

Solar B - EIS**RUTHERFORD APPLETON
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1. Scope and Relationship to other Documents

This document addresses the necessary contamination control activities required to maintain the scientific performance of the EIS instrument. It provides background information on contamination control, summarised in 'Golden rules for Contamination Control' in Appendix 3 and specific information in section 7 on the preparation and handling of EIS components.

This document is related to and subservient to the Spacecraft Contamination Control Plan (reference TBA) and is higher level than the NRL Document EIS_CC_Plan (April 2000). In issues of the authority the hierarchy is spacecraft - first, instrument- second, optics last.

2. INTRODUCTION

The objective of this document is to establish contamination control requirements and define their implementation in order to assure EIS instrument performance objectives are met through to the end-of-mission life. The EIS contamination control plan identifies, allocates, and budgets EIS instrument contamination limits and requirements to meet instrument performance specifications. This document develops plans and implementation procedures to assure EIS instrument performance at end of mission life shall not be unacceptably degraded due to contamination. It is anticipated that this document be modified and amended to follow the development of the EIS instrument.

The document is based on templates produced for the SOHO CDS and the XMM OM but with an evaluation of the particular requirements for the EIS instrument. The cleanliness requirements for the EIS instrument are challenging. **We have assumed the NRL levels defined for optics in EIS_CC_Plan** which are that the end of life molecular contamination shall be $<10^{-7} \text{ g cm}^2$ and that the particulate contamination shall be **<150 ppm. These requirements are demanding and essential for the unit to reach its full sensitivity and great emphasis will be placed on achieving them.**

Both molecular and particulate contamination is of concern for EIS. Molecular contaminants degrade the instrument sensitivity by a general attenuation which can be exacerbated at individual wavelengths by specific absorption of particular materials e.g. silicones. Particulate contamination contributes a scattered background, which reduces image contrast.

Molecular and particulate contamination will be monitored. In order to minimise the effect of molecular contaminants, careful choice of materials must be exercised both in the EIS instrument and the clean room environment in which it is assembled. Close attention must be paid to out-gassing paths and cleanliness procedures during storage, integration, transport and before launch. Small witness optics will be placed near sensitive optical elements e.g. the mirror and grating, two per position. One will be capable of being removed periodically to evaluate intermediate contamination levels, whilst the other will be left to determine total dose up to delivery. Infrared spectroscopy will be used to measure molecular contamination.

Particulate contamination can be readily controlled by the use of well-managed clean rooms. Experience with other experiments, e.g. CDS, has shown that when stringent controls are in place and clean room activity is well policed, particulate contamination problems can be avoided. Additional requirements and procedures may be introduced during the course of the design, development and fabrication of the experiment, as and when the need is identified.

Contamination Control requirements apply to flight hardware, to operations with and including flight hardware, and to instruments, equipment, facilities, tools, processes and materials used with, and in, EIS flight hardware.

3. APPLICABLE DOCUMENTS

NRL_EIS_CC_Plan	CCIP, EIS Instrument Components, NRL, April 2000
FED-STD-209B	Clean Room and Work Station Requirements, Controlled Environment
MIL-STD-1246A	Product Cleanliness Levels and Contamination Control Program
ESA-PSS-01-201	Contamination and Cleanliness Control
ESA-PSS-01-204	Particulate Contamination Control in Clean Rooms by Particulate Fallout (PFO) Measurements
ESA-PSS-01-705	The Detection of Organic Contamination of Surfaces by Infra-Red Spectroscopy
PL/TN/819/RT/870	SOHO Preferred Materials Document
PL/TN/820/RT/870	SOHO Outgassing Data

4. CONTAMINATION SOURCES - OVERVIEW

Contamination is conveniently described as either *particulate* - small discrete masses of solid or liquid matter, usually measured in terms of particle size (in μm) or *molecular* - such as water and thin film deposits on surfaces from condensed volatile organic and inorganic materials caused by contact or gaseous transfer and is measured in terms of layer thickness (e.g. \AA) or specific area (e.g. g cm^{-2}).

Sources of contamination are many, and occur at all phases of a programme beginning with component fabrication continuing through end of mission life on orbit. Minimising the effect of these sources is the prime purpose of this plan and specific implementation procedures are contained in the section on EIS Components Specifics (section 7) and the cleaning schedules in Appendix 2.

Some sources of particulate contaminants are as follows:

- Particles and non-volatile residues remaining from machining, painting and other fabrication and assembly processes which may be transferred by contact or other means.
- Airborne particles, skin flakes, hair fragments, wear-generated material from clothing and other human detritus.
- Airborne particle fallout within ground-operation environments due to turbulent air, unfiltered atmospheric air, and/or pump-down and re-pressurisation turbulence during vacuum chamber operations.
- Paint flakes, metal particles, and other forms released or generated by hardware or GSE.
- Transfer of particles from adjacent surfaces during sub-system, instrument, and / or spacecraft vibration, shake, acoustic, and/or shock testing.
- Particles in the payload fairing and acoustic blanketing of the launch vehicle that are loosened and re-distributed during ground operations and launch.
- Particles dispersed by the effects of mechanical shock due to the opening and jettisoning of launch vehicle nose-fairing.
- Trapped particles on or in the experiment package that are released and redistributed during ground operations and launch, including deployment of solar arrays, release of hold-down mechanisms and deployment of aperture doors.
- Contamination from the spacecraft and other payloads.
- Space-borne particles, micrometeoroids, and debris.

Some sources of molecular contaminants are as follows:

- Lubricants, fluid leaks, and exposed organic materials, which permit molecular components to be contact-transferred to critical surfaces during hardware handling.
- Cryodeposition of gaseous materials and organic or inorganic material arising from offgassing or outgassing during thermal vacuum testing, other vacuum operations, and/or on-orbit operations.

- Molecular cloud environment generated by operations and out-gassing of launch vehicle surfaces and motors, spacecraft surfaces and thrusters, and payloads which may condense on cooler (not necessarily cryogenic) surfaces.
- Return flux of out-gassed molecules caused by collisions with residual atmospheric molecules and self-collisions.
- Off gassing of plasticizers and other organic volatiles from the assembly/test environment (e.g. clean room materials).

5. CLEANLINESS REQUIREMENTS SPECIFICATION

5.1 Component Parts

The EIS instrument is one of four instruments on the Solar B spacecraft.

The EIS Instrument consists of:

- a. The optical assembly support structure and enclosure
 - Composite honeycomb structure with composite face panels
- b. An optical assembly (telescope/spectrometer) containing the following active parts
 - Filter and filter door mechanisms
 - Off-axis paraboloid, multilayer telescope primary mirror
 - Mirror focus mechanism
 - Slit-slot mechanism with shutter
 - Slit-slot filter
 - Spectrometer grating with multilayer coating
 - Grating mount assembly
 - Grating focus mechanism
 - Focal plane assembly with CCD detector
- c. Electronic Units containing:
 - Digital instrument control and data processing electronics
 - Analogue electronics
 - Power supply electronics
- c. Interconnecting harness units
- d. Radiator with thermal link to CCD
- e. Thermal blanket

The components described in section b above are subject to contamination control as specified in the NRL document EIS_CC_Plan, in addition to this document.

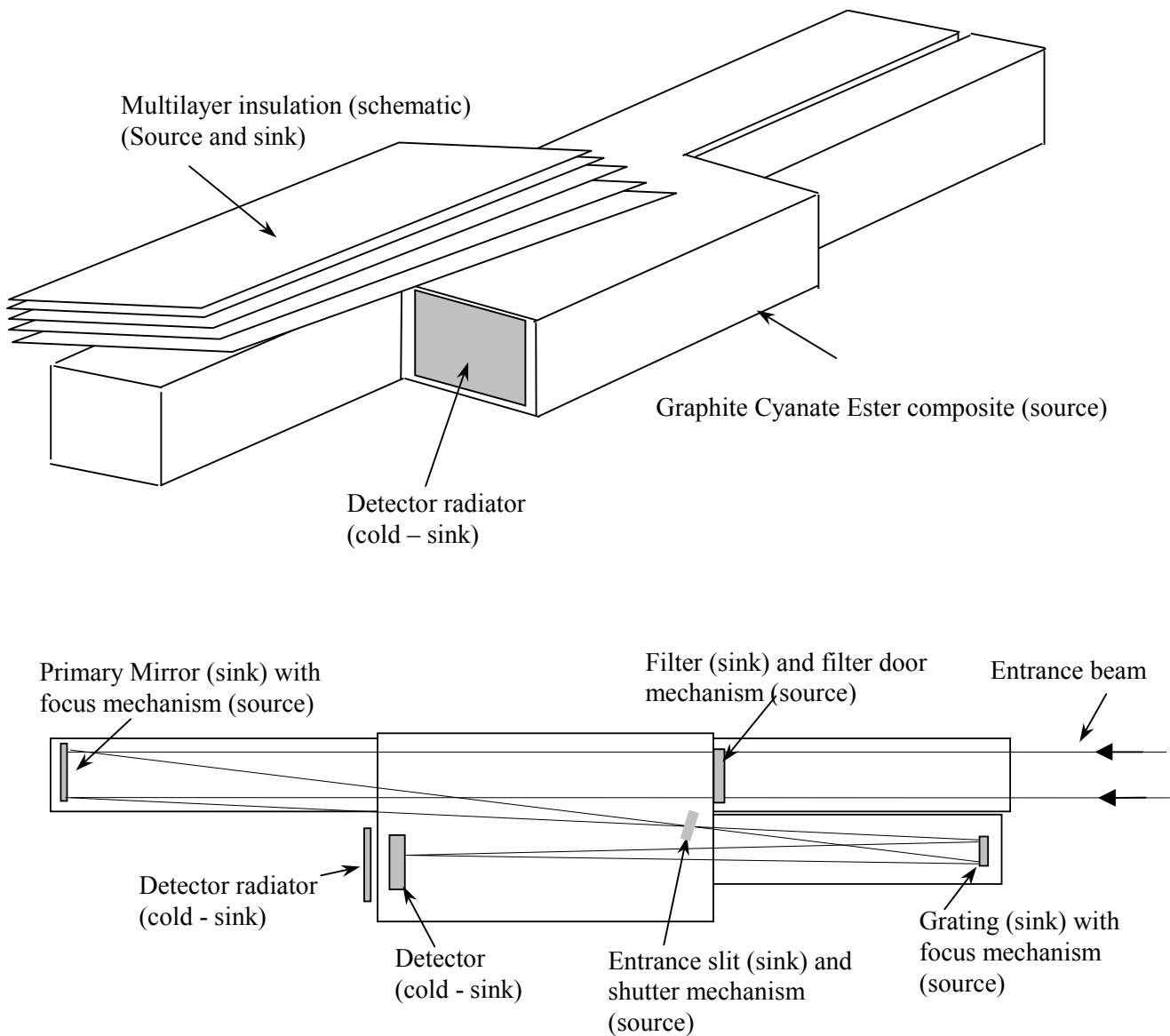


Figure 1

Figure 1 shows sketches of the instrument configuration in perspective and plan views to illustrate the number and location of component parts and their contribution (source or sink) to the contamination budget.

5.2 Critical/ Sensitive Parts

Critical components are those whose performance is compromised by either molecular or particulate contamination. Such a description is obviously appropriate for optics, both for molecular and particulate contamination of surfaces and particulate obstruction of small apertures (e.g. spectrometer or optical encoder slits) but it is also applicable to thermal control hardware in which surface properties play a significant role. Critical components are also those which are colder than their surrounds and thus act as a 'sink' for molecular contamination. When cold items are also optically sensitive such as the EIS cooled CCD detector extreme caution must be exercised in maintaining a clean environment.

The critical optical parts of EIS are the telescope, grating and detector, listed in the optical assembly above. These are central to the performance and overall sensitivity of the instrument.

The remaining parts are less sensitive to contamination, but may themselves be contamination producers. Steps to reduce and control these effects will be specified later in this document.

5.3 Degree of Sensitivity of Critical Parts

Information on the criticality and sensitivity to molecular and particulate contamination for various parts of the instrument will be established.

This information shall be broken down to the following stages:-

- End of mission
- Post launch (start of mission)
- Pre-launch
- Spacecraft integration and environmental test
- Instrument storage
- Transportation
- Assembly, integration and verification, including radiometric calibration
- Subsystem storage
- Optics manufacture

To do this, it will be necessary to calculate the effect of specific deposits of particles and condensed organic material on each of the susceptible elements.

We assume that end of life performance degradation must be no greater than 20% in the EIS wavelength range of 180 Å to 290 Å and estimate that this requires molecular contamination to be $<10^{-7}$ g cm⁻² at end of life.

For particulate contamination, the end of life figure shall be 300 ppm, assuming a distribution figure as specified in Mil Std 1246A. See figure 2.

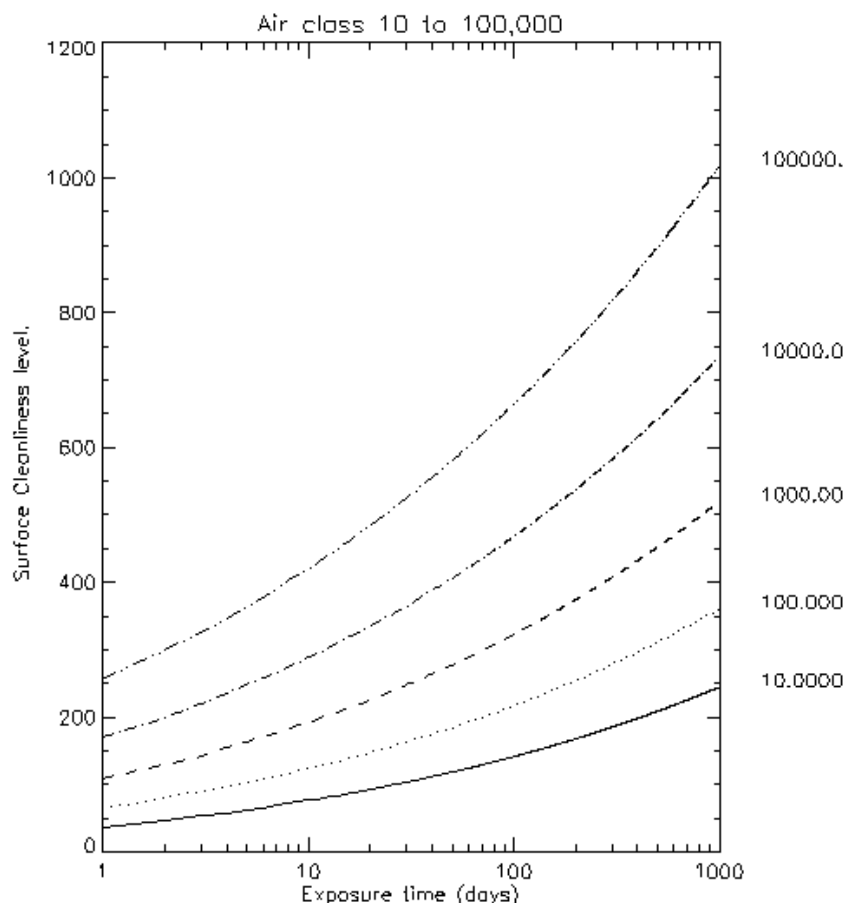


Figure 2. The plot shows the time measured in days (horizontal axis) for surfaces exposed in clean rooms of various air class defined by FED-209C (the curves for these are labeled on the right) to reach a surface cleanliness level as defined by MIL-STD-1246 (vertical axis).

The overall contamination accumulated by EIS during its entire life from assembly, through test and final operational phase can be allocated to each of these phases as shown in the following chart which indicates both molecular and particulate cleanliness budgets. Arbitrarily we have assumed that 60% of the molecular contamination will occur post launch. For particulates we have assumed 50% of contamination occurs post launch with 25% of that occurring during the immediate post launch phase.

	Budget			
	Molecular		Particulate	
	% Allocation	Accumulated Level (gm cm ⁻²)	% Allocation	Accumulated Level (ppm)
Post clean		$< 1 \times 10^{-8}$		< 40
Modules pre-integration	10	2×10^{-8}	20	50
Storage /transportation	0	2×10^{-8}	0	50
Instrument integration	10	3×10^{-8}	15	60
Storage /transportation	0	3×10^{-8}	0	60
Spacecraft integration	20	4×10^{-8}	20	75
Pre-launch	10	5×10^{-8}	10	85
Post launch/pre ops	30	7×10^{-8}	25	110
Scientific operations	30	10^{-7}	25	150
Total - End of Mission	100	10^{-7}	100	150

5.4 Sources of Contamination

Known and/or expected sources of both molecular and particular contaminants must be identified in order that appropriate steps can be taken to minimize their effects.

Sources of particulate contamination include:

- Mechanisms

 - Especially those mechanisms listed in the optical assembly and indicated in figure 1.

- Poorly finished fibrous material

 - We must be concerned over the composite material honeycomb face plate edges.

- Residual debris from machining

 - Trapped debris in composite material honeycomb.

- Purge /flush gas

 - Use of filtered high quality purge gas (at least white spot) is mandatory.

- Redistribution processes

 - Handling

 - Pump down to vacuum

 - Recovery to atmospheric pressure

Sources of molecular contamination include:

- Lubricants

- Surface treatments e.g. paints

- Residue from cleaning process

- Re-condensed products from exterior sources e.g. clean room walls/floors/filters

We must expect significant out-gassing of water vapor from the honeycomb structure and anticipated that even after a high temperature air bake the initial pump will be of long duration (perhaps a few days).

Details of the materials used in the experimental hardware will be listed in the Declared Materials List (reference TBD).

An analysis of the temperatures, mass and exposed areas of all potential out-gassing sources must be made. Knowledge of vent conductance and quantification of out-gassing data versus time and temperature will aid contamination estimation. If there is any possibility of particle generation by the equipment, then estimates of it should be made, e.g. thermal insulation, swarf, abrasion during vibration etc.

A list of processes used in the manufacture of the experiment will also be prepared as the Declared Processes List (reference TBD).

6. CLEANLINESS CONTROLS

6.1 Design

6.1.1 Design for Cleanliness

The design shall as far as possible separate contamination sources from contamination sensitive critical items. Ideally this would mean placing all optics in a separate enclosure from mechanisms and potential out-gassing sources. In EIS this ideal is not possible and both mechanisms and potential out-gassing graphite composites are part of the optical volume. Sources of molecular contamination shall be remote from 'cold sinks' and where this is not possible sources shall be cleaned to levels such that their out-gassing is compatible with required instrument performance.

Materials shall be selected bearing in mind the contamination potential in the use location. In critical areas only materials of known low rates of out-gassing shall be chosen. It may be

necessary to use adhesives, surface coatings and exceptionally potting materials, but the use of such materials will be controlled and approved by the contamination control engineer. In general materials must be selected from a recommended lists e.g. ESA PL/TN/819/RT/870 and PL/TN/820/RT/870. However, experience has shown that for EUV instruments additional material screening is needed to preserve out-gas requirements e.g. testing by ESA's Vacuum Balance Quartz Crystal (VBQC) test.

Optical components and their mounting structures should be covered when access is not required. The design shall ensure that critical areas may be protected e.g. by covers during periods when access is not needed. When access to critical components is required the design shall ensure that such items may be worked on such that workers do not contaminate the component e.g. in a clean room with workers downstream of the component.

6.1.2 Clean Rooms Facilities and Clothing

For particle control, clean-rooms/benches must be used appropriate to the cleanliness needed. The optics must see class 100 or better. The doubly bagged instrument may be exposed to class 100000. Clean room clothing, work practices and discipline must be adopted according to the procedures agreed in each case with the EIS system team.

In general clean room work is uncomfortable and the discipline exasperating, hence such work needs to have well planned specific objectives which take the minimum careful time and with time allowed to return work items to safe, clean configurations following clean room operations.

The particulate sensitive assembly work for EIS will take place in class 100 category clean rooms. CDS experience indicates that class 100 conditions are not possible unless scrupulous control is maintained over clean room practice.

The number of staff in the clean room shall be restricted to that number which does not compromise the class 100 conditions. As an approximate guide RAL SSTD experience is to limit staff to 1 person per 10 m³.

Class 100 clothing shall consist of:

- 1) Full coverall suit
- 2) Head covering of full cowl type
- 3) Face mask covering nose and mouth
- 4) Class 100 powder free gloves
- 5) Mid calf length boots

6.1.3 Purging

Critical volumes shall be purged with clean dry inert gas (at least white spot quality) distributed through clean delivery lines. It is essential to design the internal flow of this gas so that it passes first over the most critical surfaces and that no critical surface is purged by second-hand gas. It may also be important, from the point of view of neighboring sensors, that the purge gas be vented in a controlled manner.

Note the potential safety problem of asphyxiation if purge rate is large compared to the clean room refresh rate.

6.1.4 Contamination Traps

The design should avoid the creation of traps for particles during manufacture and/or assembly. The use of honeycomb structure presents a particular problem, as this material comprises a large number of particle traps. It must thus be sealed to prevent particle entry to the optics volume. The outermost surface cover should be perforated to allow the honeycomb to out-gas through the outermost face.

6.1.5 Access for Cleaning

Consideration shall be given to all critical items to allow for the ability to clean them at the latest possible stage in the final assembly process.

The use of removable covers for these devices will provide protection during storage and transportation and 'waiting for work' periods. They should provide snug but not necessarily airtight seal and be made from non-plasticised material.

6.2 Manufacture, Assembly and Test

6.2.1 Manufacturing Controls

It is essential that good design is not compromised by poor practices.

Cleaning of any part after machining must involve coarse cleaning using ultrasonic or solvent vapor dip before leaving the workshop area.

Before entry to any clean room, the hardware must undergo precision cleaning.

Suitable cleaning schedules covering instrument parts and support systems are attached as Appendix 2.

Analytical grade solvents, stored in glass containers, are required for this purpose.

Tools and MGSE/EGSE used in clean-rooms must be precision cleaned before clean room entry.

GSE must never be used upstream of flight hardware.

All clean rooms re-circulate a large proportion of the air. The standard filters used are designed only to trap dust. If there is a risk of chemical contamination, then the use of active carbon filters should be considered and molecular contamination levels monitored in any case.

6.2.2 Processes

Processes are also critical, since errors in the preparation or application of potting materials, adhesives and paints may destroy the EUV performance of optical surfaces and their use must be strictly controlled. It is considered essential to validate the choice of such materials by producing test samples, representative in size, shape and materials, prior to the application to flight hardware to confirm freedom from out-gassing in its expected life profile.

If potting is used as a technique, the flight hardware should be vacuum baked before the next assembly, providing that this will not cause any performance deterioration. The bake should be monitored to demonstrate cleanliness, as this will reveal incorrect or incomplete curing of the potting compound. Similar tests should be conducted for paints and the results of all these tests shall be recorded in the equipment logbook.

6.2.3 Inspection

Verification of cleanliness before fitting any assembly or closing any panel or cover is required.

This will be aided by inspection with UV light, which shows organic contamination by fluorescence and by a strong beam of white light arranged to graze the ostensibly clean surfaces.

The white light is best for inorganic materials and so is complementary to the UV.

A further method of verification is the tape lift test, in which a special adhesive transparent tape designed for the purpose is applied to typical areas, removed and inspected under a microscope to quantify any particles present. This technique is not applicable to optical surfaces, and only to other parts with agreement of the contamination control engineer.

After piece part manufacture, all components must be precision cleaned before entry into the clean room or before being placed into part storage. If storage is prolonged, then the need for repeated precision cleaning operation should be evaluated before the next assembly operation.

6.2.4 Monitoring

Monitoring the cleanliness of the assembly operations is mandatory. The use of witness plates, as described in ESA PSS-10-201, is recommended throughout all assembly or handling operations involving critically clean hardware. ESA specifications PSS-01-201, -204 and -705 give more details of particle and condensable monitoring. (Test specification to be verified.)

It is recommended that clean benches be "qualified" before use by exposing witness plates for 2 weeks or so prior to use. When the bench is operating witness plates will be used to verify no recorded detectable contamination. Results of these tests shall be kept in the equipment logbook.

6.2.5 Removal of Particles

For non-critical surfaces, light brushing with airflow into a vacuum nozzle is usually effective and is best carried out with the lighting described in par 6.2.3. The judicious (approved) use of tape lifting as described in par 6.2.3 may be appropriate for removal of a limited number of particles where the introduction of a vacuum hose is difficult. Note that high gas flow rates may introduce electrostatic charging problems, which apart from risks of damage to ESD sensitive components may simply attract particles to the charged surfaces. To avoid this problem, use low flow rates and de-ionized gases.

By strict adherence to the cleaning and handling instructions there should be no need to attempt removal of particles from optically critical surfaces. However in the need for accident recovery, particles may be removed from optical surfaces with the greatest of care by non-contact methods such as vacuum induced airflow. With care this may be supplemented by a jet of clean de-ionized nitrogen directed to dislodge the particle so that the gas with the freed particle is then removed via the vacuum pipe. On no account should pressurised cans of air or photographers 'puffer' bulbs be used. Particle removal from thin film filters must never be attempted.

6.2.6 Vacuum Bake-out

The removal of molecular contamination shall be carried out using a vacuum bake-out. Items should be vacuum baked prior to assembly, using a temperature compatible with the items' materials; for example aluminum approximately 150° C, wiring harnesses approximately 80° C. The duration of the vacuum bake-out shall be as described in Appendix 2 schedules as a minimum, and this could be longer depending on the out-gassing rate of the item. The chamber pressure during bake-out shall be as described in Appendix 2. A further vacuum bake-out of the assembled instrument is recommended. The temperature for this bake-out shall be no greater than the lowest temperature used during individual item bake-out.

6.2.7 Storage

Packing or temporary storage of piece parts and equipment requires some extra precautions to preserve cleanliness after any precision cleaning operation. For small metal parts and assemblies, it is recommended that clean aluminium foil be used as the primary packing material. The wrapped item is then sealed inside a suitable non out-gassing plastic bag such as Llumalloy, aluminized Kapton or Mylar. Larger items should be sealed in Llumalloy bags.

Humidity 'tell tales' and shock indicators may then also be enclosed.

Optics should be stored in a sealed metal or project approved container filled with dry inert gas. The hardware can then be transported as required from the clean room, but must not enter another clean room in this level of packaging. Following normal practice, the outer container must be cleaned before entry into a semi-clean-room area and opened to remove the treble-wrapped hardware. The wrapping is removed progressively as the hardware moves upstream towards the workstation allocated for the next operation and the final aluminium foil wrap must only be removed at the clean bench. No plastic material must ever reach the clean bench or inspection area.

Major subassemblies and/or the complete instrument may be stored in sealed containers that are capable of being purged with clean dry inert gas.

6.2.8 Thermal Vacuum Testing

Before testing of the complete experiment, it will be necessary to certify that the test chamber is adequately clean.

- a) Prior to the testing of any flight or flight spare hardware, the cleanliness of the chamber must be certified in the course of a thermal vacuum test similar in duration and temperature

extremes planned for EIS. The MGSE must be similarly cleaned as must any other test hardware as specified in Appendix 2. Quartz Crystal Monitors (QCM's) and witness plates/foils should be fitted to demonstrate the capability of the chamber to meet the required cleanliness levels.

- b) The duration of this vacuum test is unlikely to be less than 48 hours, except for small chambers, but should be determined by measuring the out-gassing rate. This should be less than 10^{-7} g/cm²/hr (TBC). At the end of this test, the witness samples and surface wipes shall be measured for contamination to confirm that the chamber is clean enough for the EIS hardware. In the interval between the bake-out and the real test, it is recommended that the chamber is back filled with dry nitrogen and closed.
- c) Recovery from thermal vacuum should take place after the chamber has returned to room temperature following a hot cycle. Clean high quality nitrogen (**TBD specification**) shall be used to purge the vacuum chamber after first passing through the instrument, i.e. the chamber is refilled via the EIS instrument until a pressure of 1 torr. At 1 torr the chamber may be pressurized in parallel with EIS provided structurally harmful pressure differentials are avoided.

6.2.9 Using Vacuum Chambers (apart from thermal vacuum)

Before testing in vacuum of the complete experiment, it will be necessary to certify that the vacuum chamber is adequately clean.

- a) Prior to the vacuum testing of any flight or flight spare hardware, the cleanliness of the vacuum chamber must be certified in the course of a vacuum test similar in duration and temperature to that planned for EIS. The MGSE must be similarly cleaned as must any other test hardware as specified in Appendix 2. Quartz Crystal Monitors (QCM's) and witness plates/foils should be fitted to demonstrate the capability of the chamber to meet the required cleanliness levels.
- b) The duration of this bake-out is unlikely to be less than 48 hours, except for small chambers, but should be determined by measuring the out-gassing rate. This should be less than 10^{-7} g/cm²/hr (TBC). At the end of this test, the witness samples and surface wipes shall be measured for contamination to confirm that the chamber is clean enough for the EIS hardware. In the interval between the test and the real test, it is recommended that the chamber is back filled with dry nitrogen and closed.
- c) Recovery from vacuum should take place by using clean high quality nitrogen (**TBD specification**) to purge the vacuum chamber after first passing through the instrument, i.e. the chamber is refilled via the EIS instrument until a pressure of 1 torr. At 1 torr the chamber may be pressurised in parallel with EIS provided structurally harmful pressure differentials are avoided.

6.2.10 Hardware Handling

At all times the minimum number of technicians and inspectors will be used to work on and handle the flight and flight spare hardware. (See also section 6.1.2.)

6.2.11 Logbook Records

Records must be kept in a logbook forming a chronological listing of the events possibly affecting the cleanliness of the flight or flight spare hardware. The contents of this logbook, or section of the Experiment's logbook, will contain:-

- a. the as built materials list

- b. process data, e.g. material batch numbers, time of mixing, application, cure and test sample data
- c. time/temperature summaries for the bake-out
- d. QCM, witness plate and wipe data relating to the assembly or test operation involved, including those applicable to a "blank test" of thermal vacuum chambers
- e. a time log of gas purging, where applicable
- f. certification at the time of delivery of the hardware, that the cleanliness records have been reviewed, are complete, correct and satisfactory. This certification is required prior to acceptance for the next level of integration

7. EIS COMPONENT SPECIFICATIONS

7.1 The optical assembly support structure and enclosure

1) Structure:

SWALES experience on FUSE suggests the following cleaning requirements for carbon composite structures:

Bake in air at 120° C for 5 days

Vacuum bake at 100° C until pressure is in low 10^{-6} torr range and partial pressure of mass 43 is less than 5×10^{-10} torr.

When not in use bag and purge with dry (white spot) nitrogen.

2) Thermal hardware:

TBD

3) Mechanisms:

TBD

7.2 Optical assembly (telescope/structure)

Follow EIS_CC_Plan NRL April 2000.

7.3 Electronics units

TBA

8. OPERATIONS

8.1 The Launch Phase

TBA

8.2 After Launch

TBA

9. APPENDIX 1. SURFACE CLEANLINESS LEVELS

Particulate Cleanliness Levels per Size Range			
CLEANLINESS LEVEL	SIZE RANGE (um)	MAX. QUANTITY OF PER PARTICLES	PER 0.1 SQ. METRE
1	>1	1	1
5	1 - 2	1	1
	3 - 4	1	1
	>5	1	1
10	1 - 2	1	2
	3 - 5	4	4
	6 - 10	2	2
	>10	1	1
25	3 - 5	30	32
	6 - 15	20	21
	16 - 25	2	3
	>25	1	1
50	6 - 15	141	152
	16 - 25	18	19
	16 - 25	6	7
	26 - 50	1	1
100	6 - 15	1520	1644
	16 - 25	187	202
	26 - 50	67	72
	51 - 100	10	11
	>100	1	1
200	16 - 25	2949	3180
	26 - 50	1070	1156
	51 - 100	154	167
	101 - 200	15	16
	>200	1	1
300	26 - 50	6434	6950
	51 - 100	926	997
	101 - 250	93	101
	251 - 300	1	1
	>300	1	1
500	51 - 100	10717	11610
	101 - 250	1074	1162
	251-500	25	27
	>500	1	1
750	51-100	86888	95370
	101 - 250	8705	9399
	251 - 500	206	222
	501 - 750	7	8
	>750	1	1
1000	101 - 250	41636	45000
	251 - 500	983	1058
	501 - 750	34	37
	751 - 1000	4	4
	>1000	1	1

10. APPENDIX 2. COMPONENT PART CLEANING SCHEDULES**List of cleaning schedules**

TYPE OF MATERIAL	APPLICABLE SCHEDULE
Metal parts in optics bench	AA
Untreated metal parts	A
Carbon composite structures	A* (see section ***)
Alochromed metal parts	A
Painted metal parts	B
Electrical/electronic wiring harness	TBA
Electronics cards	G
MGSE for optics /optical part supports	A
Mechanism parts	A
Lubricated parts	H
MLI	D
Mechanical support hardware	E
Electrical support hardware	F
Optical components	Specialist cleaning only
Detector components	Specialist cleaning only
Motors	TBA
Elastomers/plastics	K
Fibre glass units	L

Cleaning Schedule AA

Applicable to untreated or alocromed (but not painted) metal components within the optics bench.

Preliminary clean (in laboratory or workshop)

1. Remove visible surface debris, by wipe (e.g. Kimwipes RAL stores cat 33/84900) and/or vacuum cleaner.
2. Scrub wash with detergent solution, (e.g. hand cleaner in hot tap water) ensuring that all bolt holes, penetrations, crevices etc are scrubbed with a non-shedding brush.
For components containing blind small holes it may be necessary at this stage to wash in an ultrasonic bath in acetone.
3. Wipe dry.

Degrease

4. Wash in acetone (isoclean grade - RAL stores number 14/00180) bath. This procedure to be carried out in ventilated area or under fume extraction hood.
Use tongs or tweezers. **Do not use gloves for this step.**
5. Allow to dry (until visibly dry).

Clean (in cleaning area, air class at least 10,000)

6. Wash in ultrasonic bath containing approved **detergent** solution (e.g. 0.5% of dobonal ethoxylate 91-6 or surfact65 in demineralised water - *at RAL this is 500 cc of detergent in bath filled to fill level*). Wash for 5 minutes then invert part and repeat.
7. Gloved handling from this point (project approved gloves only).
8. Flow wash with large quantity of tap water.
9. Flow wash with demineralised water (analar grade - RAL stores number 14/74490).
10. Check cleanliness by water break. Loop back to 6 if part fails this check.
11. Allow to drain.
12. Handle with clean tweezers or tongs to avoid solvent contact with glove.
13. Flow rinse with isopropyl alcohol (isoclean grade - RAL stores number 14/02750).
13. Shake off excess IPA and allow to dry (visibly) under fume hood for up to 10 minutes.
14. Transfer to **class 100** flow bench.
15. Store until ready to progress in clean container - flow bench or Llumalloy bag or project supplied container.
16. **Remove from container. Vacuum bake at 100^o C for 8 hours at better than 1x10⁻⁵ torr. Record 2-100 amu mass spectrometer bar graph using 10⁻¹⁰ torr pressure range. Requirement is for mass 43 to be less than 1x10⁻¹⁰ torr and total outgas rate less than 2x10⁻⁷ torr litre sec⁻¹.**
17. Bag in new Llumalloy bag or project supplied container.
18. Record operation in cleaning log and part log.
19. Attach "**Cleaned component**" tag.

In the event of any procedure error in steps 6-17, loop back and start again at 6

Cleaning Schedule A

Applicable to untreated or alochrome (but not painted) metal components.

Preliminary clean (in laboratory or workshop)

1. Remove visible surface debris, by wipe (e.g. Kimwipes RAL stores cat 33/84900) and/or vacuum cleaner.
2. Scrub wash with detergent solution, (e.g. hand cleaner in hot tap water) ensuring that all bolt holes, penetrations, crevices etc are scrubbed with a non shedding brush. For components containing blind small holes it may be necessary at this stage to wash in an ultrasonic bath in acetone.
3. Wipe dry

Degrease

4. Wash in acetone (isoclean grade - RAL stores number 14/00180) bath. This procedure to be carried out in ventilated area or under fume extraction hood. Use tongs or tweezers. **Do not use gloves for this point.**
5. Allow to dry (until visibly dry).

Clean (in cleaning area, air class at least 10,000)

6. Wash in ultrasonic bath containing approved **detergent** solution (e.g. 0.5% of dobonal ethoxylate 91-6 in demineralised water - *see schedule AA*). Wash for 5 minutes then invert part and repeat.
7. Gloved handling from this point (project approved gloves only)
8. Flow wash with large quantity of tap water.
9. Flow wash with demineralised water (analar grade - RAL stores number 14/74490)
10. Check cleanliness by water break. Loop back to **6** if part fails this check.
11. Allow to drain.
12. Handle with clean tweezers, tongs to avoid solvent contact with gloved hands.
13. Flow rinse with isopropyl alcohol (isoclean grade - RAL stores number 14/02750).
13. Shake off excess IPA and allow to dry (visibly) under fume hood for up to 10 minutes.
14. Transfer to **class 100** flow bench.
15. Store until ready to progress in clean container - flow bench or Llumalloy bag or project supplied container.
16. Remove from container. Vacuum bake at 100°C for 8 hours at better than 1×10^{-5} torr. Record 2-100 amu mass spectrometer bar graph using 10^{-9} torr pressure range.
17. Bag in new Llumalloy bag or project supplied container.
18. Record operation in cleaning log and part log.
19. Attach "**Cleaned component**" tag.

In the event of any procedure error in steps 6-17, loop back and start again at 6

Cleaning Schedule B

Applicable to painted metal structures. This procedure assumes the component has been thoroughly cleaned by the approved pre-coating procedure prior to painting, e.g. schedule A, - and has undergone a suitable post painting cleaning by the painting contractor.

To be carried out in Class 10,000 clean area.

Clean

1. Handle with gloves (Project approved gloves only).
2. Remove visible surface debris, by dry wipe and/or vacuum cleaner.
3. Carefully scrub non painted areas by using wipe dampened with isopropyl alcohol, (isoclean grade stores number 14/02750) ensure that all bolt holes, penetrations, crevices etc are scrubbed with a brush and that **solvent does not come into contact with paint**.
4. Allow to dry (visibly dry) in class 100 clean bench.

Additional (if painted area is seen to be contaminated) or under project direction

5. Handle with clean tweezers, tongs or with gloved hands.
 6. Check paint tolerance to solvents (contact PA group).
- If appropriate a wipe dampened with isopropyl alcohol (isoclean as 3) may be used locally. Ensure that solvent does not come into contact with gloves.
7. Allow to dry (visibly dry) in class 100 clean bench.

Bake

8. Store in clean container - flow bench or Llumalloy bag or project supplied container until ready to progress.
9. Remove from container and vacuum bake at 100°C for 8 hours at better than 1×10^{-5} torr. Record 2-100 amu mass spectrometer bar graph on 10^{-9} torr pressure range.
10. Bag in fresh Llumalloy bag or project supplied container.
11. Record operation in cleaning log and part log.
12. Attach "**Cleaned component**" tag.

In the event of accidental departures from procedure loop back to step 1.

Cleaning Schedule D - Thermal Hardware

Applicable to MLI (**not ITO coated units**).

MLI will be manufactured in clean down-flow unit from clean materials. It is EIS policy to clean all subsystems to a known standard where practicable. For MLI a particular benefit is derived from the vacuum bake as this will greatly reduce potential contamination from unwanted release agents leached into adhesive tapes.

Gloves to be worn at all stages and project approved gloves only.

All stages to take place in at least **class 100 clean area**.

Preliminary clean

1. If necessary particles may be blown off with a gentle flow of filtered white spot dry nitrogen, or approved vacuum cleaning.

Degrease

2. Degrease should not be necessary. However if accident recovery requires - small local areas may be dampened wiped with IPA (isoclean grade RAL stores number 14/02750). Wiping is to be at absolute minimum as lightly as possible in one direction only. If marks cannot be removed by this procedure **STOP** do not try to remove them - contact thermal control engineer.

3. Allow to dry.

Clean

4. Store until ready to progress in clean area.

5. Vacuum bake at 100° C for 72 hours at better than 1×10^{-5} torr. Record 2-100 amu mass spectrometer bar graph using 10^{-9} torr pressure range.

6. Store in clean area.

7. Record operation in cleaning log and part log.

In the event of accidental departures from procedure loop back to step 1.

Cleaning Schedule E

Applicable to mechanical support hardware (not painted) for use in clean rooms.
For units with having direct contact with optics or optics bench use Schedule EE.

Preliminary clean (in laboratory or workshop)

1. Remove visible surface debris, by wipe (e.g. Kimwipes RAL stores cat 33/84900) and/or vacuum cleaner.
2. Scrub wash with detergent solution, (e.g. hand cleaner in hot tap water) ensuring that all bolt holes, penetrations, crevices etc are scrubbed with a non-shedding brush.
3. Flow wash with tap water to remove detergent, and wipe dry

Degrease

4. Wipe over using non-shedding wipe dampened with acetone (isoclean grade - RAL stores number 14/00180). This procedure to be carried out in ventilated area.
5. Allow to dry (until visibly dry).

Clean (in cleaning area, air class at least 10,000)

6. Gloved handling from this point (project approved gloves only).
7. Wipe over using non-shedding wipes dampened with isopropyl alcohol (isoclean grade - RAL stores number 14/02750).
8. Allow to dry (visibly).
9. Attach "**Cleaned component**" tag.

In the event of accidental departures from procedure loop back to step at the start of appropriate section.

Cleaning Schedule EE

Applicable to mechanical support hardware having direct contact with optics or optics bench - for use in clean rooms.

For other MGSE use Schedule E.

Preliminary clean (in laboratory or workshop)

1. Remove visible surface debris, by wipe (e.g. Kimwipes RAL stores cat 33/84900) and/or vacuum cleaner.
2. Scrub wash with detergent solution, (e.g. hand cleaner in hot tap water) ensuring that all bolt holes, penetrations, crevices etc are scrubbed with a non-shedding brush.
3. Flow wash with tap water to remove detergent, and wipe dry.

Degrease

4. Wipe over using non-shedding wipe dampened with acetone (isoclean grade - RAL stores number 14/00180). This procedure to be carried out in ventilated area.
5. Allow to dry (until visibly dry).

Clean (in cleaning area, air class at least 10,000)

6. Wash in ultrasonic bath containing approved **detergent** solution (e.g. 0.5% of dobonal ethoxylate 91-6 in demineralised water - *see schedule AA*). Wash for 5 minutes then invert part and repeat.
7. Gloved handling from this point (project approved gloves only).
8. Flow wash with large quantity of tap water.
9. Flow wash with demineralised water (analar grade - RAL stores number 14/74490)
10. Check cleanliness by water break. Loop back to **6** if part fails this check.
11. Allow to drain.
12. Handle with clean tweezers or tongs to avoid solvent contact with gloved hands.
13. Flow rinse with isopropyl alcohol (isoclean grade - RAL stores number 14/02750).
13. Shake off excess IPA and allow to dry (visibly) under fume hood for up to 10 minutes.
14. Transfer to **class 100** flow bench.
15. Attach "**Cleaned component**" tag.

In the event of accidental departures from procedure loop back to step at the start of appropriate section.

Cleaning Schedule F

Applicable to electrical support hardware for use in clean rooms. (support hardware cable harness should be treated under schedule C).

Preliminary clean (in laboratory or workshop)

1. Remove visible surface debris, by wipe (e.g. Kimwipes RAL stores cat 33/84900) **and vacuum clean** paying particular attention to vents.
2. Remove covers where possible and vacuum clean inner volume.

Clean (in cleaning area, air class at least 10,000)

3. Gloved handling from this point (project approved gloves only).
4. Vacuum clean using clean room vacuum cleaner.
5. Wipe over surface using non-shedding wipes dampened with isopropyl alcohol (isoclean grade - RAL stores number 14/02750).
6. Allow to dry (visibly).
7. Attach "**Cleaned component**" tag.

In the event of accidental departures from procedure loop back to step at the start of appropriate section.

Cleaning Schedule G

Applicable to electronics boards.

Preliminary clean

1. Remove contaminants (flux etc.) during construction using a non-shedding wipe moistened with isopropyl alcohol (isoclean grade – RAL stores number 14/02750).
2. Remove any visible surface debris, by dry nitrogen blow and/or vacuum cleaner.

Clean (in a least class 10,000 clean area)

3. Clean in vapour phase plant using arklone F according to SSTD electronics cleaning procedure (reference TBA).
4. Gloved handling from this point using project approved gloves.
5. Allow to dry (in class 100 clean bench). Excess solvent may be blown off using white spot nitrogen.
6. Store until ready to progress in clean anti static container or bag - e.g. Lumalloy bag.
7. Vacuum bake (8 hours at 60°C at a pressure of better than 1×10^{-5} torr). Record 2-100 amu mass spectrometer bar graph for 10^{-9} torr pressure range.
8. Bag in fresh Lumalloy bag or project supplied container.
9. Record operation in cleaning log and part log.
10. Attach "**Cleaned component**" tag.

In the event of accidental departures from procedure loop back to step at the start of appropriate section.

Cleaning Schedule K

Applicable to plastic and elastomer components.

Preliminary clean (in laboratory or workshop)

1. Remove visible surface debris, by wipe (e.g. Kimwipes RAL stores cat 33/84900) and/or vacuum cleaner.
2. Wash with detergent solution, (e.g. hand cleaner in hand hot tap water) ensuring that all bolt holes, penetrations, crevices etc are scrubbed with a **non-abrasive**, non-shedding brush.
3. Wipe dry

Clean (in cleaning area, air class at least 10,000)

4. Wash in ultrasonic bath containing approved **detergent** solution (e.g. 0.5% of dobonal ethoxylate 91-6 in demineralised water). Wash for 5 minutes then invert part and repeat.
5. Gloved handling from this point (project approved gloves only).
6. Flow wash with large quantity of tap water.
7. Flow wash with demineralised water (analar grade - RAL stores number 14/74490).
8. Allow to drain.
9. Handle with clean tweezers or tongs and avoid solvent contact with gloved hands.
10. Flow rinse with isopropyl alcohol (isoclean grade - RAL stores number 14/02750).
11. Shake off excess IPA and allow to dry (visibly) under fume hood for up to 10 minutes.
12. Transfer to **class 100** flow bench.
13. Store until ready to progress in clean container - flow bench or Llumalloy bag or project supplied container.
14. Remove from container. Vacuum bake at 100°C for 8 hours at better than 1×10^{-5} torr. Record 2-100 amu mass spectrometer bar graph using 10^{-9} torr pressure range.
15. Bag in new Llumalloy bag or project supplied container.
16. Record operation in cleaning log and part log.
17. Attach "**Cleaned component**" tag.

In the event of any procedure error in steps 4-15, loop back and start again at 4

Cleaning Schedule L

Applicable to fibre glass components (except electronic cards - see schedule G).

Preliminary clean (in laboratory or workshop)

1. Remove visible surface debris, by wipe (e.g. Kimwipes RAL stores cat 33/84900) and/or vacuum cleaner.
2. Wash with isopropyl alcohol (isoclean grade - RAL stores number 14/02750), ensuring that all bolt holes, penetrations, crevices etc are scrubbed with a **non-abrasive**, non-shedding brush.
3. Wipe dry.

Clean (in cleaning area, air class at least 10,000)

4. Wash in ultrasonic bath containing isopropyl alcohol (isoclean grade - RAL stores number 14/02750). Wash for 1 minute then invert part and repeat.
5. Gloved handling from this point (project approved gloves only)
6. Handle with clean tweezers or tongs and avoid solvent contact with gloved hands.
7. Shake off excess IPA and allow to dry (visibly) under fume hood for up to 10 minutes.
8. Transfer to **class 100** flow bench.
9. Store until ready to progress in clean container - flow bench or Llumalloy bag or project supplied container.
10. Remove from container. Vacuum bake at 100°C for 8 hours at better than 1×10^{-5} torr. Record 2-100 amu mass spectrometer bar graph using 10^{-9} torr pressure range.
11. Bag in new Llumalloy bag or project supplied container.
12. Record operation in cleaning log and part log.
13. Attach "**Cleaned component**" tag.

In the event of any procedure error in steps 4-11, loop back and start again at 4

11. APPENDIX 3. GOLDEN RULES FOR CONTAMINATION CONTROL

(with acknowledgement and thanks to Ron Thomas ESTEC)

- 1) Separate optics from all organic and particle sources.
- 2) Keep optical surfaces warm and contamination sources cold.
- 3) Minimise source size and optimise their materials.
- 4) Use vacuum baking to clean up subassemblies.
- 5) Apply purging from critical to less critical volumes.
- 6) Calculate tolerable levels of contamination for both molecular and particulate contamination.
- 7) Calculate the contributions from all contamination sources.
- 8) Measure the actual acquired contamination throughout the life of the project.

12. APPENDIX 4. ACRONYM AND ABBREVIATIONS

Acronym	Definition
amu	atomic mass unit
BU	University of Birmingham
CC	contamination control
CCD	charge coupled device
CCIP	Contamination Control and Implementation Plan
CDS	Coronal Diagnostic Spectrometer
EGSE	electrical ground support equipment
EIS	Extreme-ultraviolet Imaging Spectrometer
ESA	European Space Agency
ESD	electro-static discharge
EUV	extreme-ultraviolet
GSE	ground support equipment
IPA	isopropyl alcohol
ITO	indium tin oxide
MGSE	mechanical ground support equipment
MSSL	Mullard Space Science Laboratory
MLI	multilayer insulation
NAOJ	National Astronomical Observatory Japan
NRL	Naval Research Laboratory
NVR	non-volatile residue
OM	Optical Monitor
PA	product assurance
ppm	parts per million
QCM	Quartz Crystal Monitor
RAL	Rutherford Appleton Laboratory
SOHO	Solar and Heliospheric Laboratory
SSTD	Space Science and technology Department
TBA	to be advised
TBC	to be confirmed
TBD	to be determined
UV	ultra-violet
XMM	X-ray Multi-Mirror satellite