

LASER INTERFEROMETER GRAVITATIONAL WAVE  
OBSERVATORY

- LIGO -

CALIFORNIA INSTITUTE OF TECHNOLOGY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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## **aLIGO Contamination Control Plan**

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*Distribution of this draft: LIGO Observatory Staff*

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

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 should be used for most Class A assembly work. Below is a list of Class B tools available at the sites in limited quantities. Please check with your site liaison to see if such a kit is available for your use. If not, team leads should procure tools which should be sent to the sites for proper Class B cleaning. Make sure to buy tools which are compatible with the Class B processing steps – ie. no oiled or plastic components. 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.

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 a few specialty ovens dedicated for specific subsystem use and are labeled as such. Do not use these unless authorized by that subsystem.

## 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.

Use only the approved supplies as listed in Appendix 1.

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.

### 2.4.1 UHV FOIL

While E960022 specifically calls for Class A and Class B processed hardware to be wrapped in UHV foil and then double-bagged in CPStat bags, it is preferred to store Class A hardware in Class B hard enclosures. Stainless steel tool pans and small glass dishes with lids are very useful for storing some hardware. This type of storage is best suited for fastener stock and other small parts in bulk quantities. For larger items, use the UHV foil for wrapping the part before bagging. For super large items (entire ISI or SUS assemblies) use C3 covers.

If possible shear the foil off the roll, as opposed to tearing, as we have some data which indicates that shearing might reduce the particulate generated during the cutting. Use UHV foil dispensers mounted to areas which will not shed foil particulate onto contamination sensitive hardware and surfaces.

When setting Class A and B components onto work surfaces, first wipe the surface clean with isopropanol, then utilize Class B trays or metal sheets as a barrier between the table and the Class A or B parts. *\*Note – it is preferable to set hardware directly onto WELL cleaned stainless steel and optical table surfaces, as opposed to foiling the table first. Clean the metal tables with acetone and then isopropanol. The table should be wiped down before every use.* This is a change from the iLIGO protocols.

### 2.4.2 MAINTAINING CLEANLINESS

In order to maintain cleanliness over the coming months and years, inspect outer packages as often as possible for tears and holes. These are most likely to occur after moving or transporting items. If at any time any Class A or Class B hardware is contamination compromised, reprocess the part to restore its Class, or obtain a waiver from the VRB. Inspect inner-foil bags for abrading foil. If inner foil bags are worn, as typically happens when the foil is wrapped and unwrapped numerous times, re-wrap item with new foil.

Inspect equipment periodically for cleanliness. Check horizontal surfaces for particulate. See Section 6 for cleaning schedule. Check internal areas of equipment, such washer tanks, for particulate. Flush or cleanout, such areas as needed.

## 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.

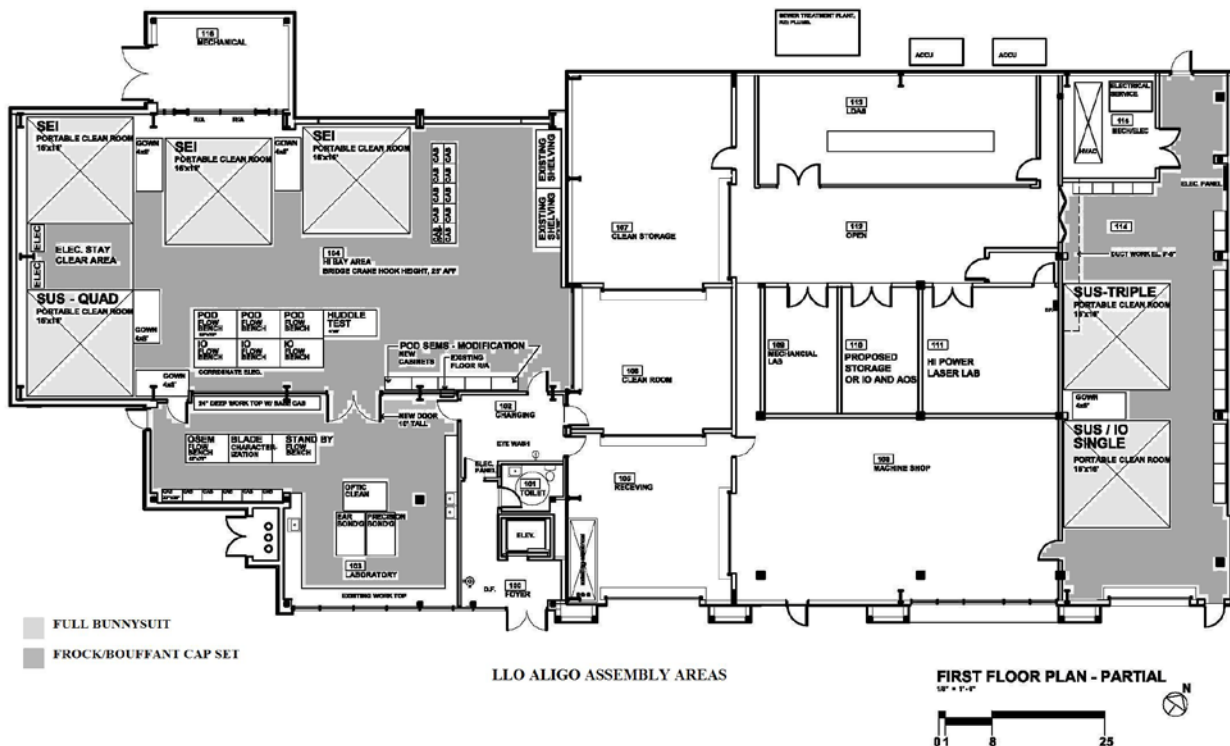
### 3.1 Work Areas

Table 1 summarizes what minimum garb is to be worn in what contamination sensitive areas at the LIGO sites. Following the table are layout diagrams of some of the areas.

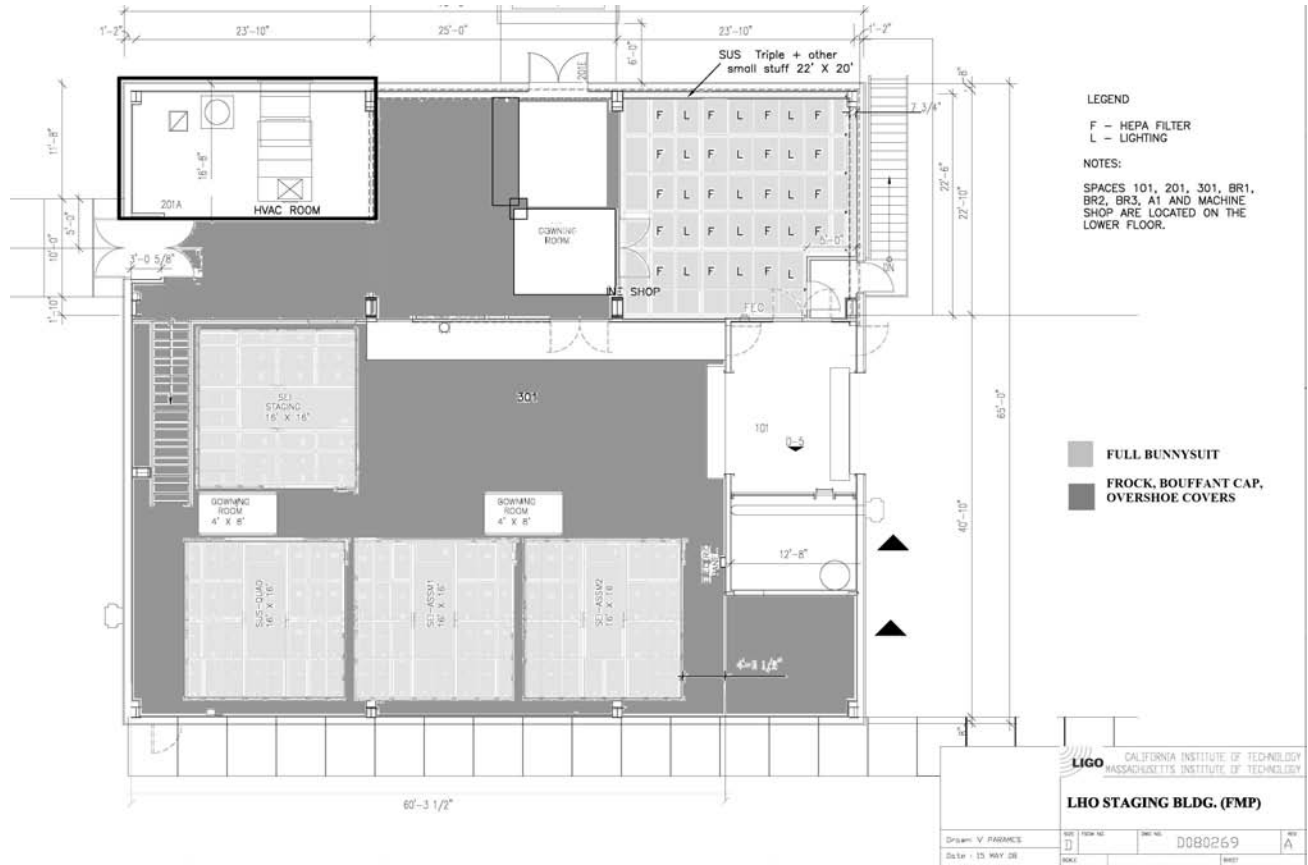
**TABLE 1 - GARB**

Where	Over shoe covers	Frock	Bouff. Cap	Mask	Hood	Suit	Over shoe boots
LSB Fiber Lab (LHO)	X	X	X	X			
LSB Bonding Lab (LHO)				X	X	X	X
OSB Optics Labs	X	X	X	X			
Vacuum Prep Warehouse Lab Spaces (VPWs)	X	X	X	X			
aLIGO cleanroom support areas	X	X	X	X			
aLIGO assembly cleanrooms				X	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			

**Diagram 1: LLO Staging Building (aLIGO Assembly Building)**



**Diagram 2:** LHO Staging Building (aLIGO Assembly building)



### 3.2 General Practices

*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.

HEPA filtered Garb rooms are to be placed just outside of all lab spaces, VEAs, assembly cleanrooms, and staging 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 - 8 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 in order to contain particulate that the paper generates. Items that will be transported into the areas (including laptops, carts, equipment, etc) should be wiped down with damp wipes. Items which are being received from shipping, must be unpacked outside the area and particulates should be removed by vacuuming or wiping down with damp wipes. For vacuuming in the aLIGO buildings, use only HEPA filtered vacuums, or ones which exhaust to the outside of the building. Plastic baskets and carts are available on site and should be used to transport bagged items into the contamination sensitive areas instead of cardboard boxes.

### **3.3 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.

### **3.4 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 Heat Sealed wipe (PNHS 99)	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

Acetone, Isopropanol and Methanol are available at the sites and are stored in yellow cabinets marked “FLAMMABLE”. Do not bring any solvents to sites. These cabinets are located throughout the VEAs and labs. Copies of Material Safety Data Sheets (MSDS) for all chemicals on site are available in the site MSDS notebooks.

It is best to use a fresh bottle of solvent for many applications.

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**

<b>Solvent needed for</b>	<b>Examples</b>	<b>What to use</b>	<b>Solvent type</b>	<b>Handling</b>
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	Spectral Grade	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. ONLY Observatory personnel should procure and stock these supplies. Anyone expecting to require an unusually large quantity of a stocked item should contact site liaison in advance to ensure availability. Likewise, if there is something not stocked at the sites which you will need, your liaison can help you get it stocked appropriately.

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:

- Do not procure items which are not on the following list, as some items need proper approval.
- Supplies which have been delivered but not yet unboxed and inspected are to be stored in the Long-term Storage room or Receiving Areas. Remove items from the cardboard boxes before introducing them to the clean areas.
- Solvents are to be stored in the outside Chemical Storage Area located between the Operations Support Building (OSB) and the water tank. Small quantities of solvents are to be stored in the Flammable cabinets located in any one of the VEAs or lab spaces.
- Contaminated items are to be discarded or placed in garment cleaning receptacles located in the Change Rooms.

- Do not introduce opened stock into back into the fresh stock of supplies. For example, do not pour smaller dispenser bottles of solvents back into the larger distributor containers of solvents. If supplies can be used for lesser controlled applications, bag and label as such and then return to the storage area. An example of this would be a stack of wipes which had been exposed to VEA Class 10,000 for a few weeks could be used to wipe down table top surfaces and cleanroom equipment.

## 6 MAINTENANCE OF CONTAMINATION SENSITIVE AREAS

All contamination sensitive areas should be cleaned with specialty cleanroom cleaning equipment. As well, cleaning staff will need to be trained on what garb to wear in which areas when cleaning.

**TABLE 4**

<b>Activity</b>	<b>Assembly Building Clean Spaces around cleanrooms</b>	<b>Assembly Cleanrooms</b>	<b>Bake Facility Clean Spaces</b>
Trash Removal	Daily	Daily	Daily
Vacuum/Damp Mop Floors	2-3x Weekly	2-3x Weekly	2-3x Weekly
Wipe down horizontal countertops/tables/handrail surfaces	Weekly	Weekly	Weekly
Wipe down horizontal hard-to-reach surfaces (tops of flowbenches, parts washer, cabinets, etc.)	Monthly	TBD As scheduled	Monthly
Wipe down extremely hard-to-reach places (Crane rails, ceiling ledges, tops of cleanrooms)	TBD As scheduled	TBD As scheduled	TBD As scheduled
Wipe down cleanroom curtains	Bi-weekly	Monthly	Bi-weekly
Wipe down walls	Monthly	Monthly	Monthly

Recommended sequence for cleaning:

- Ceilings
- Walls
- Equipment
- 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 and hydrocarbon contamination introduced by themselves, their clothes, or items that they transport into the contamination-sensitive areas. Personal hygiene is a very important factor to contamination control.

## APPENDIX 1 CONTAMINATION-CONTROL SUPPLIES AND CLOTHING

<b>Item</b>	<b>Description</b>	<b>Vendor</b>
<i>Acetone</i>	BDH ACS Grade VWR Part # BDH1101-4LG 4 L bottles	VWR Scientific
<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 (503) 540-8946 <a href="http://www.ultratape.com">www.ultratape.com</a>
<i>Acrylic Tape</i>	General use clean room tape 1" x 60 yd #1154	UltraTape see above
<i>Beard Covers</i>	Worklon 1177	UniClean Cleanroom Services 14321 NE Whitaker Way Portland OR 97230 (503) 256-5224 Fax: (503) 256-5254  Superior Uniform 800-298-7896 ACC# 10836381
<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 <a href="http://www.valuetek.com">www.valuetek.com</a>
<i>Bouffant Cap (Permanent)</i>	Worklon 1066 – Polyester  White C3 clean-room material	UniClean Superior Uniform
<i>Clean Room Boots</i>	White C3, knee-high, polyester clean-room overshoe Worklon 1117 - 939 sole	UniClean Superior Uniform
<i>CP Stat 100 Bags</i>	Static control bags cleaned/assembled in Class	Caltex Plastics (323) 583-4140

	100 environment NO ZIPPERS (40m uses these)	<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 (373) 726-9721 <a href="mailto:Sales@Seco-Ind.com">Sales@Seco-Ind.com</a>
<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 16100 Imperial Parkway Strongsville, OH 44149 800.521.0054 <a href="http://www.allfoils.com">www.allfoils.com</a>
<i>Coverall</i>	White C3 polyester clean- room coverall Sizes S, M, L, XL, XXL	UniClean
<i>Carbon Dioxide</i>	Instrument grade 50 lb. refill Part # X35530	Oxarc 716 South Oregon Street Pasco, Wa 99301 (509)547-2494
<i>Frock</i>	White C3 polyester clean- room frock (knee-length coat) Worklon 3442 (LHO) Worklon 3400 (LLO)	UniClean Superior Uniform
<i>Gloves(UHV use) Note - 1<sup>st</sup> choice has some distribution issues, 2<sup>nd</sup> choice packaging is known to shed ink, 3<sup>rd</sup> choice has higher self particulate count than other 2 choice, see E1100112s.</i>	<b>1<sup>st</sup> Choice:</b> Ansell AccuTech Ultra- Clean latex gloves Sizes 6 ½, 7, 7 ½, 8, 8 ½, 9 Part# 91-300	VWR Fischer Grainger Magid Glove & Safety Co.
	<b>2<sup>nd</sup> Choice:</b> Microflex CE4 Latex ISO4 gloves	<a href="http://www.microflex.com/Products/Clean-Environment-Product-Family/CE4-200.aspx">http://www.microflex.com/Products/Clean-Environment-Product-Family/CE4-200.aspx</a>
	<b>3<sup>rd</sup> Choice:</b> CT International SGPF Series, Class 100 latex gloves	CT International 4340 Old Santa Fe Road. San Luis Obispo, CA 93401. 800.755.7575 fax 805.544.5796
<i>Glove Liners (under latex gloves)</i>	ValueTek VTGNLR-1/2	<a href="http://www.valuetek.com">www.valuetek.com</a>
<i>Hood</i>	White C3 polyester clean- room Hood Worklon 1050 (LHO)	UniClean Superior Uniform

	Worklon 1056 (LLO)	
<i>Inside-chamber Overshoe Covers</i>	Non-marking shoe covers for standing inside the vacuum chambers (worn over the <i>Clean Room Boots</i> ) Part #LD-100 style 1096	UniClean Superior Uniform
<i>Isopropanol</i>	BDH ACS Grade VWR Part # BDH1133-4LG 4 liter bottles	VWR
<i>Mask</i>	Kimberly Clark VWR Part # 10843-197	VWR
<i>Methanol</i>	BDH ACS Grade VWR Part # BDH1135-4LG 4 liter brown glass bottles	VWR
<i>Methanol</i>	Sigma-Aldrich Gradient Grade, Chromasolv for HPLC 34885-100ML-R	VWR Scientific
<i>Mop heads (cleanroom)</i>	ValuTek VTCRMOP-716	ValuTek Corp
<i>Nitrogen</i>	UHP Nitrogen C34380	Oxarc
<i>Overshoe Covers</i>	C3 white polyester slip on overshoe covers with rubber soles Hypalon Sole (LHO) McM-C # 54165T78 (LLO)	UniClean McMaster-Carr
<i>Soft Cover-HAM Door C3</i>	white polyester with elastic drawcord. For HAM door flanges.	UniClean
<i>Soft Cover-BSC Dome-Flat</i>	C3 white polyester with elastic drawcord. For BSC dome flange.	UniClean
<i>Soft Cover-BSC Dome Tall</i>	C3 white polyester with elastic drawcord. For BSC dome flange, with stack installed	UniClean
<i>Soft Cover-68" O.D.</i>	C3 white polyester with elastic drawcord. For BSC door flanges.	UniClean
<i>Ultra-high-purity Compressed Nitrogen</i>	Cylinders of compressed gas. Oxarc Part # C34380	Oxarc

<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
<i>Wipe (Lint free) Lab use Alpha 10</i>	9"x 9" wipe VWR# TWTX8547	VWR
<i>Wipe - Lens 90 Tissue</i>	Berkshire Lens 90 9" x 9" lens tissue VWR Part # 52847-150	VWR
<i>Wipe – Absorbant (replacement product of Berkshire FastSorb)</i>	VWR Spec-Wipe 7 Wipers 9"x 9" VWR Part # 21913-214	VWR
<i>Wipe Facility cleaning use</i>		