS**

Solvent needed for	Examples	What to use	Solvent type	Handling
Cleaning Equipment	Wiping down work surfaces	Isopropanol	Reagent grade	Use standard, labeled, nalgene bottled solvent

Cleaning Class A and Class B	In-vacuum hardware and tool prep	Isopropanol Methanol Acetone	Reagent grade	See E960022 for proper usage
Cleaning non UHV optics	Drag wiping ISC table optics	Methanol	Reagent grade	Use standard, labeled, Nalgene bottled solvent
Cleaning UHV Optics	Drag wiping an IFO cavity optics	Methanol	99.99% pure	Use new, unopened 50mL bottle. Mark with opening date so solvent can be used in less critical application by another user.

## 5 PROCUREMENT AND DISTRIBUTION OF CONTAMINATION-CONTROL SUPPLIES

Numerous items related to contamination control are procured and stocked at the observatories. Reasonable quantities of each item will be on hand at all times. Anyone expecting to require an unusually large quantity of a stocked item should contact site liaison in advance to ensure availability.

The specific items stocked are described in detail in Appendix 1

The following rules apply to the procurement, receiving, stocking, and distribution of these supplies:

- Supplies which have been delivered but not yet unboxed, examined, and/or approved are to be stored in the Long-term Storage room or Receiving Areas.
- Upon examination and approval, supplies are stored in labeled cabinets in the Active Storage Area.
- Solvents are stored in the outside Chemical Storage Area located between the Operations Support Building (OSB) and the water tank.
- Re-seal partially-used packages of supplies to the Contamination Control Supplies Cabinets in the Active Storage Area.
- Contaminated items are to be discarded or placed in garment cleaning receptacles located in the Change Rooms.

## 6 MAINTENANCE OF CONTAMINATION SENSITIVE AREAS

All contamination sensitive areas should be cleaned with specialty cleanroom cleaning equipment.

**TABLE 4**

<b>Cleaning</b>	<b>Frequency</b>
Trash Removal	Daily
Damp Mop Floors	Weekly
Wipe down horizontal surfaces	Weekly
Wipe down walls and tops of flow benches	Monthly

Recommended sequence for cleaning:

1. Ceilings
2. Walls
3. Equipment
4. Floor

Wipe from top to bottom and in linear, overlapping strokes. Circular wiping re-contaminates area just cleaned. Refold wiper or replace as needed to expose a fresh surface.

## **7 GENERAL WORKING GUIDELINES**

To the maximum extent practicable, persons working in the vicinity of contamination-sensitive hardware should strive to reduce the possibility of particulate or hydrocarbon contamination introduced by themselves, their clothes, or items that they transport into the contamination-sensitive areas.

Concerning hydrocarbon contamination, the basic operating guideline is “**if you can smell it, it’s bad.**”

Specifically, persons working in the vicinity of contamination-sensitive hardware should:

- not wear articles of clothing that obviously shed particles (e.g., wool sweaters)
- bathe daily to minimize body odor
- wash work clothes frequently
- not use particularly fragrant body soap or shampoo
- not wear cologne, perfume, or excessively fragrant deodorant
- not wear make-up such as mascara, eye shadow, powder, etc.
- not smoke cigarettes or other forms of tobacco on days that they will be working in the vicinity of contamination-sensitive hardware
- not undergo strenuous physical exercise (significant perspiration) without showering prior to working in the vicinity of contamination-sensitive hardware
- not be coughing, sneezing, or have a runny nose



## APPENDIX 1 CONTAMINATION-CONTROL SUPPLIES AND CLOTHING

<b>Item</b>	<b>Description</b>	<b>Vendor</b>
<i>Acetone</i>	VWR brand, reagent grade Part # VW0330-3 4 L bottles	VWR Scientific  Account # 05-117460
<i>Acrylic Tape</i>	Long life clean room tape 1" x 60 yd #1164	UltraTape 2814 19 <sup>th</sup> St., SE Salem, OR 97302
<i>Acrylic Tape</i>	General use clean room tape 1" x 60 yd #1154	UltraTape 2814 19 <sup>th</sup> St., SE Salem, OR 97302 (503) 540-8946
<i>BayStat</i>	Clean room sheeting Class 100 stratogrey, single wound, rollstock	BayPac 3575 Haven Avenue Menlo Park, CA 94025 (650)364-3205 Voice (650)363-8079 Fax
<i>Bouffant Cap (Interim)</i>	Blue Polypropylene VTBFCBL-24	Value-Tek 1005 North 50 <sup>th</sup> Street Phoenix AZ 85008 (602) 256-0540 Fax: 602.252.1972
<i>Bouffant Cap (Permanent)</i>	White C3 polyester clean-room material	UniClean Cleanroom Services (See above)
<i>Clean Room Boots</i>	White C3, knee-high, polyester clean-room overshoe boots with 939 sole Sizes M, L, XL	UniClean Cleanroom Services 14321 NE Whitaker Way Portland OR 97230 (503) 256-5224 Fax: (503) 256-5254
<i>CP Stat 100 Bags</i>	Static control bags cleaned/assembled in Class 100 environment NO ZIPPERS (40m uses these)	Caltex Plastics <a href="http://www.caltexplastics.com/">http://www.caltexplastics.com/</a>
<i>Clean &amp; Static Sensitive Bags</i>	Static control bags cleaned/assembled in Class 100 environment WITH ZIPPERS	Seco Industries/Gramatech 6909 E Washington Blvd Montebello, CA 90649-5425 <a href="mailto:Sales@Seco-Ind.com">Sales@Seco-Ind.com</a> (373) 726-9721

<i>UHV Aluminum Foil</i>	Part # ASTM B 479 0.015" x 24" x 500' and 0.015" x 48" x 500' UHV Certified Aluminum Foil	All Foil 4597 Van Epps Road Brooklyn Heights, Ohio 44131 (216)661-0211 Voice (216)398-4161 Fax
<i>Coverall</i>	White C3 polyester clean-room coverall Sizes S, M, L, XL, XXL	UniClean Cleanroom Services (See above)
<i>Carbon Dioxide</i>	Instrument grade 50 lb. refill Part # X35530	Oxarc 716 South Oregon Street Pasco, Wa 99301 (509)547-2494
<i>Fast Sorb Towels</i>	Berkshire Fast Sorb #820 Class 100 wipers, 9" x 9" Part # 21914-208	VWR Scientific (see above)
<i>Frock</i>	White C3 polyester clean-room frock (knee-length coat) Sizes M, L, XL	UniClean Cleanroom Services (See above)
<i>Gloves(UHV use)</i>	Ansell Ultraclean latex gloves Sizes 6 1/2, 7, 7 1/2, 8, 8 1/2, 9 Part# 1009-395763,764, 766, 768	VWR, Grainger
<i>Hood</i>	White C3 polyester clean-room hood Sizes S, M, L, XL	UniClean Cleanroom Services (See above)
<i>Inside-chamber Overshoe Covers</i>	Non-marking shoe covers for standing inside the vacuum chambers (worn over the <i>Clean Room Boots</i> ) Sizes M, L, XL Part # LD-100 style 1096- M,L,XL	UniClean Cleanroom
<i>Isopropanol</i>	VWR brand, reagent grade Part # VW5520-3 4 liter bottles	VWR Scientific (see above)
<i>Mask</i>	Part # 10843-103 Kimberly Clark	VWR Scientific (see above)
<i>Methanol</i>	Reagent grade Part #VW4300-3 4ea. 4 liter brown glass bottles	VWR Scientific (see above)
<i>Methanol</i>	Sigma-Aldrich Gradient Grade, Chromasolv for HPLC 34885-100ML-R	VWR Scientific (see above)
<i>Mop heads (cleanroom)</i>		

<i>Nitrogen</i>	UHP Nitrogen C34380	Oxarc (See above)
<i>Overshoe Covers</i>	C3 white polyester slip on overshoe covers with rubber soles Sizes S, M, L, XL	UniClean Cleanroom Services (See above)
<i>Soft Cover-HAM Door C3</i>	white polyester with elastic drawcord. For HAM door flanges.	UniClean Cleanroom Services (See above)
<i>Soft Cover-BSC Dome- Flat</i>	C3 white polyester with elastic drawcord. For BSC dome flange.	UniClean Cleanroom Services (See above)
<i>Soft Cover-BSC Dome Tall</i>	C3 white polyester with elastic drawcord. For BSC dome flange, with stack installed	UniClean Cleanroom Services (See above)
<i>Soft Cover-68" O.D.</i>	C3 white polyester with elastic drawcord. For BSC door flanges.	UniClean Cleanroom Services (See above)
<i>Ultra-high-purity Compressed Nitrogen</i>	Cylinders of compressed gas. Part number C34380	Oxarc (See above)
<i>Vacuum (HEPA)</i>		
<i>Wipe (Lint-free) Lab use Contec</i>	Multi-knit polyester wipe, 9" x 9" Part # 1022-00699 Contec PNHS 99	VWR Scientific (see above)
<i>Wipe (Lint free) Lab use Alpha 10</i>		
<i>Lens 90 Tissue</i>	Berkshire Lens 90 9" x 9" lens tissue Part # 52847-149	VWR Scientific (see above)
<i>Wipe Facility cleaning use</i>		