



Controlled Area Practices

for the

Panametrics controlled areas
supporting GOES N, O, P, Q

prepared for

Hughes Space and Communications Company
1700 E. Imperial Highway
El Segundo, CA 90245

by

Panametrics, Inc.
221 Crescent Street
Waltham, MA 02454-3497

Signed and Dated/by:

Product Assurance _____
Frank Fantasia Date

Configuration Control _____
Gil Andrade Date

Program Engineer _____
Jeffrey E. Belue Date

Program Physicist _____
Frederick A. Hanser Date

Program Manager _____
Paul R. Morel Date



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Table of Contents

1.0	Reference Documents.....	5
2.0	Introduction and Purpose	6
3.0	Controlled Areas	6
3.1	Visitor Control	7
3.2	Preparing and Qualifying Cleanrooms and Clean Tents.....	7
3.3	Entering Controlled Areas	8
3.4	Entering a Cleanroom or Clean Tent	8
3.4.1	Portable Clean Tent Entry	9
3.4.2	Moving Equipment, Parts, & Materials Into a Cleanroom	9
4.0	Working in the Cleanroom and Clean Tent	10
4.1	Glove Practices	11
4.2	Use and Removal of Tapes and Adhesives.....	12
4.2.1	Tape Use	12
4.2.2	Tape and Adhesive Removal	12
4.3	Bagging and Sealing	12
4.4	Particle Fallout Alarm.....	13
4.5	Blacklight Inspection	13
4.6	Visual Inspection.....	14
4.7	Initial Cleaning of Cleanrooms	15
5.0	Maintaining and Monitoring the Controlled Areas.....	16
5.1	Controlled Area Maintenance	16
5.2	Cleanroom and Clean Tent Maintenance.....	17
5.3	Particulate Monitoring in Controlled Areas, Cleanrooms, and Clean Tents	18
5.4	Particulate Monitoring in Cleanrooms.....	18
5.5	Monitoring Organic Contamination in Cleanrooms	18
5.5.1	Preparing witness foils	18
5.5.2	Changing witness foils.....	19
5.6	Environmental Monitoring in Cleanrooms	20
6.0	Leaving the Cleanroom	20
6.1	Removing Hardware From The Cleanroom.....	21
6.2	Leaving the Controlled Area.....	21
7.0	List of Acronyms and Definitions	21
	Appendix A, Cleanroom Buyer's Guide	23



List of Tables

Table 1, Possible External Contamination Sources	11
Table 2, Cleanliness Inspection Levels per SN-C-0005	15
Table 3, Certification tag for witness foil	20

1.0 Reference Documents

The below list of Panametrics documents is provided for reference only. Some of the material in those documents is appropriate backup material for this document.

Panametrics

GOESN-ENG-001	Contamination Control Plan for the Solar X-Ray and EUV Sensor (XRS/EUV), the Energetic Particle Sensor (EPS), and the High Energy Proton and Alpha Detector (HEPAD) for GOES NO/PQ
GOESN-RTP-190	Thermal Vacuum Bake-out Procedures
GOESN-RTP-197	Handling, Storage, Packaging, and Transportation Procedures for the XRS/EUV
GOESN-RTP-198	Handling, Storage, Packaging, and Transportation Procedures for the EPS/HEPAD
GOESN-ENG-005	Controlled Area Practices (this document) Cleanroom Buyer's Guide (Appendix A, this document)
GOESN-SPL-001	SCDRL # 16, Summary of Parts List and Part Specifications
GOESN-M&P-001	SCDRL # 17, Materials and Processes List and Specifications

ASTM

ASTM E1234	Standard Practice for Handling, Transporting, and Installing Nonvolatile Residue (NVR) Sample Plates Used in Environmentally Controlled Areas for Spacecraft
ASTM E1235	Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft.

Military and Federal

MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program
FED-STD-209	Airborne Particulate Cleanliness Classes in Cleanrooms and Cleanzones*
SN-C-0005	Contamination Control Requirements for the Space Shuttle Program

* Available from Standardization Documents Order Desk, Bldg. 4 Section D.
700 Robbins Ave., Philadelphia, PA 19111-5094, Attn. NPODS.

2.0 Introduction and Purpose

This guide establishes safe contamination control guidelines for personnel working in the Panametrics Controlled Areas and Clean Zones. The information provided herein serves as a supplement to the contamination control training course and follow-up 'spot-training' sessions, which are provided for all personnel who work in the controlled areas. All personnel who work in the controlled areas or clean tents must receive prior contamination control training appropriate for the tasks they will be performing. See Section 3.1, 'Visitor Control' for access requirements for temporary visitors. Strict observance of the following practices will ensure that the GOES instruments meet the specified cleanliness requirements upon delivery.

While this document focuses on the contamination control aspects of controlled area operations, it is important to also adhere to ESD (Electrostatic Discharge) guidelines and other practical issues (such as standard safety and QA procedures) when working in the controlled areas.

3.0 Controlled Areas

A 'controlled area' (as defined in ASTM E1234) is an area that is controlled and monitored for environmental conditions such as humidity, temperature, pressure, electrostatic charge, or particulate or molecular contamination levels. Controlled areas are operated as cleanrooms, but may not have the final stages of HEPA or other cleanroom filters, and are not monitored for particulate levels. Panametrics has two such areas. The 'Panametrics Controlled Area' (PCA) is a controlled area with HEPA filtered air input, and temperature and humidity monitoring, but no particulate monitoring. The 'Panametrics Cleanroom' (PCR) is a controlled area with full HEPA air filtration and particulate monitoring, and is operated as a Class 10,000 Cleanroom. All of the inspection, assembly, and test of GOES flight hardware is performed either in the PCA or the PCR. Final assembly of the XRS/EUV will be performed exclusively on a laminar flow bench within the PCR. Access to the thermal vacuum chamber is from inside the PCR. All personnel who participate in activities in the PCA or the PCR must adhere to the controlled area practices described herein. In addition, all personnel who work within Class 10k (per FED-STD-209) or cleaner areas (the PCR) must be trained in cleanroom operations, or must be accompanied by a trained individual. See Section 3.1, 'Visitor Control' for cleanroom (PCR) access requirements for temporary visitors.

A 'clean zone' (or 'clean tent' or 'cleanroom', as per ASTM E1234) is an area that is controlled to a specified cleanliness level. It is a controlled working environment consisting of lighting fixtures and HEPA (High Efficiency Particulate Air) filters, which is typically enclosed within clear walls. Clean tents will be used in a number of locations to provide a clean, controlled working area, and to protect flight hardware from contamination. Strict cleanliness requirements are always in affect within the clean tents. A portable tent shall be used during testing at outside locations (during vibration and calibration of the XRS/EUV, for example), unless it is possible to suitably bag the instrument to prevent contamination.

Portable clean tents will be constructed, cleaned, and monitored in similar fashion to the fixed cleanroom (the PCR). Prior to utilizing a portable clean tent as a clean area, the interior of the tent will be

thoroughly cleaned typically by using Panametrics approved IPA-dampened cleanroom wipes. Panametrics approved IPA is listed in Appendix A , Cleanroom Buyer's Guide. All items and hardware within the enclosed tent will also be similarly cleaned. Surfaces within the clean tents that cannot be thoroughly cleaned will be otherwise prepared to eliminate, isolate, or minimize, the risk of contamination. For example, vibration tables will be cleaned as well as practical, and then all exposed surfaces will be covered with layers of approved bagging material and Kapton tape. All of the contamination control guidelines for working in cleanrooms also apply to portable environments. See Section 3.2, 'Preparing and Qualifying Cleanrooms and Clean Tents' below on preparation and qualification of portable clean tents.

3.1 Visitor Control

Personnel not associated with the Panametrics Space Instrumentation Division (SID) ('visitors') can only enter a controlled area (the PCA or PCR) when escorted by personnel who are associated with the Space Instrumentation Division (an 'escort') and who have been trained in these procedures. Visitors may be required to handle flight hardware while in the controlled areas, and must therefore be trained in contamination control practices commensurate with their required activities within the controlled areas. Under these circumstances the following minimum practices must be observed:

1. Visitors must be made aware of the controlled area practices at the time of their first visit. A 'Visitor Log' shall be maintained in the Controlled Area, and visitors shall sign this log to indicate that they have been advised of the contamination control practices in effect. The escort shall initial next to the visitor's signature. ESD and safety issues must also be described at this time.
2. Visitors must initially be accompanied into the Controlled Area, and proper gowning techniques must be demonstrated upon entering.

The Product Assurance Manager, the Program Engineer, or the Program Manager shall be responsible for ensuring that these visitor practices are observed. If a visitor will be repeatedly entering the Controlled Areas, contamination control training by the CCE will be required.

3.2 Preparing and Qualifying Cleanrooms and Clean Tents

Prior to exposing flight hardware within a newly built cleanroom or portable clean tent, a thorough interior cleaning must be done. Observe the following procedures for such clean zones.

For initial cleaning and preparation of clean zones, clean the area using standard household cleaning techniques, including sweeping, mopping, etc. Vacuum all surfaces that may contain large quantities of dust or particulate matter.

Assemble the cleanroom or clean tent as designed so that a contamination-controlled area is well defined. This typically requires 100% coverage of the area above, and to the sides of the area in which flight hardware will be exposed. If the cleanroom includes HEPA filters, they shall be turned on following assembly, and must remain on for at least 12 hours prior to exposing flight hardware to the airflow.

Don cleanroom garments, and enter the area as described in Section 3.4, 'Entering a Cleanroom or Clean Tent'. Prepare the entire exposed surface area within the cleanroom by cleaning and/or covering all

exposed surfaces. This includes wiping down the interior walls and floors of the area as in Section 4.7 'Initial Cleaning of Cleanrooms'. Isolate or cover any exposed areas that are difficult to clean or contain materials that are listed in the 'table of Restricted Materials' in the Contamination Control Plan, GOESN-ENG-005. Use approved ESD bagging material (Llumalloy) and Kapton tape to fully isolate such surfaces. Materials that may produce particulate contamination shall also be isolated in this way. Focus shall be placed on areas in which flight hardware will be placed, and these areas must be wiped several times, using clean wipes each time. The entire area must pass the 'white glove test' prior to use, which means that when a Panametrics approved, IPA-moistened cleanroom wipe is used to wipe the surface, there are no visible signs of contamination when inspected under normal room lights when held at arm's length (VCS, see Table 2).

When the zone has been fully cleaned, and HEPAs have been turned on, GSE and supplies can be brought into the new clean zone. All articles entering the clean zone must be cleaned upon entry as described in Section 3.4.2, 'Moving Equipment, Parts, & Materials Into a Cleanroom'. The clean zone is ready for flight hardware when the above conditions have been met. Maintain and monitor the clean zone as described in Section 5.0.

3.3 Entering Controlled Areas

The Panametrics SID incoming inspection, assembly, and test areas are examples of controlled areas (PCA). Entrance requirements for controlled areas are not as strict as for entrance to a cleanroom (PCR). Most of the Panametrics controlled areas only require the use of ESD-safe gowns (and wrist-straps). Tacky-mats are provided, however, to reduce the amount of debris entering the controlled area due to the use of street shoes. When entering a controlled area:

- Step first onto the tacky-mat at the controlled area entrance. Step side-to-side several times to dislodge any debris from street shoes.
- Select a gown from the rack, and fully zip the gown. Gowns are not to be worn outside of the controlled areas (into hallways, for example).
- Observe proper ESD safety procedures (wrist-straps are required)
- Sign visitors into the controlled area (See Section 3.1, 'Visitor Control')
- If other tacky-mats are present at the subsequent entryways, step onto the mat, and step side-to-side several times before entering controlled area.
- Change the mat if you notice that it no longer provides a 'sticky' surface. Remove the old mat by peeling it back from the corner, to expose a clean surface.

3.4 Entering a Cleanroom or Clean Tent

Proper apparel (hood, smock, beard cover, gloves, and shoe covers) must be worn in order to enter the cleanroom (PCR), even if entry is only for a brief period. It is important to never compromise the integrity of an operating cleanroom by entering the room without proper attire or appropriate preparation of incoming hardware. Fixed cleanrooms have a separate gowning area called an anteroom. Portable tents may not always have a gowning area. If one does not exist, observe the techniques below, but gown inside, and near the entrance to the clean tent. To enter a cleanroom or clean tent:

- Cut open (do not tear) garment bags. Scissors shall be available at all cleanroom entryways.
- There shall be a tacky-mat outside of the cleanroom entrance. Step onto the mat with street shoes, and step side-side several times to dislodge any loose particles from street shoes. Put on a pair of shoe-covers outside of the cleanroom, and step inside and onto the tacky-mat that is located just inside of the cleanroom entrance. Step onto the mat with both feet, and then side-to-side several times to dislodge any loose particles.
- Place a bonnet or bouffant on the head. Be sure to capture all hair inside the bonnet.
- Put on a smock next, and fully zip the smock. Do not allow the smock to contact the floor at any time.
- Place a wrist-strap on wrist, underneath wrist cuff (in contact with skin).
- Put on glove liners and gloves next. Be careful not to touch the glove anywhere except in the cuff area. Pull the gloves well beyond the cuff of the smock so that there are no 'gaps' at the wrist.
- Put on facemask last, using gloved hands. Avoid touching exposed areas of the face or skin with gloved hands. If there is a beard, beard covers shall be required, and shall be used instead of the mask.
- If it is anticipated that you will be in the cleanroom for a long time, and that numerous glove changes will be necessary (i.e. that you are working on very sensitive hardware), you may choose to put on a second pair of gloves at this time. This is referred to as 'double-gloving', and is used to facilitate glove-change without contaminating the new gloves with finger oils, etc.
- Step into the cleanroom, and directly onto the inner tacky-mat. Transfer articles into the room from this position (half in, half out). See procedures below for transferring articles into the clean area.

Note: All of this apparel may be worn several times before it must be discarded or cleaned, except for gloves, which must be discarded after each use. Use discretion as to whether or not to use new apparel, based upon the upcoming task, and the level of cleanliness of each item. Smocks must be cleaned and bagged to cleanliness level 100 per MIL-STD-1246.

3.4.1 Portable Clean Tent Entry

All of the above rules for entering cleanrooms apply for entering portable tents. The portable tents will be stocked with all of the required garments and cleanroom materials. Portable particulate monitors will be used in these environments to monitor the particle level when flight hardware is present (and to qualify the area prior to exposing flight hardware.)

3.4.2 Moving Equipment, Parts, & Materials Into a Cleanroom

Equipment, parts, and materials must be brought into the cleanroom in order to perform work in that area. Every item that enters a cleanroom must be considered 'dirty', and must be precision cleaned prior to entering the cleanroom. Items that are already clean to GOES XRS/EUV requirements and are suitably protected by approved packaging material (see Section 4.3) do not need to be re-cleaned. At a minimum, all GSE shall be Visibly Clean Sensitive (VCS, see Section 4.6, Table 2 for definitions) and free of oils or lubricants. Flight hardware shall meet VCHS+UV light levels of cleanliness. Cleaning procedures are given elsewhere (see the GOES Contamination Control Plan in Section 1.0, 'Reference Documents'). The proper procedure for taking an item into a cleanroom is described below.

To move GSE and flight items into a cleanroom:

- Remove the item(s) from any external packaging material. Always cut open (never tear) bags. If the item has already been precision cleaned, remove only the outer, moisture-barrier bag, not the inner two bagging layers or toteboxes. Place the item(s) on a rack or table outside the entrance to the cleanroom. Perform a gross cleaning of dirty items (typical household-style cleaning of the item: vacuuming, sweeping, and initial wiping with Panametrics approved IPA and cleanroom wipes).
- Transfer the item to a shelf or rack inside the gowning area, or anteroom.
- Don cleanroom attire as described in Section 3.4, 'Entering a Cleanroom or Clean Tent'.
- Prepare the item for entry into the cleanroom. The intent is to remove dust and other debris, and to prohibit or mitigate the transfer of molecular contamination to flight hardware. Every single item that enters a cleanroom must be cleaned prior to entry. All items must be cleaned such that if left in the cleanroom, others may assume it has been cleaned appropriately. Certain items may require additional preparation such as isolating or enclosing incompatible materials with Kapton tape and/or ESD bagging material, etc. An example of an item that must be isolated this way is an oscilloscope power cord, which can be sealed either with Kapton tape or with ESD-bagging tubes. Contact the CCE if you are unsure how to prepare an item for entry into the cleanroom.
- For items that are already precision-cleaned, including double-bagged items, or items in approved precision-cleaned toteboxes, wipe the outside of the second bag or totebox with Panametrics approved IPA dampened cleanroom wipes (hands shall be gloved).
- Transfer the item to the rack or table inside the cleanroom and step inside, observing proper clean area entrance protocol.
- Double-glove if necessary, and remove the item from the totebox or second bagging layer to perform final wipe-down with Panametrics approved IPA-moistened cleanroom wipes if required. Immediately transfer the totebox or outer bag layers back into the anteroom.
- Wipe the transfer area with Panametrics approved IPA-moistened wipes to remove residue or packaging material, and discard the used wipes prior to fully entering the cleanroom.
- Precision clean remaining items as necessary.

4.0 Working in the Cleanroom and Clean Tent

While working in clean areas, always be aware of possible contamination sources. Consult the Contamination Control Plan or the CCE regarding common sources of contamination, or how to prevent contamination events. It is prudent to 'clean-as-you-go' when working in clean areas. Do not leave particles or debris lying in piles. Even the debris generated by installing screws into hardware can damage flight hardware, and shall be cleaned up immediately. Typically, such cleaning only requires wiping with an alcohol-dampened cleanroom swab or wipe. The only approved alcohol for wipes is Panametrics approved IPA (Isopropyl Alcohol). Discard swabs and wipes immediately after use. The area is typically considered clean if no particles or residue can be seen on the wipe or swab when held at arm's length in a well-lighted room. This is the 'white-glove' test for clean areas.

Contamination events are sometimes the result of distant, external sources, unrelated to cleanroom activities. An example of such an event would be a sudden 'whiff' of paint or diesel fuel, while working

in the cleanroom. If such a contamination event occurs, quickly enclose, cover, or otherwise protect all exposed flight hardware, starting with the most sensitive item(s). It may be prudent to turn OFF the HEPA filters if the event is serious enough to be capable of clogging them (for example, a small electrical fire in a nearby room). Always try to be aware of such activities that may be taking place, and take necessary precautions. The table below illustrates some possible external contamination sources.

Table 1, Possible External Contamination Sources.

Activity	Examples
Painting	Halls, GSE, doorways, adjacent buildings
Adhesive bonding, gluing	Installation of carpets, flooring, base board molding, epoxies
Combustion engine operation	Near air intakes: cranes, forklifts, delivery trucks
Insecticide spraying	Inside or outside the building
Storage of materials that outgas	Storing large quantities of plastics, wood products, laminates, lubricants, when the air volume where they are stored can enter the cleanroom or cleanroom air supply
Roof or road sealing operations	In and around building and especially near building air intakes
Sealant, caulks	Windows, bathrooms, ceiling tiles, HEPA filters
Sandblasting, sanding, grinding, jack hammering	Near air supply intakes, in areas adjacent to cleanroom
Miscellaneous fumes	Fires, heat-generating processes, chemical reactions, oven or vacuum pump exhaust
Repair, replacement, or lubrication of cleanroom equipment	Air handling equipment, cranes, doors, etc.

The clean areas will be regularly maintained and monitored, but it is everybody's job to clean up after oneself (in addition to sometimes cleaning up after others). If a work area is observed to be 'dirty', clean the area immediately. It is good practice to clean and prepare all work areas prior to, and following, your work.

Do not use the horizontal flow bench for any activity that would compromise the cleanliness level of the bench. The horizontal flow bench shall be used for assembly of the XRS/EUV telescopes and temporary storage of flight hardware.

4.1 Glove Practices

Do not touch face or skin with gloved hand (fingers), as this will transfer oils to the finger tips, which will in turn transfer oils to flight hardware. When working in the cleanroom, always be aware of everything that 'clean' gloves contact. Change gloves often when working with flight hardware, and whenever the gloves have contacted possible contamination sources. 'Double-gloving' is often easier than changing gloves due to sweat on hands. Gloves may be cleaned during certain applications (not when handling

flight hardware) by wiping them with Panametrics approved IPA and cleanroom wipes. Use discretion as to whether or not the future use of gloves will require a glove change or an alcohol wipe.

4.2 Use and Removal of Tapes and Adhesives

Residues from tapes and other adhesives are a large source of contamination. Whenever tapes or adhesives are used on flight hardware, observe the following practices:

4.2.1 Tape Use

- Use only approved tapes (see the Materials and Processes List and Specifications)
- Limit quantity of tape used and duration of use
- Minimize the temporary use of tapes to fasten items during ground operations
- Remove tape ASAP (the longer the tape is attached the harder it is to remove the residue); likewise clean off the residue immediately
- Use tape with caution; some surfaces are impossible to clean without risk of damage (titanium, thermal control paints, sensor surfaces, etc.)
- Do not use flight surfaces to temporarily hold cut pieces of tape
- Be careful not to get adhesive residues onto your gloves (and change them if this happens)
- When applying tapes that will be flown be sure to smooth down all surfaces to prevent exposure of adhesive surfaces
- Where possible, use approved cable tie wraps instead of tape for temporarily fastening harnesses and other items
- Do not use tape to temporarily hold nuts, bolts, screws or other small parts
- Clean all residues thoroughly and inspect with black light as required

4.2.2 Tape and Adhesive Removal

When removing tapes, it is best to pull the tape at an angle of 145 degrees or more from the surface (almost doubled-back on itself). At this angle, the adhesive has a greater tendency to remain stuck to the tape than to the hardware. All residues from tapes or other attached sensors (accelerometers, strain-gauges, thermocouples, etc.) must be thoroughly removed. If the residue cannot be removed, contact the contamination engineer. Do not use sharp instruments to remove adhesive or epoxy residues from the surfaces of the flight hardware. This can damage the surface, and alter the desired properties of the surface finish.

If a large quantity of adhesive does remain on the item following tape removal, attempt to 'ball-up' the adhesive residue, as you would do for rubber cement on paper. If the residue is too dry for this, moisten it with Panametrics approved IPA, let the IPA evaporate, and then attempt to ball it up again while the adhesive is still damp. After all large quantities of adhesive are removed, wipe away the remaining residue with a non-particulating cleanroom wipe or swab that has been moistened with IPA.

4.3 Bagging and Sealing

When transporting clean items outside of the clean tent, all items must be double bagged (see below for items that leave the building). The bags must be of an approved ESD-bagging material. Re-sealable 'zip-lock' ESD bags may be used for small items (anything small enough to fit inside of a bag). Kapton tape seals may be used instead of, or in addition to, sealers or zip-lock bags. For transportation within the building, a precision cleaned ESD-safe totebox or clear polyethylene (HDPE) or polypropylene container may be used in lieu of the second, outer ESD bag. However, if the item is to leave the building, it must be double bagged as above, and then a third moisture barrier bag must be used. The third, outer bag must be an approved, heavy gauge moisture barrier.

Bag sealers may be used to seal small parts for storage or transportation. Be sure to seal the bag fully. Also be sure that the seal is intact (incorrect sealing time and temperature may result in a range of sealing conditions from loose seals to burn holes.) Always double-bag clean parts that will leave the cleanroom, so that they do not need to be re-cleaned following return.

4.4 Particle Fallout Alarm

Particle monitors are used within the cleanroom areas to indicate the quantity and size of particulate contamination present in the area. The monitor alarms are preset by the CCE to indicate when the particle level exceeds the safe (for flight hardware) working level. The particle monitor alarm is a continuous, high-pitched 'beep'. The alarm will typically indicate that too many people are working in the clean area. Send non-critical personnel out of the area if this is the case. If the particle monitor alarm continues to sound, prepare to cover any exposed work to protect it from high levels of particulate fallout. This typically only requires covering the work with approved ESD-safe bagging material. Note the time and details of any particle-monitor alarms in the instrument assembly log and the cleanroom log. If there is a possibility of particulate contamination to flight hardware, alert the Contamination Control Engineer. It may be necessary to inspect and clean the instrument and the cleanroom area. Alert the CCE to any unusual or persistent alarm conditions.

4.5 Blacklight Inspection

Periodic blacklight inspections shall be performed to ensure that the flight hardware meets the individual particle level specifications. This applies to both internal and external surfaces of the XRS/EUV, but only to external surfaces of the EPS/HEPAD. Use of a blacklight significantly increases the visibility of particulate contamination. The high level of ultraviolet (UV) light emitted from some commercial blacklights can cause retina damage if the eyes are not properly protected. It is therefore necessary that all personnel working in the vicinity of blacklight inspections wear UV absorbing protective lenses or goggles. Room lights must typically be turned OFF during a blacklight inspection, which may also impact other activities taking place outside of the inspection area. Personnel working within the cleanroom must be advised of the ongoing blacklight inspection, and shall don appropriate protective eyewear (or leave the area). Prior to performing blacklight inspections, warning signs must be posted that state:

-- Warning --

**"Blacklight inspection of flight hardware is in progress.
Hazardous levels of ultraviolet light are present.
Do not enter this area without UV protective goggles."**

Blacklight inspections will be called out on the assembly instruction sheets. They will typically be performed prior to 'closing out' an area, which may be the last time that access will be possible. Particles that are identified during blacklight inspections will be removed immediately using Panametrics approved IPA dampened swabs or wipes, according to the table below, and as required by the assembly instructions.

4.6 Visual Inspection

This and other procedures call for the visual inspection of GSE and flight hardware surfaces. The following table illustrates the criteria for the different types of specified inspections. If a procedure calls for one of the following levels, and the item does not pass, it must be cleaned until it reaches the required level:

Table 2, Cleanliness Inspection Levels per SN-C-0005

Inspection Level	Incident Light Level (1)	Requirement and Method	Remarks
Visibly Clean (VC)	50 foot-candles	Clean (free of dust, debris, or films) when viewed from a distance of 5 to 10 feet in normal room lighting conditions, 50 foot-candles. If cleaning with solvent or water dampened wipes, the wipe will show no visible contamination when viewed from the same distance.	(2) (3) (5)
Visibly Clean Sensitive (VCS)	50 foot-candles	Clean (free of dust, debris, or films) when viewed from a distance of 2 to 4 feet in normal room lighting conditions, 50 foot-candles. If cleaning with solvent or water dampened wipes, the wipe will show no visible contamination when viewed from the same distance.	(2) (3) (5)
Visibly Clean Highly Sensitive (VCHS)	100 foot-candles	Clean when viewed obliquely or normally at a distance of 0.5 to 1.5 feet. If cleaned with solvent dampened wipes, the wipes will show no visible contamination when viewed from the same distance.	(3) (4)
Visibly Clean Highly Sensitive + UV light (VCHS+UV)		Clean to VCHS level plus clean when viewed in a darkened room with ultraviolet light at a distance of 1 to 3 feet (see special instructions in Section 4.5). The presence of up to 3 visible particles per square foot is acceptable.	

NOTES:

- (1) One foot-candle (lumens per square foot) is equivalent to 10.76 lumens per square meter.
- (2) Cleaning is required if the surface in question does not meet VC under the specified incident light and observation distance conditions.
- (3) Exposed and accessible surfaces only.
- (4) Initial cleaning is mandatory; Note (2) applies thereafter.
- (5) Areas of suspected contamination may be examined at distance closer than specified for final verification.

4.7 Initial Cleaning of Cleanrooms

The cleanroom and entry/gowning area shall be cleaned according to the following procedure. This procedure shall be used upon initial assembly, and when any large contamination event compromises the integrity of the room (such as a prolonged loss of air-handler, fire, serious breach of cleanroom protocol,

breakdown of portable facilities, or opening a cleanroom ceiling-tile to change out light bulbs). Use only approved class 100 cleanroom wipes, mops, and buckets. Records shall be kept in the cleanroom logbook, and will indicate the task, the date, and by whom the work was completed.

- Always work from ceiling to floor. Wipe walls and vertical surfaces, using Panametrics approved IPA dampened cleanroom wipes. For large areas, use a mixture of 30% IPA to 70% DI water. This minimizes the exposure of personnel to high concentrations of IPA and associated fumes. A cleanroom mop (with a new head) shall be used for these surfaces.
- Damp-mop floors, using Panametrics approved IPA or Simple Green Solution (10% Simple Green to 90% de-ionized water) and cleanroom mop. Whenever Simple Green Solution is used the area must be rinsed 2 to 3 times with IPA and/or DI water.
- Always work towards the entryway from the point farthest away from the entryway (do not paint yourself into a corner). Wipe all horizontal surfaces, using Panametrics approved IPA moistened cleanroom wipes.
- Vacuum walls and floors using approved ULPA vacuum cleaner. Walls need only be vacuumed upon initial cleaning.
- Clean all furniture and GSE to a level of Visibly Clean (VC) or better.
- Verify initial cleaning process by sample inspection using blacklight to cleanliness level VCHS+UV.

5.0 Maintaining and Monitoring the Controlled Areas

To maintain quality and performance standards, all assembly and test areas must be kept as clean as practical during the assembly of flight instrumentation. While the XRS/EUV parts will be cleaned prior to assembly, some contaminants are very difficult to remove (and may be difficult even to detect). It is therefore most prudent to prevent the hardware from ever contacting molecular contamination sources. Contamination can be prevented if a conscious effort is taken to maintain clean work areas.

5.1 Controlled Area Maintenance

Good housekeeping practices must be used within the controlled areas (assembly and test areas, PCA). Items within the controlled areas may be inspected to insure that they are visibly clean (see Section 4.6). Use Panametrics approved IPA and cleanroom wipes for cleaning tasks (for floors and large areas, use 10% Simple Green or IPA to 90% DI water). . Whenever Simple Green Solution is used the area must be rinsed 2 to 3 times with IPA and/or DI water. Good housekeeping maintenance practices include:

- Maintain clean work areas by wiping daily with IPA dampened wipes. Discard assembly remnants as generated, and do not allow debris piles or clutter to accumulate around work areas.
- Inspect/change entrance tacky-mats daily or as needed.
- Pull all ESD smocks from hangers every month for laundering. Gowns must be laundered and packaged to Class 100 cleanliness conditions.
- Wipe all exposed horizontal surfaces, including floors, shelves, etc., monthly.
- Wipe all exposed vertical surfaces every 60 to 90 days.
- Clean all 'hard-to-reach' surfaces every 6 to 12 months.
- Wear approved gloves whenever handling completed and cleaned printed circuit boards.

- Refresh tacky-mat whenever the adhesive no longer provides 'stiction.' Tacky-mats are refreshed by peeling from the corner, removing, and discarding the top-most layer.

Wax and oil-based products contaminate the air through outgassing, and leave residues on surfaces that can be transferred to flight hardware. Do not use such cleaning products on floors or work surfaces. Mops, buckets and other supplies used to clean the floor and work surfaces shall be kept in good repair and shall not be heavily soiled. They shall be made of materials that will not contaminate the room. Stainless steel or polypropylene buckets and polyurethane sponge-mops or cleanroom mops are recommended. Do not use string mops or cellulose sponges.

5.2 Cleanroom and Clean Tent Maintenance

Cleanrooms shall be maintained according to the schedule below. Cleaning methods are outlined in Section 4.7. Maintenance records shall be kept in the cleanroom logbook, and will indicate the task, the date, and by whom it was completed.

- Restock cleanroom supplies, including gloves, shoe-covers, beard-covers, face masks, garments, cleanroom wipes and swabs, solvent squirt-bottles, and other supplies daily or as needed.
- Perform a top-down cleaning of the entire area prior to use or storage of flight hardware (the CCE will assist in this cleaning). This is especially true for portable clean tents. See Section 3.2.
- Wipe or mop all exposed horizontal surfaces, including floors weekly.
- Clean and inspect all work surfaces to VCHS prior to and during each use.
- Launder garments weekly (no more than 40 hours usage). The best technique is to remove all hanging garments each Friday. Garments must be bagged and packaged to Class 100 cleanliness condition.
- Clean exposed vertical surfaces every 45 to 60 days. (Walls typically do not need to be cleaned after the initial cleaning.)
- Clean and vacuum 'hard-to-reach' areas every 6 months.
- Refresh tacky-mat whenever the adhesive no longer provides 'stiction'. Tacky-mats are refreshed by peeling from the corner, removing, and discarding the top-most layer.

Portable tents shall be maintained in a similar fashion. Since portable tents will not be used continuously, the cleaning and monitoring need not be continuous. When the activity level increases within a portable tent, however, standard operating procedures (for cleaning and monitoring) must resume. Cleaning and monitoring protocols for all clean areas may be suspended whenever the area is not in active use. The room shall be cleaned from top-down if the air-handling system has been shut down for more than 12 hours.

Wax and oil-based products contaminate the air through outgassing, and leave residues on surfaces that can be transferred to flight hardware. Do not use such cleaning products on floors or work surfaces. These materials shall not be used in any area immediately adjacent to a Class 10K area. Mops, buckets and other supplies used to clean the floor and work surfaces shall be kept in good repair and shall not be heavily soiled. They shall be made of materials that will not contaminate the room. Use only stainless steel or polypropylene buckets and polyurethane sponge-mops or cleanroom mops.

5.3 Particulate Monitoring in Controlled Areas, Cleanrooms, and Clean Tents

While there is no requirement for particulate monitoring of controlled areas, the assembly and test areas shall be surveyed periodically (roughly every 6 months) via hand-held meters. The survey results shall be included in the cleanroom log, and shall be available for inspection. The cleanroom shall be monitored continuously with particulate monitors at a single location in the cleanroom. Portable tents shall be monitored using the hand-held meter. (only during use of the portable facility). Particulate levels shall be maintained in the different areas as follows:

<u>Location</u>	<u>Particulate Level</u> (goal - requirement)
Controlled Areas:	< Class 50,000 - 300,000 (no requirement)
Clean Tents:	< Class 1000 - 10,000
Laminar Flow Bench:	< Class 10 - 100

- Survey the particle level in controlled areas roughly every 6 months. The particle monitor shall be located near the central work areas, within roughly 12" vertical height above the tabletop. Monitor any 2 locations per room, always in the same spot, during normal activities.
- Log the particle-levels, and provide particle level logs to CCE.

5.4 Particulate Monitoring in Cleanrooms

The following practices shall be utilized in this regard:

- Monitor the particle level continuously in a single location. The monitor must be located near the work area, within roughly 12" vertical height above the tabletop. The time-resolution of continuous monitoring shall be hourly, or more frequent, depending upon logging capability. Continuous monitoring shall be done 24/7. Particle fallout alarms will sound if the level exceeds the requirement. Survey the flow-bench and work areas periodically (~ monthly) using the hand-held monitor. Note all readings in the cleanroom logbook, and provide readings to the CCE. Monitor any central location within the cleanroom, during normal activities.
- Log particle levels weekly and provide monthly particle level logs to CCE.
- Monitoring may be suspended during periods when the cleanroom is not in use.

5.5 Monitoring Organic Contamination in Cleanrooms

The XRS/EUV assembly area bench and cleanroom shall be monitored for molecular contamination using aluminum foil witness-samples. These foils shall be placed out of the way of the working areas (typically near the ceiling), and must not be handled in any way until they are changed. The molecular witness foils shall be changed out every 30 to 90 days depending upon activity level. A summary log of measured NVR will be kept, and appropriate action will be initiated for anomalous (high) measurements. The handling of witness foils conforms to ASTM E1234, and is described as follows:

5.5.1 Preparing witness foils

- Put on a pair of Nitrile gloves.
- Cut 6 pieces of heavy gauge aluminum foil, 13" x 12" rectangle (± 0.125 ") (provides a 1" margin for handling).
- Label each piece with a unique, easy-to-read serial number (e.g.. PAN-1 through PAN-4, with PAN-A and PAN-B as the control samples) by embossing with a pen on cleanroom paper placed over the foil sample.
- Label 6 new approved zip-lock bags with corresponding serial numbers above.
- Clean witness foils to Level 100A per MIL-STD-1246.
- Prepare and clean mounting clips to the same cleanliness level. Approved 'alligator' clips soldered together by ~1-2" of bus-wire will suffice.
- Using approved Nitrile gloves, place clean foils in serialized bags. The foils may be loosely folded twice into a square, if necessary. Always fold the serial numbered side inwards. This is the measured surface.
- Enclose the first 3 serial numbered bags in a clean, approved zip-lock bag.
- Enclose remaining 3 bags in a clean, approved zip-lock bag.
- Enclose these bags in an approved moisture-barrier zip-lock bag.
- Store bags in a clean, dry place within the cleanroom. (In accordance with procedures for entering the cleanroom, Section 3.4.2, the outer moisture bag will be removed upon entering the cleanroom.)

During high levels of critical flight assembly (when sensitive flight hardware is exposed daily), change and measure foils every 30 days. Change witness foils every 60 days when only light to moderate activity is taking place, and every 90 days if little, or no cleanroom activity is taking place.

Two foils will be exposed at a time. One foil will be used as a control, and will only be exposed momentarily. The control foil will be measured along with the exposed samples. After measuring, the foils will be precision cleaned and bagged, and will remain in the cleanroom, ready for subsequent changing. The exposed foils will be placed as follows. One foil will be hung inside the laminar flow bench, and the second from a ceiling HEPA grid. The foils will hang vertically, and will be located 'out of the way' so that they will not affect, or be affected by daily operations in the cleanroom.

5.5.2 Changing witness foils

- One at a time, remove the exposed foils, placing them in the corresponding serialized bags. The foils may be loosely folded twice into a square, if necessary. Always fold the serial numbered side inwards. This is the measured surface. Care shall be taken never to touch this surface.
- Record the location and serial number of each witness foil.
- One at a time, remove the second set of foils from their bags, and place them in the sampling locations. Log the locations and serial numbers of each of the witness foils. Seal all bags whether-or-not the samples are enclosed. Try to put the same foils in the same places each time to simplify record keeping.
- Remove the control sample from the bag, handling it in an identical manner to the new foils (this may mean unfolding, etc.), and then placing it back in the original serialized zip-lock bag.
- Enclose the serialized bags with the two exposed samples and the control sample in an approved zip-lock bag, and then within a moisture barrier bag. Attach a certification tag of the following form to the outer bag:

Table 3, Certification tag for witness foil

Panametrics GOES Cleanroom Molecular Witness Foils Certificate		Removed by:
Inspected by:	Date Removed:	
PAN Work Order #:	Date Tested:	
Measurement: NVR	Quantity: B/H (PAN-1)	
Quantity: (PAN-A)	Quantity: B/H (PAN-2)	
Quantity: (PAN-B)	Quantity: B/H (PAN-3)	
Foil location: circle either B(ench) or H(HEPA Grid)	Quantity: B/H (PAN-4)	
Comments:		

- Package samples according to ASTM E1234 and send samples to a pre-approved measurement laboratory for analysis according to ASTM E1235.
- Upon return to Panametrics following analysis, precision clean, bag, and store the foils as stated in Section 5.5.1, 'Preparing witness foils'.

5.6 Environmental Monitoring in Cleanrooms

In addition to particle and molecular contamination level monitors, the cleanroom used for XRS/EUV assembly shall be controlled and monitored to the following conditions: 70±10°F, and 30% to 60% RH. Monitoring shall be done with either continuous scroll-recorders or other means that are capable of indicating difficulty with environmental controls. Special care shall be exercised to assure that the Dew Point is avoided at all times when flight hardware is present.

6.0 Leaving the Cleanroom

Prior to leaving the cleanroom, place all work in appropriate storage containers. Protect large objects or exposed work-in-progress by covering the work with ESD-safe bagging material. Small, non-ESD sensitive parts can be covered with Pyrex glassware. Do not turn OFF the blower in the laminar flow

bench: it must be left ON at all times. (If the flow bench will be unused for an extended period, it may be turned OFF, but it must be turned ON at least 12 hours prior to use with any flight hardware.)

Leaving the cleanroom is done in the reverse order of entering. The key to removing cleanroom garments is to not contaminate them (if they will be reused) by touching them with ungloved or otherwise contaminated fingers. Leaving the cleanroom shall be performed in the following order:

- Step out of the clean area, and onto the tacky-mat that is located just inside of the cleanroom entrance, the anteroom.
- Remove facemask or beard cover, and bonnet.
- Remove garment and hang it up immediately if it will be reused, or place it directly into the garment cleaning container if it is dirty. Always hang the garment 'inside-in' or 'outside-out'. Do not 'store' bonnets in the sleeve of the garment.
- Step outside of the anteroom, and remove shoe-covers. Place the shoe-covers in the re-use container if they are only lightly soiled, discard them if they are dirty or torn.
- Remove and discard gloves. Do not reuse gloves.
- Remove glove liners, discard if necessary.
- Remove wrist-strap (ESD), and leave in anteroom.

Note: All of this apparel may be worn several times before they must be discarded or cleaned, except for gloves, which must be discarded after each use. Use discretion as to whether or not to use new apparel, based upon the upcoming task, and the level of cleanliness of each item. Garments shall be cleaned every month regardless of level of use and more often if used regularly.

6.1 Removing Hardware From The Cleanroom

In general, GSE or flight hardware that is removed from the cleanroom must be protected so that it does not need to be re-cleaned. Even if the hardware needs to be exposed to levels greater than Class 10K, it shall be protected during this exposure to minimize contamination. Gloves shall be worn when handling the flight hardware and any GSE that contacts the hardware. Exceptions are for GSE items which will be used in a non-cleanroom environment for an extended period, or for flight hardware which must be exposed to a non-clean environment and thus must be cleaned prior to further use. These practices will reduce the amount of cleaning required to return the item to the cleanroom. Bag the hardware per Section 4.3.

6.2 Leaving the Controlled Area

There are no special requirements for leaving a controlled area (the PCA) other than standard practices. When leaving the area defined by tacky-mats, it is permissible to step on tacky-mat(s) while leaving the area. Remove smock and personal wrist-strap (if issued), and hang them in the provided enclosure. Do not leave controlled area wearing smocks.

7.0 List of Acronyms and Definitions

Controlled Area	Any area that is carefully controlled and monitored for environmental conditions such as humidity, temperature, pressure, electrical discharge, or particulate or molecular levels.
24/7	24 hours per day, 7 days per week
CCE	Contamination Control Engineer
ESD	Electrostatic Discharge
DI	De-ionized (water)
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HDPE	High Density Polyethylene
HEPA	High Efficiency Particulate Air (Filters)
IPA	Isopropyl Alcohol
NVR	Non-Volatile Residue
PCA	Panametrics Clean Area
PCB	Printed Circuit Board
PCR	Panametrics Cleanroom
QA	Quality Assurance
RH	Relative Humidity
SID	Space Instrumentation Division
UV	Ultraviolet
VC	Visibly Clean
VCHS	Visibly Clean Highly Sensitive
VCHS+UV	Visibly Clean Highly Sensitive Plus Ultraviolet Light
VCS	Visibly Clean Sensitive

Appendix A, Cleanroom Buyer's Guide

The following table shows recommended cleanroom supplies & materials and preferred vendors. Vendor or manufacturer substitutions are acceptable if identical items are available. This is not intended to be a controlled list (as with the Material and Process List), but is included for purchasing guidance only.

Item	Type	Manufacturer Number	Vendor	Vendor Number	Comments	Contact
Gloves	Ansell Edmont, Nitrile	365614	VWR	Small:32890-290	Case of 10 packs of 100	800-932-5000
		365615		Medium:32890-292	"	
		365616		Large::32890-294	"	
		365617		X-large:32890-296	"	
Bootes	Conductive Booties		Marshall	805	150 pair	800-432-2223
Face masks	Texwipe Comfort Mask	TX8300	VWR	TWFX8300	50 masks/bag, 6 bags/box, 1-fits-all	800-932-5000
Bouffants	Cleanroom		Marshall	BC201-21	1000 bouffants	800-462-2223
Glove Liners	Cotton		Marshall	53-03	Dozen, open fingers	800-432-2223
Tacky-mats	Alma Industries or similar		VWR	21924-106	18"x36" white	800-932-5000
Kapton Tape	Permacell 224, 1" wide Acrylic adhesive, polyethylene core	P224X1PC	Arrow Electronics	P224X1PC	36 rolls/case	508-664-9355
Misc. Tape	3M, polyester, acrylic adh., 1" 36 rolls/case, 72 yds.	3M850	Arrow Electronics	3M850-width-color	White, red, black, silver, gold, or clear	508-664-9355
Misc. Tape	3M,ESD safe tape poly core, 1" wide	3M40	Arrow Electronics	3M40	Labeled 'ESD'	508-664-9355
ESD Bagging Material	Courtaids Llumalloy, LL50HSC	650442A	Courtaids	650442A	48" rolls, ESD-safe film, 2 mil thick	800-746-8661
Outer Bags	Ultraclean Polyethylene Lay-flat tubing Per NASA JSCM 5322 Level 100 Package for class 100 cleanroom		CRP	L.T106:2400	6 mil thick, 24"x500 ft.	800-777-2532
Squirt Bottles	Unitary LDPE, safety-labeled	NNI#2426-0503	Fisher Scientific	Methyl03-409-9D	500 ml, 2 bottles/pack	800-766-7000
		NNI#2426-0504		Iso:03-409-9E	"	
		NNI#2426-0505		DIH20:03-409-9F	"	
Cable Ties	Thomas & Betts Cable Ties, 3.62"	TYZ523M	Allied Electronics	TYZ523M	Tefzel, Special Order!, 1000/pk	800-433-5700
		TYZ525M		TYZ525M	Tefzel, Special Order!, 1000/pk	
		TYZ528M		TYZ528M	Tefzel, Special Order! 500/pk	
Swabs	Texwipe Mini Alpha ESD Swab	TX754E	VWR	TWTX754E	500/bag, 3/5" handle, ESD use	800-932-5000
		TX761D		TWTX761D	10 bags, 100/bag, 6"handle, ESD use	
		TX1010		TWTX1010	100/bag, 10 bags/case, 9" x9"	
Wipes	Texwipe Alpha 10, sealed edge	TX1010	VWR	TWTX1010	100/bag, 10 bags/case, 9" x9"	800-932-5000



Item	Type	Manufacturer Number	Vendor	Vendor Number	Comments	Contact
Solvents	HPLC Isopropyl Alcohol		Fisher Scientific	A451-4	Case of 4 amber glass 4-liter bottles	800-766-7000
	HPLC Methyl Alcohol			A452-4	Case of 4 amber glass 4-liter bottles	
Cleanroom Mop	Texwipe Alpha Mop	TX7108	VWR	TWTX7108	Fiberglass Handle	800-932-5000
	Texwipe Alpha Mop, xtra heads	TX7118	"	TWTX7118	150 heads, 6 pads/case	
Cleaning Solution		Simple Green	OEC Environmental Inc.	#19055	Can use on some flight H/W, floors,	908-685-5925
Cleanroom Shelves	4 shelves, 18" x 36"		Marshall	Q1836C		800-432-2223
Black Light	UVP B-100AP	95-0127-01	VWR	36595-020	UV Inspection Lamp	800-932-5000
Cleanroom Paper	8-1/2" x 11" blue	TX5812	VWR	TWTX5812	250 sheets/pack, 10 packs/box	800-932-5000
Purge Tubing	85A Polyurthane Tubing _ I.D. _ O.D.	IJ-425-81	Frelin-Wade		100 ft. bags	503-434-5561
	85A Polyurthane Tubing _ I.D. _ O.D.	IJ-405-81			"	
Teflon Tubing	Atlantic PFA 450HP	HP-xxx-yyy	Harrington		Xxx is I.D. in mil, yyy is wall thickness in mils; request Ultrapur PAK cleaning	909-597-8641
Tote boxes	Olympic Conductive Polypropylene	TB92060-CAS	Contact East	120-220		800-925-1720
Tote box covers	Olympic Conductive Polypropylene	CO32000-CAS		120-159		
Tote box dividers lengthwise	Olympic Conductive Polypropylene	DL92060-CAS		120-175		
Tote box dividers widthwise	Olympic Conductive Polypropylene	DS92060-CAS		120-195		
Static Shielding Bags	3M™ 1910 Metal-In		Arrow Electronics			508-664-9355
Static Shielding Bags	DESCO Statshield® Metal In Construction,Zipper	136xx.137xx	DESCO Charleswater			781-821-8370