XMM Optical Monitor

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CLEANLINESS CONTROL PLAN

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1. INTRODUCTION

The cleanliness requirements for the telescope unit are severe and these are specified in par 5.10.1 of the Experiment Interface Document, Part A. This states that the molecular contamination shall be <10 $^{-7}$g/cm^{2}and that the particulate contamination shall be <300ppm. A separate study into the appropriate level of cleanliness has been conducted by MSSL. This work has been presented in a report titled "Preliminary Considerations for the Cleanliness Budget" ref XXMM-OM/MSSL/NT/0022. The conclusions were that the specified levels of contamination were broadly correct for the design objectives of the experiment. These demanding requirements are essential for the unit to reach its full sensitivity and great emphasis will be placed on achieving them.

The sensitivity is degraded by attenuation with molecular contaminants and by scattered background contributed by particulate contamination. Experience with other experiments, e.g. HST, has shown that even when stringent controls are in place, contamination can be a problem.

In order to minimise the effect of these contaminants, careful choice of materials will be exercised and close attention paid to outgassing paths and cleanliness procedures during storage, integration transportation and before launch.

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.

2. APPLICABLE DOCUMENTS

Mil Std 1246A

Mil Std 209B

PSS-01-201

PSS-01-204

PSS-01-705

PL/TN/819/RT/870 SOHO Preferred Materials Document

PL/TN/820/RT/870 SOHO Outgassing Data

XMM-OM/MSSL/RD/0035 SOHO Cleanliness Conference

XMM-OM/MSSL/RD/0039 XMM Cleanliness Workshop

3.0 CLEANLINESS REQUIREMENTS SPECIFICATION

3.1 Component Parts

The Optical Monitor Instrument consists of 4 units:

a. The telescope Unit (OM1), containing the following active parts:

- optical/UV telescope
- dichroic unit which reflects the beam to either the main or redundant blue detectors
- filter wheel mechanisms with 7 filters, 2 grisms and a magnifier
- 2 blue photon counting detectors (1 redundant)
- power supplies and electronics

b. Two Digital Electronic Units (OM2), one redundant, each containing:

- data processing electronics
- instrument control electronics
- power supply electronics

c. One interconnecting harness unit(OM3)

3.2 Critical/ Sensitive Parts

The critical optical parts are the first 4 items listed for the telescope unit (OM1). These impact on the 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.

3.3 Degree of Sensitivity of Critical Parts

The relevant design engineers will supply information on the criticality and sensitivity to molecular and particulate contamination for their part of the experiment.

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

- End of mission (10 years operation)
- Post launch (start of mission)
- Pre-launch
- Instrument storage
- Integration
- Transportation
- 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. For molecular contamination, to ensure a degradation of less than 20% in the wavelength range 160nm to 650nm, a contamination level $\leq 10^{-7}$g/cm^2 at end of life is required.

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

The following chart indicates the cleanliness budget for the instrument:-

	Budget	
End of Mission	Molecular <10-7g/cm2	Particles<300ppm
Scientific Ops	20%	20%
Post Launch/Pre-Ops	20%	20%
Prelaunch	10%	10%
Integration on S/C	20%	20%
Storage/Transportation	0%	0%
Instrument Integration	15%	15%
Storage/Transportation	0%	0%
Modules Pre-Integration	15%	15%

3.4 Sources of Contamination

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

These sources could be handling, vacuum chambers, flush gas, the spacecraft, space, other parts of the experiments, or from inside the OM itself. Details of the materials used in the experimental hardware will be listed in the Declared Materials List (XMM-OM/MSSL/SP/0028).

An analysis of the temperatures, mass and exposed areas of all potential outgassing sources must be made. Knowledge of vent conductance and quantification of outgassing 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 (XMM-OM/MSSL/SP/0029).

4.0 CLEANLINESS CONTROLS

4.1 Design

4.1.1 Design for Cleanliness

Ideally, only materials known not to outgas, or with very low rates of outgassing, shall be chosen. It will of course be necessary to use adhesives, paints and potting materials. These should preferably be chosen from ESA recommended lists e.g. PL/TN/819/RT/870 and PL/TN/820/RT/870. Other materials must be tested for example by ESA's Vacuum Balance Quartz Crystal (VBQC) test.

4.1.2. Facilities and Assembly Areas

For particle control, clean-rooms/benches must be used appropriate to the cleanliness needed. Clean room clothing, work practices and discipline must be adopted according to the procedures agreed in each case with the OM system team. A description of the MSSL clean-room facility and the procedures for its operation are shown in Appendix A.

4.1.3 Purging

Critical volumes shall be purged with clean dry inert gas 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.

4.1.4 Contamination Traps

The design should avoid the creation of traps for particles during manufacture and/or assembly.

It is desirable to ground all optical surfaces to eliminate charge that may attract and retain particles and condensed molecules.

4.1.5 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. Cleaning procedures shall be specified for all optical elements.

The use of removable covers for these devices may also provide protection during storage and transportation. They should provide an air tight seal and be made from non-plasticised material.

4.2 Manufacture, Assembly and Test

4.2.1 Manufacturing Controls

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

Cleaning of any part after machining must involve coarse cleaning before leaving the workshop area using ultrasonic or solvent vapour dip. However, before entry to any clean room, the hardware must undergo precision cleaning. Analytical grade solvents, stored in glass containers, are required for this purpose. Typically isopropyl alcohol would be the preferred solvent.

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.

4.2.2 Processes

Processes are also critical, since errors in the preparation or application of potting materials, adhesives and paints may destroy the UV performance of adjacent optical surfaces. 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 outgassing 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. Should there be a concern with respect to this, then potting should not be considered. 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.

4.2.3 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 (ASTM-E21.01), in which an adhesive transparent tape is applied to typical areas, removed and inspected under a microscope to quantify any particles present. This technique is not applicable to optical surfaces.

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 a repeated precision cleaning operation will be required before the next assembly operation.

4.2.4 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.

It is recommended that clean benches be "qualified" before use by exposing witness plates for 2 weeks or so when the bench is operating and verifying that the plates have not recorded detectable contamination. Results of these tests shall be kept in the equipment logbook.

4.2.5 Removal of Particles

Particles deposited on optically critical surfaces must normally be removed by non contact methods such as vacuum induced air flow. This is supplemented by a jet of de-ionized gas directed to dislodge the particle so that the gas with the freed particle is then removed via the vacuum pipe.

For non critical surfaces, light brushing with air flow into a vacuum nozzle is usually effective and is best carried out with the lighting described in par 4.2.3. The judicious use of tape lifting as described in par 4.2.3 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 gasses if possible.

4.2.6 Storage

Packing or temporary storage of piece parts and equipment requires some extra precautions to preserve cleanliness after any precision cleaning operation. For metal parts and assemblies, it is recommended that clean aluminium foil is used as the primary packing material. The wrapped item is then sealed inside a plastic bag or aluminized Kapton or Mylar. Desiccant can then be placed with this bag into another bag or container with protection against mechanical shocks, if these are expected. Optics should not be stored like this. They are best stored in a sealed 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.

4.2.7 Thermal Vacuum Testing

Parts and sub-assemblies should be baked out as part of the precision cleaning process. The highest practical temperature should be employed with a pressure less than 10^{-4}Torr(10^{-2}Pa). The temperature used will be dictated by the sensitivity of the components present.

Before testing of the complete experiment, it will be necessary to certify that the test chamber is adequately clean. It is recommended that this be done in 2 parts:-

a. about 6 months before the testing of any flight or flight spare hardware, the cleanliness of the chamber must be determined in the course of a thermal vacuum test similar in duration and temperature extremes planned for the Optical Monitor. 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. about 2 weeks before the test, the chamber should be cleaned by solvent wiping all surfaces. The MGSE must be similarly cleaned as must any other test hardware. The MGSE and hardware, witness plates/foils and QCM's should be fitted and the whole chamber baked out at 10^{-4}Torr or lower, at a temperature well above the maximum foreseen for the real test. 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 outgassing rate. This should be less than 10^{-7}g/cm^2/hr. 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 Optical Monitor 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.

4.2.8 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.

4.2.9 Logbook Records

It is required that records are 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

5. OPERATION

5.1 The Launch Phase

TBA

5.2 After Launch

TBA

APPENDIX A

M.S.S.L.

CLEANROOM

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6TH December 1994