Title: **Contamination Control Plan**

CI-No: 120 000, 150 000

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Issue	Date	Sheet	Description of Change	Release
1	27.05. 2002	all	First Issue	
1.1	15.11. 2002	36, 37, 46 - 52	Update acc. to PDR RID 8247: Section 6.2.12 Service Module (SVM) added Budgets in Section 9 updated to comply with the current status as given in H-P-1-ASPI-RP-0314, Issue 1	
2	16.04. 2004	12, 29, 32, 38, 39, 40, 44, 46 - 54	Para 2.1: Requirements updated to comply with latest issues of cleanliness team report H-P-1-ASPI-RP-0314 and cleanliness requirements H-P-1-ASPI-SP-0035 Para 5.2: Purging of LOU included Para 5.5: Baking on PLM level described in more detail Para 6.2.3: Verification method for internal molecular cleanliness of HTT / HOT added Para 6.2.7: BOLA withdrawn, LOU optical windows added Para 6.3, 6.4. 8.1: tbc's removed Para 9: Contamination budgets incl. internal outgassing and air permeation added, LOU optical windows separately considered in the budgets, as requested in AI 02 of HP-2-ASED-MN-0355	see cover

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1 INTRODUCTION

1.1 Scope

The objective of this Contamination Control Plan is to describe the tasks necessary to achieve and to maintain the cleanliness requirements as defined in AD[2]. These tasks, the established controls and procedures shall apply to all Herschel system level activities during AIT/AIV, launch preparations and launch site operations. Its implementation will be finally reflected in the Herschel test plans and test procedures. The plan is applicable for the models EQM and PFM.

This Contamination Control Plan also presents the outcome of the Herschel/Planck cleanliness team meetings, as far as it is applicable for the Herschel program. For a complete summary see AD[5]

1.2 Purpose

The instruments (FPUs) and the telescope are very sensitive to particulate and molecular contamination. A great effort will be taken to keep these items as clean as possible and consequently all adjacent critical surfaces enveloping these cleanliness sensitive surfaces must be kept as clean as possible too! This means all surfaces inside the CVV have to comply with a relatively high cleanliness level. As the telescope is positioned outside the CVV, the outer surface of the PLM has to be clean as well, to minimise redistribution of contamination to the telescope.

The purpose of cleanliness control for Herschel is to avoid unacceptable degradation by contaminants on the sensitive surfaces of the instruments. This will be accomplished by providing effective contamination protection, cleanliness verification controls and monitoring of the sensitive areas / surfaces during all AIT/AIV activities, to assure that the stringent cleanliness requirements can be achieved, so that Herschel meets its performance objectives.

1.3 General Approach

This plan outlines the contamination control philosophy, describes in detail the activities to be performed and identifies control analysis techniques and related verification methods.

The plan is based on the document Herschel/Planck Cleanliness Requirements Specification, AD[2], and on the results of the Herschel/Planck cleanliness team meetings, AD[5].

In case that no sufficient outgassing data are available for materials used in critical areas a VBQC test sample program will be considered.

Baseline of the contamination protection is the ´closed´ spacecraft philosophy: 1. When the PLM is closed, there is no contamination growth inside the CVV. 2. Whenever possible the cleanliness sensitive surfaces shall be covered, packed or enveloped by foils, caps, covers etc.. This approach shall be applied also in clean rooms of any class.

Integration of the instruments will take place in a class 100 clean room. Immediately after integration of the FM FPUs the PLM closing sequence begins. After PLM closure the instruments inside the CVV are protected against contamination from outside the CVV.

The telescope cover will remain on the telescope whenever possible, to ensure that the telescope achieves the required cleanliness level without cleaning. The goal is to remove the cover only for TV / TB thermal cycling test on system level and during part time of acoustic noise- and vibration test.

Cleaning of the PLM surface may become necessary if the results of the contamination monitoring show inadmissible high values.

The approach of cleanliness control for Herschel is based on the selection of monitoring methods and verification controls which are compatible to the derived cleanliness requirements.

The major steps (see section 6.) of the approach for the Herschel program are:

- Generate the Contamination Control Plan
- Perform a Contamination Assessment
- Provide the appropriate clean room environments according to the requirements
- Establish contamination control methods to verify subcontractor H/W
- Establish cleanliness monitoring system
- Provide contamination protection for specific surfaces / units
- Establish cleanliness controls for specific surfaces
- Establish cleaning procedures for specific surfaces

All of this will be covered in consecutive sections of this plan.

1.4 Responsibilties

Astrium GmbH is responsible for the implementation and supervision of the cleanliness requirements for the H-EPLM program and the Herschel AIT activities as specified in AD[2]. This implies the implementation of this Contamination Control Plan with all stated contamination protection, cleanliness verification and monitoring methods.

1.5 Documents

The following documents of the latest agreed issue form part of this plan to the extent specified herein, and may be used in such cases where more detailed information on contamination control issues, as addressed within this document, is desired.

In the case of any conflict between this Plan and documents listed as applicable documents the inconsistency shall be brought to attention of the author.

In the case of conflict between this Plan and documents listed as reference documents this Plan shall have precedence.

1.5.1 Applicable Documents

AD[1]	HP-2-ASED-SP-0002	PA Requirements for Herschel EPLM Subcontractors
AD[2]	H-P-1-ASPI-SP-0035	Herschel/Planck Cleanliness Requirements Specification
AD[3]	H-P-1-ASPI-SP-0056	Herschel/Planck NCR/NRB Instruction Handbook
AD[4]	H-P-1-ASPI-SP-0028	Herschel/Planck Waiver/Deviation Request Instruction Handbook
AD[5]	H-P-1-ASPI-RP-0314	Cleanliness Team Report

1.5.2 Reference Documents

RD[1a]	HP-2-ASED-PL-0022	Herschel PLM/EQM AIT Plan
RD[1b]	HP-2-ASED-PL-0025	Herschel AIT Plan Part 1: EPLM & S/C-STM Qual. Phase
RD[1c]	HP-2-ASED-PL-0026	Herschel AIT Plan Part 2: EPLM & S/C-PFM Accept. Phase
RD[2]	HP-2-ASED-SP-0004	H-EPLM Environment and Test Requirements Specification
RD[3]	H-P-1-ASPI-TN-0197	Cleanliness EOL Technical Note
RD[4]	HP-2-ASED-TN-0034	Permeation through CVV Sealings
RD[5]	ISO AS 1300 TN 0429	ISO Cleanliness Policy
RD[6]	ECSS-Q-70-01	Contamination and Cleanliness Control
RD[7]	ESA PSS-01-202	Preservation, storage, handling and transportation of ESA spacecraft hardware
RD[8]	ESA PSS-01-204	Particulate Contamination Control in Clean Rooms by Particle Fall-out (PFO) Measurements
RD[9]	ECSS-Q-70-02A	Thermal Vacuum Outgassing Test for the Screening of Space Materials
RD[10]	ESA PSS-01-705	The Detection of Organic Contamination of Surfaces by Infra Red Spectroscopy
RD[11]	YTO/BLD/REP/1028/	Report of the Testfloor Contamination Measurements during SAX Environmental Test Campaign
RD[12]		ARIANE 5 User's Manual

RD[13]	FED-STD-209E	Clean Room and Work Station Requirements Controlled Environment
RD[14]	ASTM-E-1216-87	Standard Practice for Sampling for Surface Particulate Contamination by Tape Lift
RD[15]	MIL-HDBK-406	Cleaning Materials for Precision Pre-cleaning and Use in Clean Rooms and Clean Work Stations
RD[16]	MIL-HDBK-407	Precision Cleaning Methods and Procedures

Astrium GmbH internal reference documents:

RD[17]	CDS-TEA024-IN-D	Surveillance of clean rooms and clean benches by the Quality Assurance Department
RD[18]	CDS-TEA026-IN-D	Reinraumvorschrift für das Raumfahrt IC in FN.
RD[19]	CDS-TEA022-IN-D	Cleanliness control in the clean areas of the Astrium-FN IC.

1.6 Terms and Definitions

Baking (Bake-out) Act of removal of unwanted volatile substances.

Cleaning Act of removal of unwanted substances under application of cleaning procedures.

Cleanliness level The (Product) Cleanliness Levels are defined in RD[6]. The cleanliness levels concern basically particulate and molecular contaminants. The particulate cleanliness level of a surface is expressed as an obscuration factor with the unit ppm (parts per million), the molecular cleanliness level is defined as mass per unit area (g/cm^2).

Clean packaging The application of clean preservation and packaging measures and material to maintain the cleanliness of a clean item during handling, storage or shipment.

Clean room A clean room is an enclosed area employing control over particulate matter in air with temperature, humidity, and pressure control as required. To meet the requirements of a clean room the area must meet the particulate count as specified in RD[13].

Clean room Class The Clean room Class is defined by FED-STD-209E. It describes the air cleanliness in units of particles per cubic foot, dependent on their size. The air in a clean room of class ´c´ contains c particles/ft^3 with a size equal to or greater than 0.5 μm.

Clean room garment This garment is specially designed for wear by all personnel who enter a clean room. Special particle/lint-free garments such as overalls, caps, gloves, finger cots, boots and shoes are primarily manufactured from

	synthetic fabrics and materials. Their purpose is to minimise the contamination of clean rooms by particulate matter from an individual's skin, hair, clothing or shoes such as dust, lint, dandruff, etc.
Clean work station	A work bench or similar working enclosure characterised by having its own filtered air supply. The filters must by capable of providing the required air-cleanliness level.
Contaminant	Any material or substance whose presence on or within a system or equipment is unwanted. Any contaminant which adversely affects an equipment or system or which poses a credible threat to an equipment, system or person.
Contamination	The presence of one or more contaminants in or on the contaminee.
Contamination control	The planning, organisation and implementation of all activities needed to determine and maintain a required cleanliness level in, on or around the contaminee.
Contaminee	Item which is or can be contaminated. Contaminees can be products, materials, devices, people, gases or surfaces.
Critical surface	Surface which can potentially distribute contamination to sensitive surfaces or which is in the vicinity of sensitive surfaces.
Molecular contaminat.	Contamination by sub-microscopic constituents, as molecular clusters or layers.
Non-Volatile Residue	Material remaining after evaporation of a liquid.
Obscuration factor	The ratio of the projected area [mm^2] of particles to the total area [m^2] is expressed in parts per million of area [ppm], acc. to RD[6].
Particulate contaminat.	Contamination by solid contaminants having measurable dimensions.
Precision cleaning	Final or fine cleaning accomplished in controlled environment (materials cleaning room) to remove minute quantities of contaminants to better then visual clean standards. Refer to MIL-STD-406 and -407.
Pre-cleaning	That cleaning which is accomplished outside of a clean area for the purpose of removing contaminants such as rust, oxidation, grease, oil, heavy scale, or soil deposits to control the amount of contaminants brought into the clean room. Pre-cleaning is used to achieve visibly clean articles.
Purge	To flow an inert gas through a system (or line, container, etc.) for the purpose of ridding the system of a residual fluid or for providing a positive flow of gas from some opening in the system.
Sensitive surface	Surface which has to be protected against contamination, because contamination will degrade its performance.
Solvent	That solution or constituent of a solution which exhibits the capability to dissolve other substances through chemical action.

Visibly clean There shall be no visual evidence of contaminants or foreign materials such as particles, debris or liquid films or droplets when inspected visually without magnification from a distance of 30 to 50 cm and with 1100 to 2200 lumen/m^2 of illumination. (According RD[6], visibly clean corresponds to an obscuration factor of 300 ppm).

1.7 List of Abbreviations

BAF	Final Assembly Building (Batiment d'Assemblage Final)
CCLB	Contamination Control Log-Book
CRC	Clean room Class
CVCM	Collected Volatile Condensable Material
EMC	Electromagnetic Compatibility
EOL	End of Life
IC	Integration Center
LEAF	Large European Acoustic Facility
LSS	Large Space Simulator
MAIT	Manufacturing, Assembly, Integration & Testing
NVR	Non-volatile Residue
PFLS	Particle Fall-Out Log-Sheet
PMP	Parts, Materials and Processes
PPM	Parts per Million [10^{-6}]
Q3LS	Q III detector Log-Sheet
QCM	Quartz Crystal Micro balance
RML	Recovered Mass Loss
TLLS	Tape-Lift test Log-Sheet
TML	Total Mass Loss
VBQC	Vacuum Balance Quartz Crystal
VILS	Visual Inspection Log-Sheet
WPLS	Witness Plate Log-Sheet
WTLS	Wipe Test Log-Sheet

2 General Contamination Control Requirements

2.1 Baseline Requirements

The instruments have provided the following information on their requirements End Of Life (EOL) as far as the FPU and the front optics are concerned, ref. AD[5]:

Numbers in ppm are related to particulate contamination, numbers in g/cm^2 to molecular contamination.

HIFI:

HIFI FPU: 1200ppm and $6x10^{-6}$ g/cm^2

HIFI demand on telescope mirrors: M1: 4650 ppm, M2: 4300ppm; for particulate contamination the distribution between M1 and M2 can be changed provided that the sum remains unchanged. Molecular req. for M1 and M2: $4x10^{-6}$ g/cm^2

LOU optical windows (for each surface of the window): 1200ppm and $8.5x10^{-6}$ g/cm^2

LOU inside: 300ppm and $4x10^{-6}$ g/cm^2

SPIRE:

FPU internal parts: 500ppm and $5x10^{-5}$ g/cm^2

FPU external parts: 10^{-4} g/cm^2 (no partic. requirement)

SPIRE demand on telescope mirrors M1 and M2: 5000 ppm and 10^{-5} g/cm^2, provided self emission budget is met

PACS:

FPU external parts: 1500ppm and $6x10^{-6}$ g/cm^2

PACS demand on telescope mirrors M1 and M2: 5000ppm and $6x10^{-6}$ g/cm^2, provided self emission budget is met

Telescope:

The most stringent EOL requirements for the telescope mirrors come from HIFI, namely 4300 / 4650 ppm and $4x10^{-6}$ g/cm^2, see above. Acc. to AD2 the maximum allowed level at end of AIT is 2190 ppm and $6x10^{-7}$ g/cm^2

Spacecraft:

Acc. to AD2 the maximum allowed level at end of AIT is 2500 ppm and $2.7x10^{-6}$ g/cm^2.

Helium S/S:

The He S/S is contamination sensitive mainly due to tightness requirements of the electromagnetic valves used in the cryo subsystem. Cleanliness of surfaces without direct access (inner side of He S/S incl. He-tanks) shall be verified by classification of filtered particles in used cleaning solvents, see table below.

Particle size [microns]	Maximum number of particles per 100 ml isopropyl alcohol sample
>100	0
51 - 100	1
26 - 50	3
11 - 25	15
5 - 10	39

Table 1: Particle Cleanliness requirements for He S/S

2.2 Cleanliness Verification, Monitoring and Reporting

Cleanliness monitoring will be established to determine the cleanliness levels of clean room environmental conditions and spacecraft hardware surfaces on regular basis.

The monitoring shall include :

<u>for particular supervision :</u>

- airborne particle counting according to FED-STD-209 E, RD[13]
- determination of the particle fall-out (PFO) acc. to ESA PSS-01-204, RD[8]
- determination of the particulate deposit by Tape-Lift sampling acc. to RD[14]
- sampling of the surface deposited particles with the Q III detector (Option)
- regular visual inspections with black-light and white light

<u>for molecular supervision:</u>

- determination of the molecular contamination by Wipe-Test acc. to RD[10]
- determination of the molecular contamination by Witness Plate analysis acc. to RD[10]

The monitoring shall be done in the direct vicinity of the hardware surfaces during AIT/AIV operations, nevertheless without disturbing these activities.

Documentation of results:

Results of individual contamination measurements shall be reported to the Herschel cleanliness responsible on the specific Contamination Control Log-Sheets like the print record of the airborne particle counter, the PFLS, TLLS, Q3LS, VILS, WTLS and WPLS.

The Log-Sheet formats are included in the appendices of this document.

All these results will be summarised in the Herschel Contamination Control Log-Book.

The cleanliness verification sequence therefore consists of :

- Measuring the environmental conditions
  - => reporting on Calibration Test Reports (Astrium regular half-year check)
  - => reporting on Particle Counter print-out
  - => reporting on PFLS and WPLS

- Visual inspection and determination of the particle deposit for cleanliness critical or sensitive subcontractor H/W during the DRB
  - => reporting on VILS, Q3LS, TLLS or alternatively
  - => reporting on subco cleanliness verification sheets

- Visual inspection of cleanliness critical subcontractor H/W during the Incoming Inspection
  - => reporting on VILS, Q3LS

- Measuring the particle deposit with the Q III detector (Option)
  - => reporting on Q3LS

- Analysing Witness Plates (e. g. applied for transport monitoring)
  - => reporting on WPLS

- Measuring the molecular deposit (if necessary) by Wipe-Test
  - => reporting on WTLS

- Logging of particle deposition on system level
- Logging of molecular deposition on system level

Outputs of these steps will be summarized and reported in the Herschel-EQM/PFM Cleanliness Monitoring Reports. A detailed description of the different contamination measurement techniques is given in chapter 3.3. The monitoring and verification sequence to be applied for Herschel is established in section 3.4 in this document.

Routine contamination control progress reporting will normally take place within the frame of the Herschel progress reporting:

- status of documentation
- status of contamination controls
- materials and processes
- results of audits and mandatory inspections and measurements
- NCR and waiver status related to contamination

2.3 Audits

In cases where significant problems with the achievement and the maintenance of the Herschel cleanliness requirements are to be investigated, dedicated Cleanliness-Audits will be performed.

Audits are intended as preventive and/or corrective means for ensuring proper implementation of requirements and procedures. Alcatel/ESA is permitted to witness audits or inspect any operation or document associated with the subject.

Audits will be implemented covering all aspects of contamination control at the different facilities where AIT activities are carried out. Reports will be supplied to Alcatel/ESA for review.

2.4 Non-Conformance Definition and Reporting

Non-Conformances concerning cleanliness issues shall always be reported in parallel to the cleanliness responsible. Serious issues shall be reported in NCR´s and be handled according to the project NCR procedure, refer to AD[3].

Cleanliness NCR´s shall be raised in the following situations :

- the particle fall-out rate in the clean room environments exceeds the values specified in RD[8]
- the molecular growth rate in the clean room environments exceeds the value of 0.5×10^{-7} g/cm^2 during a continuous period of one whole month
- the molecular or particle deposit on cleanliness critical or sensitive surfaces is above the cleanliness requirements
- leakage in CVV after PLM closure

- damage of protective covers, foils, bags when stored in a CRC worse than 100
- damage of the transport or storage containers

All other situations obviously jeopardising the cleanliness of sensitive surfaces shall be reported directly to the cleanliness responsible of the Herschel program.

2.5 Training

All personnel directly involved in the flight hardware AIT phases shall be adequately trained with respect to cleanliness issues. This includes attendance of clean room specific instructions like RD[17] and RD[18], which are applicable for all Astrium GmbH personnel authorised to enter the clean rooms!

3 CLEANLINESS / CONTAMINATION MONITORING

3.1 Clean Room Environmental Control

All activities concerning MAIT will be performed in a clean room. The Astrium GmbH clean rooms will be controlled by the Quality Assurance Department in regular intervals according to RD[17], Surveillance of clean rooms and clean benches by the QA Department, and acc. to RD[19], Cleanliness control in the clean areas of the Astrium GmbH Integration-Center (IC).

The objective of these specifications is to define clean rooms inclusive controlled areas, clean benches and their equipment to determine the correspondingly required environmental conditions, such as permissible airborne particles, air temperature, relative humidity, air pressure and other environmental conditions (noise level, vibrations, magnetic fields, ionisation, etc.) and to describe the procedure for monitoring these conditions. The results of all these regular standard examinations are documented by the QA inspector in an inspection record and will be collected during the Herschel program in the Contamination Control Log-Book.

Astrium GmbH clean rooms and controlled areas are marked as such and entrance is possible only for authorized personnel with an identification card of the company.

For the Herschel program the monitoring of the clean rooms shall be tightened by the additional use of molecular witness plates and PFO sensors. The particle counter checks the airborne particle distribution during all cleanliness critical activities. The results of these examinations will be reported on the corresponding Log-Sheets and collected in the Herschel Contamination Control Log-Book.

3.2 Clean Room and Personnel Behaviour

Only authorized persons have the allowance to enter Astrium GmbH clean rooms respectively environmental controlled areas. Clean room and personnel behaviour is described in detail in RD[18], Reinraumvorschriften für das Raumfahrt-IC in FN. This is applicable for the facilities in OTN as well.

This document establishes the rules for warranty and maintenance of the specified clean room quality. It describes the performance and equipment of the Astrium GmbH -IC clean rooms and establishes the requirements for the entrance allowance and control, and the prohibitions and commands for a correct behaviour. A list of forbidden parts, materials and activities, rules for the transport of parts and units into the clean room, and two lists ´Conduct of Persons in the Clean Rooms´ as well as ´Security Rules for Guests working at Astrium GmbH´ completes this document.

3.3 Measurement of Contamination

Only the measurement methods applied for the Herschel program are mentioned in the following.

3.3.1 Measurement of Particulate Contamination

Particles in air will be measured by using an airborne particle counter according to RD[13] and RD[17]. It must be noted, that only a poor practical correlation between airborne particle cleanliness acc. to FED-STD-209E and the surface product cleanliness is given, ref. RD[6], RD[8]

Indirect measurement method :

- Measurement of the obscuration factor, the most practical expression for product surface cleanliness, by using a PFO-black-mirror according to RD[8].

Direct measurement methods :

- Measurement of particle deposition with the Tape-Lift Test according to RD[14]. It must be noted, that not on all surfaces a tape-lift test is possible. The best results will be achieved on smooth surfaces like foils or polished metal. The application of an appropriate tape is mandatory since no residual adhesive should remain on the inspected areas.
- Measurement of particle deposition by using a Q III detector. This measurement method is based on counting particles, which are removed from a known surface by blowing and sucking air without touching the surface. Therefore, also cleanliness sensitive surfaces as well as rough or painted surfaces could be inspected by applying this detector. A calibration between the Q III results compared with tape-lift test results will provide a better reliability. (Option)
- Visual inspection of surfaces with the naked eye or with the aid of a microscope. An UV-lamp (or white light applied in a flat angle) increases the visibility of particles. Nevertheless, the visibly clean level (acc. to RD[6] approx. 300 ppm) depends very much on the circumstances in which the examination was made.

3.3.2 Measurement of Molecular Contamination

ESA experience with the Micro-VCM tests has shown that levels of organic contamination above 1x 10^{-6} g/cm^2 could be visible to the naked eye. In the Herschel program a visually detected molecular deposit will lead to a verification by a Wipe-Test according to RD[10] or alternatively direct to a cleaning of the contaminated hardware.

Indirect measurement methods :

- Measurement of the molecular deposit on a stainless steel reference surface of a Witness Plate acc. to RD[10]. The witness plate detection area will be washed with spectral grade chloroform, the remaining substrate will be transferred on a IR NaCl window, and analysed by using a IR spectrophotometer. Witness plates can be applied under atmospheric conditions as well as under vacuum.

Direct measurement method :

A surface of known area will be wiped with an ultra clean (special pre-treatment necessary) lens paper. This lens paper is subject to extraction with spectral grade chloroform and the residue of the chloroform will be analysed by IR in accordance with RD[10]. The detection limit of organic contamination level is about $3x10^{-9}$ g/cm^2 dependent on the used IR spectrophotometer and the size of the wiped area. This method requires smooth, blank metallic surfaces, chemically compatible with the chloroform, for good results.

Wipe tests on surfaces of organic materials (paints, composites) may be performed with an appropriate solvent other than chloroform (e. g. IPA) or with a dry lens paper.

3.4 Contamination Control and Verification Sequences

General :

The individual unit specifications define the cleanliness requirements and all bake-out parameters for materials used for H-EPLM. The definition of the bake-out requirements is based on ISO heritage. In most cases a maximum residual outgassing rate is specified instead of a minimum bake-out duration.

Therefore, the molecular cleanliness requirements are already reached on unit- respectively on subsystem level when they arrive at Astrium GmbH. That means, through a consequent protection of the hardware the molecular cleanliness level can be ´frozen´ if water absorption and outgassing effects during Thermal Vacuum activities would not be considered. The protective measures are described in sections 5.1 and 6.2.

Considering the above mentioned, it is necessary to monitor the molecular cleanliness level of the clean rooms where the units / subsystems, foreseen for integration on Herschel, must be assembled respectively where these sensitive items must be handled in an unprotected phase, e.g. to perform assembly, integration, alignment or test-activities.

Individual monitoring / contamination records will be kept for traceability. These records will be delivered as part of the ´Herschel-EQM/PFM Cleanliness Monitoring Reports´.

The monitoring and recording must be sufficiently precise and accurate for the specified area requirements. The monitoring devices have to be regularly checked and calibrated to the manufacturers instructions.

Any discovered non-compliance with the specified contamination levels will be reported in a NCR and become subject to the formal project procedures and ultimately to the disposition of a Non-Conformance Review Board.

Verification Sequences :

Verification Object	Methods particular [p] molecular [m]	Number of detectors	Analysis Intervals	Report	Remark
CR 100.000 environm. ctrl.	PFO [p] Witn.plates[m]	1 6 *)	weekly monthly	PFLS WPLS	environmental check
CR 100 environm. ctrl.	PFO [p] Witn.plates[m]	1 6 *)	weekly monthly	PFLS WPLS	environmental check
protected H/W	visually [p]	N/A	regular	VILS	H/W protection check
unprotected H/W	Q III / Tape-lift[p] Wipe-Test [m]	N/A	after visual inspection shows cont.	Q3LS/TLLS WTLS	will be performed if necessary
CRC 100.000 activities	PFO [p] Witn.plates[m]	1 2	weekly monthly	PFLS WPLS	activity monitoring
CRC 100 activities	PFO [p] Witn.plates[m]	2 2 *)	3-4 days 2 weeks	PFLS WPLS	activity monitoring

*) on a turnaround basis: After each interval 1 sample will be analysed.

Table 2: Contamination monitoring sequences

Cleanliness critical activities require CRC 100 and a corresponding garment according CRC 100. Exposure of cleanliness sensitive H/W to CRC 100 000 environment shall be limited to the necessary extent and will be protected as soon as possible after handling activity.

3.5 Unpacking and Incoming Inspection

After receiving of the spacecraft hardware transport containers, they will be cleaned and transferred to the clean room 100.000 sluice. There, the transport container will be opened and a first preliminary incoming inspection will be performed checking the container status itself and the outer packaging of the H/W.

Removal of the outer package foil takes place in the CRC 100.000 front part and the complete unpacking of the inner protection will take place in the CRC according to the unit cleanliness requirements. The outer H/W surface will be visually inspected supported by UV-light, white light, Q III detector and / or Tape-Lift (if necessary).

The results of this incoming inspection will be reported on the corresponding Log-Sheets which will be collected in the Herschel Contamination Control Log-Book.

Units or subsystems which are highly sensitive against contamination will be transported in special containers, providing their own environmental control of CRC 100 conditions. Others are precision cleaned prior to packaging and the transport respectively storage phase will be monitored by witness plates assembled in the direct vicinity of the H/W.

<u>perceived problems :</u>

Possible contamination when removing covers or packaging material, further contamination during integration requires additional or substitutive protective devices.

4 CONTAMINATION ASSESSMENT

In consideration of the sensitivity against contamination of certain Herschel units it will be necessary to assess the impact of contamination during the whole system AIT / AIV and during mission concerning the performance requirements.

The most contamination sensitive units are the FPUs and parts in the vicinity of the optical bench. The telescope is also a contamination sensitive item, but with significant more allowable contamination compared to the FPUs. Due to the baseline to avoid a cleaning of the telescope, it has to be protected by a cover. In addition the He S/S is contamination sensitive mainly due to tightness requirements of the electromagnetic valves used in the cryo subsystem.

A detailed assessment of the effect of molecular and particular contamination to the above mentioned items and furthermore, to adjacent satellite items is explained in the Summary Report of the Herschel/Planck Cleanliness Team Meetings, AD[5], and in the Cleanliness EOL TN, RD[3].

5 PRECAUTIONS AGAINST CONTAMINATION

5.1 Protective Measures

Baseline of the contamination protection is the ´closed´ spacecraft philosophy, as explained in chapter 1.3.

The preferred materials for the protection applications are MYLAR, POLYETHYLENE or LLUMALLOY. Special protective covers for the sensitive surfaces of the instruments, i. e. telescope as well as FPUs, shall be designed and delivered by the telescope- and instrument-providers.

In case of any doubt if the material for protection or packaging is suitable from the molecular contamination point of view, a contact test or an immersion test will be performed to determine the compatibility to the Herschel requirements. A particle cleanliness verification can be done by a tape-lift test or with the Q III detector.

5.2 Purging

On request of the HIFI instrument the LOU will be purged during all ground AIT activities until launch, except for certain environmental tests, e. g. TB/TV, acoustic noise, vibration.

5.3 Cleaning Considerations

All from subcontractors received spacecraft hardware has to fulfil specific cleanliness requirements according to the applicable procurement specification. The level of cleanliness / contamination will be checked during the DRB and during the incoming inspections at Astrium GmbH facility.

Therefore, potential cleaning activities are only necessary if the contamination monitoring reveals that a specific surface is nearby or over the requirement limit, or to achieve and to maintain the cleanliness levels again after non-appropriate handling, storage or after accidental mishandling.

In case a cleaning of a specific surface will be necessary the subcontractor of this unit has to provide a cleaning procedure or an individual cleaning procedure must be established. This procedure has to implement the precision cleaning method, the compatibility of potential cleaning solvents (NVR !) etc. with respect to the constraints of the item to be cleaned like surface roughness, surface treatment, painting etc..

Refer also to RD[15] and RD[16].

Potential cleaning methods :

Particle contaminants deposited on sensitive surfaces will be removed by non-contact methods such as vacuum induced air flow and vacuum pipes or light brushing with air flow into a vacuum nozzle. Other (non sensitive) surfaces will be cleaned by light brushing with air flow into a vacuum cleaner and by wet wiping using appropriate tissues and solvents (NVR !).

The judicious use of tape lifting is appropriate for the removal of a limited number of particles where the introduction of a vacuum hose is difficult or not possible.

It must be noted, that high flow rates may induce electrostatic charging problems which apart from the risk of damage to ESD sensitive components may simply attract particles to the charged surfaces.

Cleaning of mirror surfaces may only be performed in accordance with procedures agreed by instrument contractor and/or Herschel Mission Prime and is presently not foreseen in the nominal planning.

For a number of optical surfaces no cleaning is allowed after a certain stage in its fabrication, and for these items the cleanliness requirements must be met during all stages up to the end of mission.

Each cleaning activity as well as each cleaning procedure must be released by the Astrium cleanliness responsible for Herschel.

5.4 Contamination traps

It has been observed that charged surfaces attract and retain particles and, probably, condensable molecules. It is therefore desired to ground all cleanliness sensitive surfaces and components.

Further contamination traps are:

- thermal vacuum test (because of molecular evaporation (outgassing))
- acoustic test (because of particle release and internal redistribution)
- vibration test (because of particle release and redistribution)

The necessary precautions against contamination during the above mentioned tests are described in section 6.4.

5.5 Baking

Component Level:

Baking of components and materials can only be performed on unit level, since the assembled satellite configuration dimensions are too large. Baking is necessary in order to reduce the pump-down time of the cryostat, to reduce outgassing and to remove contaminants and water from the material. The bake-out parameters were selected such that the residual contamination from all elements will meet the cleanliness requirements on Herschel system level. The bake-out parameters are defined in the unit specifications.

PLM Level:

A bake-out of the PLM with simultaneous vacuum pumping shall be performed before the first cool down to cryo temperatures after FM FPU integration, mainly to remove humidity from inside CVV. The bake-out will be performed by leading hot gas through the He-vent lines. This bake-out has to be repeated after each opening of the cryostat!

6 CLEANLINESS CONSIDERATIONS DURING SATELLITE AIT/AIV ACTIVITIES

6.1 General

This phase is characterised by the assembly, integration and testing of the Herschel satellite. Throughout this phase, a continuous contamination control is maintained to assure compliance to the cleanliness requirements.

The tasks are:

- Provision of test facilities with appropriate cleanliness levels
- Provision of test equipment
- Performance of measurements
- Assembly, Integration and Testing of the satellite

Astrium PA will support the following tasks:

- Preparation of the test logs and maintenance of logbook records
- Preparation of non-conformance reports

Measures will be implemented to minimise the built-up of contamination on the satellite, and to maintain it within the specified limits. The specific constraints on satellite AIT are described in the next chapters.

In principle the cleanliness sensitive surfaces are not allowed to be exposed to clean room environments worse than CRC 100. Otherwise the exposure time to environments worse than CRC 100 must be limited to the absolute necessary minimum, and the cleanliness sensitive surfaces have to be protected immediately afterwards.

<u>For all testing and assembly activity the following limitation will apply:</u>

- The number of personnel working around the spacecraft must be restricted.
- The position of the spacecraft within the facility will be such, that the cleanliness sensitive subsystems benefit most from the air-flow.
- Personnel working in the vicinity of sensitive surfaces shall wear masks and lint free gloves (e. g. Latex gloves) in addition to the normal protection garments. (garment depends on CRC)
- Whenever possible the cleanliness sensitive surfaces shall be protected

6.2 SUB-ASSEMBLIES Cleanliness Control

The following chapters describe the main function of the sub-assemblies, the specific design precautions for achieving and maintaining the cleanliness requirements, the protective considerations during AIT/AIV activities and the established cleanliness verification / monitoring techniques from the contamination protection point of view.

Monitoring samples may be valid for several sub-assemblies at the same time if the latter are close together, e. g. during PLM integration.

6.2.1 Telescope

main function :

- reflect IR light with low transmission loss

design precautions :

The telescope is a customer furnished equipment. Design precautions shall be considered by the provider, e. g.:

- a special cover which can remain on the telescope during most of the AIT steps
- cleanability of reflecting surface in case of accidental contamination

environments :

- AIT/AIV activities shall be performed in CRC 100 000
- cover applied whenever possible

cleaning :

- baseline is to fulfil the cleanliness requirements without any cleaning.
- in case of necessity particles could be removed blowing clean air in combination with vacuum extraction
- the cleaning process is depending on the material characteristics of the reflective surface. A cleaning procedure should be provided by the telescope supplier.

storage :

- storage in transport container or appropriately protected in a clean room until integration to H-EPLM
- after integration storage in CRC 100 000 with cover applied

cleanliness monitoring :

- molecular : molecular witness plates in appropriate position close to the mirror surface
- particular : PFO samples in appropriate position close to the mirror surface

cleanliness verification :

- molecular : wipe test on tbd surface (maybe at the outer rim of the mirror surface), if requested
- particular : visual inspection, tape-lift test on tbd surface, if requested

6.2.2 Cryostat Vacuum Vessel (CVV)

main function :

- provide a highly tight high-vacuum environment for the He S/S on ground and during early orbital operations
- provide a thermal insulation system for cryostat and the scientific instruments
- mechanical support for internal components (He S/S, heat shields, Optical Bench with instruments)
- mechanical support for external components (I/F structures for telescope, HSS, SVM, BOLA, LOU, radiators

design precautions :

- an electrically actuated shut off valve at the vacuum port of any pumping unit connected to the cryostat to avoid contamination by pump oil inside the CVV

environments :

- AIT/AIV activities shall be performed in CRC 100 until PLM closure, activities with PLM closed in CRC 100 000

cleaning :

- pre-baking of MLI for heat shields and all other organic material
- bake-out on PLM level before each first cool down to cryo temperature after FM FPU integration
- on metal surfaces standard cleaning processes like vacuum air flow and IPA wiping.

storage :

- storage in CRC 100 with protection foil coverage until PLM closure

- storage in CRC 100.000 with protection foil coverage if CVV is completely closed
- storage in transport container

cleanliness monitoring :

- molecular : molecular witness plates
- particular : PFO samples

cleanliness verification :

- molecular : wipe test inside before PLM closure
- particular : visual inspection, tape-lift test

6.2.3 Helium Subsystem (He S/S) incl. He-Tanks

main function :

- provide the cooling of the scientific instruments inside the CVV
- the He II tank is the reservoir for the superfluid Helium
- the He I tank is the reservoir for the normal fluid Helium (for certain ground tests and pre-launch operations)

design precautions :

- special design of welded joints to avoid internal contamination caused by the welding process
- special tank design to avoid local areas which complicate cleaning operations
- venting holes at screw grounds in order to avoid that air can be trapped with the consequence of long-term outgassing in orbit.
- protective covers on sealing interfaces until short before integration
- blind flanges/caps for closure of tank apertures

environments :

- AIT/AIV activities shall be performed in CRC 100 until PLM closure

cleaning :

- bake-out on PLM level before first cool down to cryo temperature

- Cleaning of the outer surfaces of the components by standard cleaning processes like vacuum air flow and IPA wiping.
- Cleaning of surfaces without direct access by rinsing out the components with a solvent, until filter extraction of the solvent meets the requirements of table 1 in chapter 2.1. Solvents can be Isopropylalcohol (IPA) or Forane 141b DGX (1.1 dichloro-1-fluoroethan).

<u>storage :</u>

- storage in CRC 100 with protection foil coverage
- storage in transport container

<u>cleanliness monitoring (before PLM closure) :</u>

- molecular : molecular witness plates
- particular : PFO samples

<u>cleanliness verification :</u>

- molecular : wipe test on outer surfaces, internal cleaning with solvent circulation, verification by weighing NVR in the cleaning liquid, acc. to ECSS-Q-70-01, § 4.3.4, table 3 (performed by Air Liquide)
- particular : visual inspection of inner surfaces with endoscope where possible, filter extraction and counting of particles in solvents after internal cleaning; tape-lift test on outer surfaces

6.2.4 Optical Bench (OB)

<u>main function :</u>

- provide a mechanical support for the FPU's, the related harness, the venting tubes and the instrument shields

<u>design precautions :</u>

- only very few non-metallic parts with low total mass
- aluminium parts allow excellent cleaning

<u>environments :</u>

- AIT/AIV activities shall be performed in CRC 100 until PLM closure cleaning :

- pre-baking of non-metallic parts
- procurement in clean condition, in addition standard cleaning processes like vacuum air flow and IPA wiping.
- bake-out on PLM level before each first cool down to cryo temperature after FM FPU integration

storage :

- storage in CRC 100 with protection foil coverage
- storage in transport container

cleanliness monitoring (before PLM closure):

- molecular : molecular witness plates
- particular : PFO samples

cleanliness verification :

- molecular : wipe test
- particular : visual inspection, tape-lift test

6.2.5 Tank Support and Spatial Framework

main function :

- load distributing structure between CVV and He II tank
- mechanical interfaces to OB and He I tank

design precautions :

- amount of non-metallic material as low as possible
- aluminium parts allow excellent cleaning

environments :

- AIT/AIV activities shall be performed in CRC 100 until PLM closure

cleaning :

- pre-baking of non-metallic parts

- procurement in clean condition, in addition standard cleaning processes like vacuum air flow and IPA wiping.
- bake-out on PLM level before each first cool down to cryo temperature after FM FPU integration

storage :

- storage in CRC 100 with protection foil coverage
- storage in transport container

cleanliness monitoring (before PLM closure):

- molecular : molecular witness plates
- particular : PFO samples

cleanliness verification :

- molecular : wipe test
- particular : visual inspection, tape-lift test

6.2.6 Focal Plane Units (FPU's)

main function :

- scientific instruments (HIFI, PACS, SPIRE), refer to specific requirement specifications

design precautions :

- tbd by the instrument providers, e. g. covers on sensitive surfaces

environments :

- AIT/AIV activities shall be performed in CRC 100 until PLM closure

cleaning :

- no cleaning foreseen; in case of necessity a cleaning procedure shall be established by the instrument provider

storage :

- storage in CRC 100 with protection foil coverage or other appropriate protection recommended by the instrument provider
- storage in transport container

cleanliness monitoring (before PLM closure):

- molecular : molecular witness plates
- particular : PFO samples

cleanliness verification (before PLM closure):

- molecular : wipe test
- particular : visual inspection, tape-lift test

6.2.7 LOU and optical windows

main function :

- Functional parts of HIFI instrument, LOU located outside CVV, optical windows located in CVV wall, refer to specific requirement specifications

design precautions :

- special precautions tbd by the HIFI instrument provider, during AIT sensitive surfaces like LOU openings and optical windows will be protected by covers; only for certain tests these covers have to be removed. Cleanability is required for the optical windows.

environments :

- AIT/AIV activities shall be performed in CRC 100 000 or better, LOU will be purged, see 5.2.

cleaning :

- no cleaning foreseen; in case of necessity a cleaning procedure shall be established by the instrument provider

storage :

- storage in CRC 100 with protection foil coverage or other appropriate protection recommended by the instrument provider
- storage in transport container

cleanliness monitoring :

- molecular : molecular witness plates
- particular : PFO samples

cleanliness verification :

- molecular : wipe test (TBC for optical windows)
- particular : visual inspection, tape-lift test (TBC for optical windows)

6.2.8 Cryostat Cover and -Baffle

main function :

- Cover: Close and tighten CVV during ground and launch operations, safe single opening in orbit to provide sufficient free entrance for the telescope beam into the cryostat
- Baffle: Protect the CVV entrance from undesired stray radiation

design precautions :

- mainly metallic materials, good cleanability
- after integration of the telescope: Cavity protected by the telescope cover

environments :

- AIT/AIV activities in CRC 100 until PLM closure, after PLM closure CRC 100 000

cleaning :

- pre-baking of non-metallic parts
- standard cleaning processes like vacuum air flow and IPA wiping.

storage :

- storage in CRC 100 000 with protection foil coverage
- storage in transport container

cleanliness monitoring :

- molecular : molecular witness plates

- particular : PFO samples

cleanliness verification :

- molecular : wipe test
- particular : visual inspection, tape-lift test

6.2.9 Structures outside CVV (Struts, Sunshield / Sunshade, Radiators)

main function :

- Struts: Mechanical interface structures
- Sunshield/Sunshade: Shadow the CVV and the Telescope from solar radiation and provide the electrical power for the Herschel spacecraft.
- Radiators: Enlarge the CVV radiation area

design precautions :

- edge of honeycomb panels covered. e. g. with Kapton foil
- exhausting of outgassing molecules towards space, where feasible

environments :

- AIT/AIV activities shall be performed in CRC 100 000

cleaning :

- pre-baking of components with non-metallic materials
- standard cleaning processes like vacuum air flow and IPA wiping.

storage :

- storage in CRC 100 000 with protection foil coverage
- storage in transport container

cleanliness monitoring :

- molecular : molecular witness plates
- particular : PFO samples

cleanliness verification :

- molecular : by comprehensive bake-out cycles and appropriate material/process selection
- particular : visual inspection, tape-lift test

6.2.10 Cryo Harness

main function :

- electrical power and signal lines

design precautions :

- selection of cable insulation material with low TML and CVCM

environments :

- AIT/AIV activities shall be performed in CRC 100 000. Integration of the harness part inside CVV will take place in CRC 100.

cleaning :

- pre-baking of harness bundles
- standard cleaning processes like vacuum air flow and IPA wiping.

storage :

- storage CRC 100 or in CRC 100 000 in sealed PE- or Mylar bag
- storage in transport container

cleanliness monitoring :

- molecular : molecular witness plates
- particular : PFO samples

cleanliness verification :

- molecular : by comprehensive bake-out cycles and appropriate material/process selection
- particular : visual inspection with black light

6.2.11 Multi Layer Insulation (MLI)

<u>main function :</u>

- Thermal insulation

<u>design precautions :</u>

- No specific

<u>environments :</u>

- AIT/AIV activities shall be performed in CRC 100 for the MLI inside CVV, MLI outside CVV may be integrated in CRC 100 000

<u>cleaning :</u>

- pre-baking

<u>storage :</u>

- storage in sealed bags

<u>cleanliness monitoring :</u>

- molecular : molecular witness plates
- particular : PFO samples

<u>cleanliness verification :</u>

- molecular : by comprehensive bake-out cycles
- particular : visual inspection, tape-lift test on MLI samples

6.2.12 Service Module (SVM)

<u>main function :</u>

- I/F structure to launcher and PLM
- carrying instrument warm units, avionics etc.

<u>design precautions :</u>

- to be considered by the SVM supplier Alenia environments :

- AIT/AIV activities shall be performed in CRC 100 000.

cleaning :

- A cleaning procedure for the SVM shall be provided by Alenia. Two cleaning steps are foreseen to be performed on S/C level with integrated SVM: One before MLI completion and one during launch campaign.

storage :

- storage in transport container

cleanliness monitoring :

- molecular : molecular witness plates
- particular : PFO samples

cleanliness verification :

- molecular : wipe test
- particular : visual inspection, tape-lift test

6.3 TESTS on Satellite System Level

Several tests during the qualification and acceptance test campaign of the spacecraft could potentially affect the cleanliness level of sensitive and critical surfaces outside the CVV. An appropriate protection against contamination (e. g. by covers) is often not possible since the performed tests require ´flight´ configuration, to receive results which can be interpreted ´correctly´.

Therefore, the test facilities and their environment respectively their environmental control and purging possibilities becomes more important.

The environments in the ESTEC integration and preparation rooms as well as in the test chambers, like the LEAF and LSS, itself are well analysed and documented in the ESA report RD[11]. Additional information about the environmental conditions of the ESTEC test facilities was gained from the measurements during the XMM test campaign. The results are documented in the XMM Contamination Control Log-Book.

It must be noted, that the measurement results of the report RD[11] and the contamination monitoring measurements during the XMM test campaign are not directly transferable to the Herschel test campaign. But nevertheless, these results could be seen as a basis for the assumed contamination influence by the test facilities.

In the following the most critical tests, related to their influence on the molecular and particular cleanliness level, will be introduced. The environmental conditions of the test facilities respectively of the integration and preparation rooms are explained in section 6.4f.

6.3.1 Thermal Balance / Thermal Vacuum Test

The Herschel TB/TV test on S/C level will take place in the Large Space Simulator (LSS). The preparation phase and the test sequence in detail is described in the PFM AIT Plan part II, RD[1c].

There will also be a TB/TV test on EPLM level in satellite configuration (tbc) with integrated STM-components, e. g. with mass dummies mounted instead of the flight instruments, see PFM AIT Plan part I, RD[1b].

The main critical activities during the TB/TV test are characterized by the hot case temperature sequence, which leads to increased outgassing of all non-metallic materials, and the chamber re-pressurization after the test, which could, due to the gas stream into the chamber, lead to a significant particle stir within the chamber.

During the test the cryostat cover will remain closed, thus the FPU's are protected against the chamber environment. An appropriate contamination protection of the telescope is not possible since the test configuration requires it uncovered.

<u>recommended potential protective measures during Vacuum Testing :</u>

- cleaning of chamber before placing H/W into it
- removal of protective devices (covers, hoods) as late as possible
- constraints on pumping rates and pressurization rates
- cold traps to minimise contamination (under investigation)
- refilling of chamber with dry GN2 and minimizing of turbulences
- cleaning of all MGSE entering the chamber

6.3.2 Sine Vibration Test

The sine vibration test will take place in the hydra shaker facility. The vibration test hall environment complies to CRC 100.000.

Critical during the vibration tests is the significant increase of released and redistributed particles from the spacecraft hardware. Therefore, it must be investigated if the protective cover may remain on the telescope. In case that the cover has to be removed, the telescope shall be inspected for cleanliness after the test. Moreover, monitoring samples will be installed during the test activities.

A final decision which activities are necessary after all vibration test steps will be determined by a contamination verification analysis during the STM program.

6.3.3 Acoustic Noise Test

The acoustic noise test will be performed at fully assembled satellite level and take place in the Large European Acoustic Facility (LEAF). The complete test sequence is described in the AIT Plan RD[1]. The LEAF test facility environment will be introduced in the chapter 6.4.4 of this document.

Similar to the vibration test effects, concerning a significant increase of new released and redistributed particles, the acoustic noise test will provide the same problem.

Therefore, it must be investigated if a protection of the telescope with its special cover is possible. In case that the cover has to be removed, the telescope shall be inspected for cleanliness after the test. Monitoring samples will be installed anyway.

6.4 Test Facilities

6.4.1 Astrium Integration Center

For the Herschel program activities in FN and OTN clean rooms with CRC 100.000 and CRC 100 are available at both Astrium sites. Nearly all cleanliness critical activities with the ´open´ PLM and therefore with unprotected exposure of the cleanliness sensitive FPU surfaces take place in CRC 100 and must be completed within the shortest possible time. The established contamination monitoring and verification sequences and techniques are described earlier in this document.

<u>some perceived problems :</u>

- High number of personnel being active around the S/C-H/W.
- Other equipment within the integration center.
- High number of GSE close to the satellite.
- Possible contamination when removing covers.
- Air flow in CRC 100 in FN is in vertical direction (top-down); CRC 100 in OTN: Horizontal flow

6.4.2 ESTEC Integration Center

The ESTEC integration and preparation clean rooms provide an environment according CRC 100.000.

During the SAX satellite environmental test campaign ESTEC established a report with testfloor contamination measurements of the integration hall as well as from the LSS and LEAF test chambers, collected during a long period (11 and 21 days) with a high level of cumulated hours of men activity, so far similar to the Herschel needs. The contamination verification was performed by molecular witness plates, PFO mirrors and dust counting probes.

All exposed molecular witness plates in the integration facility show a deposit of < $0.2x10^{-7}$ g/cm^2 after 11 respectively 21 days. The measured obscuration factor was in the maximum 178 ppm/24h.

Despite these excellent values a full contamination monitoring and protection program will be applied for Herschel as described in this document.

6.4.3 Large Space Simulation (LSS) Chamber

The LSS test chamber provides a standard environment according to CRC 100.000.

Nevertheless, the ESA report RD[11] and the XMM Contamination Control Log-Book issue molecular witness plate results which are quite well below the Herschel requirements, except the deposit on the cryo-panel with $3.0x10^{-7}$ g/cm^2 and a particle deposit of max 540 ppm/24 h (!! depending on the sample location).

These results will be considered for the Herschel test.

potential perceived problems :

Because of thermal vacuum environment it is necessary to remove all non-vacuum compatible covers etc. Therefore the cleanliness sensitive surfaces will be exposed to contamination from the chamber environment not only during the test phase but also during preparation and post-test phases. This contamination may not only be particular, but also molecular due to the chamber pump down.

6.4.4 Large European Acoustic Facility (LEAF)

The LEAF test chamber provides a standard environment according to CRC 100.000.

SAX testfloor contamination measurement results show a molecular deposit of < $0.2x10^{-7}$ g/cm^2 for all exposed witness plates in the chamber and a particular deposit of approx. 330 ppm/24h !!

These results will be considered for the Herschel test.

potential perceived problems :

For this test the spacecraft has to be configured into the launch mode, therefore nominally all protective covers have to be removed (necessity for removal of telescope cover is under investigation). Redistribution of particles is considered to be critical.

6.4.5 Vibration Facility (Hydra shaker)

The vibration shaker test facility shall provide a standard environment according to CRC 100.000.

At least, the ´CVV-internal´ particle release / redistribution represents the contamination problem and less the external environment, if the cover can remain on the telescope.

potential perceived problems :

The problem is basically the same as for the acoustic test, the spacecraft has to be configured with all protective covers removed (necessity for removal of telescope cover is under investigation). Therefore any contamination in the vibration area and vibration machinery will be stirred up around the spacecraft.

6.5 Ground Support Equipment applied for Tests

The amount of GSE inside the test chambers will be limited to that amount which is absolutely necessary.

The following considerations are pertinent :

- GSE which will be brought into the test areas will be designed not to harbour contaminants and to be cleanable prior to entry into the test areas.
- GSE will be cleaned before it (re-)enters the test chambers.
- All GSE will be located downstream of the S/C where practicable.
- GSE cooling exhaust ducts will be vented away from the S/C.
- Ventlines from pumping units will be routed outside the clean room

7 LAUNCH SITE OPERATION

The activities to be performed at CSG will take place in the S5 (tbc) and the BAF (tbc) building, known as Payload Preparation Complex (EPCU).

The AIT/AIV activity sequence is described in RD[1]. In the following the environmental conditions of the above mentioned buildings will be introduced.

The cleanliness sensitive FPU surfaces are protected by the closed CVV. The telescope cover will be applied whenever possible.

7.1 S5 Operations (S5 tbc)

The S5 halls and airlocks provide an environment of CRC 100.000 at 25°C with a humidity level between 60-65% relative humidity.

The main Herschel activities in these buildings are unpacking of the S/C, the electrical check-out and the necessary alignments, short functional and system validation tests.

potential perceived problem :

Possible contamination when removing covers.

7.2 BAF Operation (BAF tbc)

The BAF and the launch pad provide an environment of CRC 100.000 with an adjustable temperature range between 10-25°C and a humidity level of ≤ 50%, which is not adjustable.

Furthermore, an airflow of max. 6000 Nm3/h is can be considered.

7.3 Satellite under Fairing

The environment to which the satellite will be exposed under the fairing is specified in the ARIANE 5 User's Manual and can be assumed to be according to CRC 10.000.

During the encapsulation phase and once mated to the launch vehicle the spacecraft will be supplied with clean, temperature and humidity controlled air, via pneumatic umbilical.

The Herschel telescope will be purged with nominal flows up to about L-2 days**, tbc.**

The Herschel launch configuration can be assumed as ´closed´, except the telescope.

During the ARIANE-501 launch preparation ESA has performed a series of contamination measurements (Draft report) with the following results :

- chemical contamination response after 3 weeks (acc. to ESA PSS-01-705)
- fairing : 0.3 and 0.4 x 10^{-7} g/cm^2
- Speltra : 0.4 and 0.6 x 10^{-7} g/cm^2

- particle contamination after 3 weeks (acc. to ESA PSS-01-204)
- fairing : ≈ 54 ppm / 22 days (2.5 ppm / 24h)
- Speltra : ≈ 257 ppm / 21 days (12 ppm / 24h)

In consideration of the above measured excellent values and considering the spacecraft launch configuration it can be expected that a significant deterioration of the cleanliness levels in the fairing would not take place.

8 PACKING, TRANSPORTATION AND STORAGE

8.1 Packing and Transportation

The requirements for packing, handling and transportation of ESA spacecraft which are given in ESA PSS-01-202 will be applicable.

Containers will be designed and constructed such to be easily cleanable both on the inside and the outside, will contain no traps which can harbour dirt or contaminants, and will not cause any degradation to the satellite components. Consequently materials used in the construction of the container will not induce contamination. Entry of contaminants from external sources will not be possible. All further design aspects such as location of gas purge inlets and hose fixation will be taken into account. Monitoring of contamination will be carried out. Cleaning procedures for the transport container will be developed and applied prior to the use for flight hardware.

<u>protective measures during transportation :</u>

Packing and transportation of the satellite will require the following aspects to be considered and performed :

- flushing of transport container with dry GN2
- limitation of purge interruptions
- protective hood(s) and cover(s) must be installed, internal protective devices or deployable cover(s) in closed position

8.2 Ground Support Equipment

The amount of GSE admitted to the clean rooms will be restricted to the absolute necessary extent. GSE which has to be admitted to the clean room will be (precision) cleanable. The GSE will be placed within the clean room such that it takes the most benefit from the clean room air flow, i.e. the GSE will be located as far as possible downstream with respect to the cleanliness sensitive surfaces.

8.3 Cleaning Procedures and Equipment

As soon as the materials and components have been selected and the processes and/or manufacturing techniques are known, cleaning procedures will be determined such that the required cleanliness levels can be achieved. The choice of cleaning methods and equipment will depend on the type of contaminants to be removed and on the physical / chemical nature of the item to be cleaned.

8.4 Storage of GSE

GSE which is intended for use in clean rooms will be subject to contamination control procedures until it is definitely no longer required in the clean room. This is particularly important for GSE which is used intermittently in the clean areas, and needs to be stored while not in use.

8.5 Storage of Flight Hardware

Packing and temporary storage of piece parts and equipment of spacecraft hardware requires some extra precautions to preserve cleanliness, e.g. after any precision cleaning operation. The use of amide and silicone free plastic bags or foils is not sufficient. Packing material shall be such that no shedding or delamination of the foil material can occur.

The hardware can then be transported as required from the clean room but must not enter another clean room in this level of packing. Refer to AD[2].

Following the normal practice the outer container will be cleaned before entering to a semi clean room area (clean room sluice) and opened to remove the wrapped hardware. The wrapping will be removed in advance to the hardware entering the integration area.

9 AIT Sequence with Contamination Budgets

9.1 Particle Contamination growth during AIT

The following table shows the calculation of particle contamination for the Herschel EPLM AIT sequence. It was agreed during the Cleanliness Team Meetings, to calculate with the half of the maximum values for the particle fallout given in PSS-01-204, taking into account 8 h work, 12 h H/W covered and 4 h margin per day.
A conclusion of the results is given at the end of the table.

	days	ppm		local budgets (ppm)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB	CVV extern	Teles -cope
ppm / day (Cleanroom requirements in PSS-01-204)		225	1.5				
ppm / day for calculation		112.5	1.5 *)				
(8 h work, 12 h H/W covered, 4 h margin)							
Cryostat Integration							
Requirement at delivery to Astrium				50	50	100	
Assembly SFW to He-II Tank	5		7.5	7.5	7.5	7.5	
Preparation Tank & SFW (harness, MLI...)	14		21	21	21	21	
Assembly CVV & He-II Tank & cyl. shields	15		22.5	22.5	22.5	22.5	
Installation internal harness	30		45	45	45	45	
Integration He-I Tank	6		9	9	9	9	
Integration lower shields and lower bulkhead	13		19.5	19.5	19.5	19.5	
PLM PFM (STM) Integration							
Integration optical bench incl. FPUs (STM)	16		24	24	24	24	
PLM PFM (STM) closure	40		60	60	60	60	
PLM PFM (STM) Qual. Test Sequence 1							
Evacuation & leak check	8	900				900	
Vibration warm	10	1125				1125	
Prep. cooldown & filling, alignment	6	675				675	
cooldown & filling	10	1125				1125	
S/C Structure Qual. (SM Campaign)							
Integration EPLM (sunshield & telescope)	16	1800				1800	
Preparation & mating SVM-SM / EPLM	13	1462.5				1462.5	
Acoustic qualification (He-II tank filled with He I)	15	1687.5				1687.5	
Vibration cold	13	1462.5				1462.5	
Separation shock test	5	562.5				562.5	
Demating SVM-PLM	5	562.5				562.5	
Deintegr. sunshield & telescope (EPLM->PLM)	3	337.5				337.5	
PLM PFM (STM) Qual. Test Sequence 2							
He II production & top-up	11	1237.5				1237.5	

	days	ppm		local budgets (ppm)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB & FPUs	CVV extern	Teles-cope
Preparation of TV/TB test	15	1687.5				1687.5	
TV/TB test	25		25**)			25	
Removal from test chamber & packing	5	562.5				562.5	
Transport to Astrium	1		25**)			25	
Depletion & warm-up	7		10.5			10.5	
Partial deintegration of PLM	14		21	21	21	21	
Contamination level of Optical Bench before integration of FM FPUs					**279.5**		
Integration PLM (after Qual. Test Sequence 2)							
Instruments at delivery					(300)		
Cleaning of Opt. Bench Assy and FPUs outside to a level of < 200 ppm					200		
Integration FM FPUs	32		48	48	48	48	
Closing PLM PFM	18		27	27	27	27	
Total after PLM PFM closure				**354.5**	**275**	**15 652**	**0**
PLM Acceptance Test Sequence							
Evacuation & leak test / bake-out	7/10	787.5	15			802.5	
Vibration warm	5	562.5				562.5	
Prep. cooldown & filling	18	2025				2025	
Cooldown & filling, functional test cold	10	1125				1125	
Alignment cold	5	562.5				562.5	
He II production & top-up	3	337.5				337.5	
Integr. Module test incl. instrum. oper. program	20	2250				2250	
Dark background test	10	1125				1125	
Conversion to He I & transp. to system tests (OTN)	1	112.5				112.5	
Cleaning PLM outside							
Contamination value after cleaning				**354.5**	**275**	**1000**	**0**
S/C Integration							
Mating SVM / Cryostat & Sunshield	15	1687.5				1687.5	
Cleaning and MLI installation				**354.5**	**275**	**1000**	**0**
S/C AIT Sequence							
He II production & top-up	10	1125				1125	
System (S/C) function and performance tests IST1	30	3375				3375	
EMC and short function test	10	1125				1125	
Conversion to He-I	5	562.5				562.5	
Transport to ESTEC	15		25**)			25	
Telescope at delivery							300

	days	ppm		local budgets (ppm)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB & FPUs	CVV extern	Teles-cope
Integration telescope & sunshade	5	562.5				562.5	
Alignment telescope	5	562.5				562.5	
Alignment LOU	5	562.5				562.5	
Short function test	2	225				225	
Acoustic noise test & AFT	22	2475				2475	825
Sine vibration & AFT	20	2250				2250	750
Alignment check	5	562.5				562.5	
Mechanical properties	5	562.5				562.5	
SVT1	15	1687.5				1687.5	
He II production & top-up	10	1125				1125	
TV / TB thermal cycling	30		25**)			25	25
Alignment check	5	562.5				562.5	
IST2	30	3375				3375	
Conversion to He-I	7	787.5				787.5	
S/C delivery to ALCATEL at ESTEC	1	112.5				112.5	
Contingency (assumption: storage in class 100)	63		94.5			94.5	
PFM AIT total amounts	**775**			**354.5**	**275**	**22 745**	**1 900**
Transport to Kourou	10		25**)			25	
Launch campaign: preparations in S5	74	8325				8325	
Cleaning S/C outside, Value after cleaning:						**1500**	
Activities from last cleaning to encapsulation	5	560 ***				**560**	******)**
Total before-encapsulation				**354.5**	**275**	**2060**	**1900**

Table 3: Particle contamination growth during EPLM AIT

*) For environment class 100 the original value of 1,5 ppm/day was taken for the calculation. 0,5 PPM/day would be too optimistic. PFO measurements during former programs showed that 1 ppm/day is a realistic figure for class 100 cleanrooms and 8 hours working time per day, so that 1,5 ppm/day includes some margin.

**) Assumption made by the Cleanliness Team: 25 ppm per transport and per TV / TB test.

***) Cleanroom class 100 000, 12 h S/C protected, i. e. 112.5 ppm per day for calculation

****) Assumption made that protection is removed just before encapsulation

Particulate contamination conclusion:

The particulate contamination inside the cryostat results in 354,5 ppm on structure parts and 275 ppm on the Optical Bench and FPUs.

The particulate contamination of the telescope results in 1900 ppm before encapsulation. The baseline is to keep the protective cover on the telescope during all AIT activities. Only for TV/TB test and during parts of acoustic noise and vibration testing the cover will have to be removed. Assuming that during acoustic noise and vibration testing the cover shall be removed for 33 % of the test duration, the particle fallout on the telescope was calculated here as 33 % of the value in column CVV extern.

The total value of 22 745 ppm outside PLM at the end of the AIT phase requires additional cleaning steps or a cleaner environment.

The final cleaning could be done in a step approach:

- one cleaning in Europe before mating with the S/C service module
- one cleaning in Kourou during launch campaign

This will result in a PLM outside contamination of nominally 500 ppm. Considering that not all areas can be reached properly during cleaning, a figure of < 1000 ppm after cleaning on PLM level and < 1500 ppm after cleaning on S/C level will be considered for further calculation.

9.2 Particulate contamination budget

Based on the calculations under 9.1 the following budget overview was established. The figures are worst case calculations plus a margin. They can be interpreted as contamination goals in order to meet the EOL requirements. Note that some Values were provided by Alcatel.

PARTICULATE in ppm	PLM inside CVV	FPU and Optical Bench	S/C outside	TELESCOPE	HIFI-LOU Optical Windows
Level at delivery to Astrium	200	300	(400) 4)	300	100
AIT, incl. cleaning steps up to encapsulation	500	200	2500 6)	1890 1)	200 7)
From encapsulation to separation	0	0	2300 3)	2300 3)	230 8)
In orbit (redistribution, µmeteorides) 3)	50	50	10	10	10
Total EOL	**750**	**550**	**4810**	**4500**	**540**
Requirements from instrumenters	1200	1200	n. a. 2)	4500 5)	1200
Remaining margin	450	650	n. a.	0	660

Table 4: Particulate contamination budget

1) No cleaning foreseen, but protection with cover during majority of AIT sequence
2) No requirement, requirements outside S/C only for telescope and LOU windows
3) Values provided by Alcatel
4) Not relevant for EOL value because of several cleaning steps
5) This value is an average of the requirement for M1 and M2
6) Value at fairing encapsulation
7) Protected with a cover during majority of AIT sequence, windows are cleanable.
8) Because of the limited view factor compared to the telescope, the venting under the fairing and the vertical orientation of the windows, it is assumed that not more than 10 % of the 2300 ppm growth for S/C outside during launch is applicable to the windows.

9.3 Molecular Contamination growth during AIT

The following table shows the calculation of molecular contamination budget for the Herschel EPLM AIT sequence. Only contamination coming from the environment is taken into account. The growth rates are based on measurements at ESTEC facilities, ref. doc.: YTO/REP/ALL/0474/C. Measurements at Astrium facilities revealed growth rates far below 1 ng/day, even in class 100 000.
Contamination of sensitive instrument surfaces due to outgassing S/C materials is part of another calculation, see AD[5]. Contamination due to permeation through CVV sealings is calculated in RD[5]. The results of both, internal outgassing and permeation, are included in the budget table in section 9.4.
A conclusion of the results is given at the end of the table.

	days	ng / cm2		local budgets (ng / cm2)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB	CVV extern	Telescope
ng / cm2 / day		**4**	**1**				
(8 h work, 12 h H/W covered, 4 h margin)							
Cryostat Integration							
Requirement for PLM parts at delivery to Astrium			100	100	100	100	
Assembly SFW to He-II Tank	5		5	5	5	5	
Preparation Tank & SFW (harness, MLI...)	14		14	14	14	14	
Assembly CVV & He-II Tank & cyl. shields	15		15	15	15	15	
Installation internal harness	30		30	30	30	30	
Integration He-I Tank	6		6	6	6	6	
Integration lower shields and lower bulkhead	13		13	13	13	13	
PLM PFM (STM) Integration							
Integration optical bench incl. FPUs (STM)	16		16	16	16	16	
PLM PFM (STM) Closure	40		40	40	40	40	
PLM PFM (STM) Qual. Test Sequence 1							
Evacuation & leak check	8	32				32	
Vibration warm	10	40				40	
Prep. cooldown & filling, alignment	6	24				24	
cooldown & filling	10	40				40	
S/C Structure Qual. (SM Campaign)							
Integration EPLM (sunshield & telescope)	16	64				64	
Preparation & mating SVM-SM / EPLM	13	52				52	
Acoustic qualification (He-II tank filled with He I)	15	60				60	
Vibration cold	13	52				52	
Separation shock test	5	20				20	
Demating SVM-PLM	5	20				20	
Deintegr. SSD & telescope (EPLM --> PLM)	3	12				12	

	days	ng / cm2		local budgets (ng / cm2)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB & FPUs	CVV extern	Teles cope
PLM PFM (STM) Qual. Test Sequence 2							
He II production & top-up	11	44				44	
Preparation of TV/TB test	15	60				60	
TV/TB test	25		25			25	
Removal from test chamber & packing	5	20				20	
Transport to Astrium	1		1			1	
Depletion & warm-up	7		7			7	
Partial deintegration of PLM	14		14	14	14	14	
Contamination level of Optical Bench before integration of FM FPUs					253		
Integration PLM PFM							
Instruments at delivery					3000		
Cleaning of Opt. Bench Assy and FPUs outside to a level of < 200 ng / cm2					200		
Integration FM FPUs	32		32	32	32	32	
Closing PLM PFM	18		18	18	18	18	
Total after PLM PFM closure				**303**	**250**	**876**	**0**
PLM Acceptance Test Sequence							
Evacuation & leak test / bake-out	7/10	28	10			38	
Vibration warm	5	20				20	
Prep. cooldown & filling	18	72				72	
Cooldown & filling, functional test cold	10	40				40	
Alignment cold	5	20				20	
He II production & top-up	3	12				12	
Integr. Module test incl. instrum. oper. program	20	80				80	
Dark background test	10	40				40	
Conversion to He I & transp. to system tests (OTN)	1	4				4	
Cleaning PLM outside							
Contamination value after cleaning				**303**	**250**	**200**	**0**
S/C Integration							
Mating SVM / Cryostat & Sunshield	15	60				60	
Cleaning and MLI installation				**303**	**250**	**200**	**0**
S/C AIT Sequence							
He II production & top-up	10	40				40	
System (S/C) function and performance tests IST1	30	120				120	
EMC and short function test	10	40				40	
Conversion to He-I	5	20				20	

Transport to ESTEC	15		15			15	
Telescope at delivery							200
Integration telescope & sunshade	5	20				20	
Alignment telescope	5	20				20	
Alignment LOU	5	20				20	
Short function test	2	8				8	
Acoustic noise test & AFT	22	88				88	30
Sine vibration & AFT	20	80				80	27
Alignment check	5	20				20	
Mechanical properties	5	20				20	
SVT1	15	60				60	
He II production & top-up	10	40				40	
TV / TB thermal cycling	30		30			30	30
Alignment check	5	20				20	
IST2	30	120				120	
Conversion to He-I	7	28				28	
S/C delivery to ALCATEL at ESTEC	1	4				4	
Contingency (assumption: storage in class 100)	63		63			63	
PFM AIT total amounts	**775**			**303**	**250**	**1076**	**287**
Transport to Kourou	10					10	
Launch campaign: preparations in S5	74	296				296	
Cleaning S/C outside (only removal of particles)							
Activities from last cleaning to encapsulation	5	20				**20**	*
Total before encapsulation				**303**	**250**	**1402**	**287**

Table 5: Molecular contamination growth during EPLM AIT

*) Assumption made that protection is removed just before encapsulation

Molecular contamination conclusion:

The molecular contamination inside the cryostat, except for the instruments, results in 3.03 x 10E-7 g/cm2.

On the cleanable surfaces of the instruments on the Optical Bench a level of ≤ 2.5 x 10E-7 g/cm2 can be achieved. The contamination level on the non cleanable surfaces is mainly depending on the level at delivery.

Contamination caused by internal outgassing and air permeation through seals is not considered in above table, the results of these analyses have to be additionally taken into account, refer to RD[5] and to section 6-3-2 and Annex 2-3 of AD[5].

The molecular contamination of the telescope before encapsulation results in 2,87 x 10E-7 g/cm2 including the contamination level of 2 x 10E-7 g/cm2 at delivery to Astrium GmbH. The baseline is to keep the protective cover on the telescope during all AIT activities. Only for TV/TB test and during parts of acoustic noise and vibration testing the cover will have to be removed. Assuming that during acoustic noise and vibration testing the cover shall be removed for 33 % of the test duration, the particle fallout on the telescope was calculated here as 33 % of the value in column CVV extern.

The total value of 1.4 x 10E-6 g/cm2 outside PLM is well within the requirement of 2.7 x 10E-6 g/cm2 acc. to AD[2].

9.4 Molecular contamination budget

Based on the calculations under 9.3 the following budget overview was established. The figures are worst case calculations plus a margin. They can be interpreted as contamination goals in order to meet the EOL requirements. Note that some Values were provided by Alcatel.

MOLECULAR in 10-7 g/cm2	**PLM inside CVV**	**FPU and Optical Bench**	**S/C outside**	**TELESCOPE**	**HIFI-LOU Optical Windows**
Level at delivery to Astrium	2	30	2	2	2
AIT, incl. cleaning steps up to encapsulation	4	1	25	4	4
Contamination from CVV internal outgassing	n. a.	25	n. a.	n. a.	0
Water ice from air permeation through seals	1	12 1) (40)	n. a.	n. a.	0
From encapsulation to separation	0	0	8 3)	8 3)	8
In orbit (outgassing, thruster plume) 3)	2	2	200	26	tbd 2)
Total EOL	**9**	**70**	**235**	**40**	**tbd**
Requirement	60	60	n. a. 4)	40	85
Remaining margin	51	-10 5)	n. a.	0	tbd

Table 6: Molecular contamination budget

1) Acc. to issue 3 of HP-2-ASED-TN-0034, taking into account 575 days of cold condition of the cryostat until launch (40 is valid for HIFI housing only).
2) To be calculated by Alcatel. For the optical windows the back scattering effects will be limited by the LOU- and CVV-radiators.
3) Values provided by Alcatel
4) No requirement, requirements outside S/C only for telescope and LOU windows
5) A lower contamination level at delivery to Astrium would allow to achieve positive margin

10 Log-Sheets

Contamination control log-sheets see following 5 pages.

10.1 Visual Inspection Log-Sheet

10.2 PFO Log-Sheet

10.3 Tape-Lift Log-Sheet

10.4 Witness Sample Log-Sheet

10.5 Wipe Test Log-Sheet

<table>
<tr><td>EADS Astrium

PROJECT:
Herschel</td><td>CONTAMINATION CONTROL

VISUAL INSPECTION LOG-SHEET</td><td>CONTAMINATION CONTROL LOG-BOOK

DATE :

SHEET :</td></tr>
</table>

<table>
<tr><td colspan="4">Contamination Control Log-Sheet : Visual Inspection

Contamination Control by Visual Inspection</td></tr>
<tr><td colspan="4">Inspection related information</td></tr>
<tr><td>Operator :</td><td></td><td>Clean room class :
(Fed.Std. 209)</td><td></td></tr>
<tr><td colspan="4">Remarks :</td></tr>
<tr><td>Description of Hardware, surface, activities, etc. :</td><td colspan="3"></td></tr>
<tr><td colspan="4">Inspection results</td></tr>
<tr><td colspan="4"><u>Visual Inspection Results :</u></td></tr>
</table>

EADS Astrium PROJECT: **Herschel**	CONTAMINATION CONTROL PFO MIRROR LOG-SHEET	CONTAMINATION CONTROL LOG-BOOK DATE : SHEET :

Contamination Control Log-Sheet : PFO Sample Plate

Particular PFO mirror analysis acc. ESA PSS-01-204

Exposure / Location related information

Clean room class : (Fed.Std. 209)		Operator :	
Temperature [°C] : Relative Humid. [%]		PFO location : Test chamber :	
Description of activities / remarks :			

Analysis related information

PFO	1. M. [ppm]	2. M. [ppm]	Δ - ppm	Exposed from – to	Δ - days	ppm / 24 hours

Analyst : PFO – Detector :		Signature : Date :	

EADS Astrium PROJECT: **Herschel**	CONTAMINATION CONTROL TAPE LIFT LOG-SHEET	CONTAMINATION CONTROL LOG-BOOK DATE : SHEET :

Contamination Control Log-Sheet : Tape Lift Test

Tape Lift analysis acc. ASTM-E-1216

Sample / location related information

Operator :		Clean room class : (Fed.Std. 209)	
Remarks :			
Description of Hardware surface, precleaning activities, etc. :			

Analysis related information

TL	ppm	TL-Location	Remark

ANALYST : Testlab :		Signature : Date :	

Contamination Control Log-Sheet : Molecular IR Sample Plate

Molecular IR sample analysis acc. ESA PSS-01-705

Sample related information			
Operator :		Sample identification :	
Remarks :			
Exposure / Location related information			
Exposure date :		Clean room class : (Fed.Std. 209)	
Removal date :		Temperature [°C] : Relative Humidity [%]	
Exposed time : [days, hours]		Sample location : Test chamber :	
Description of Hardware, test, activities and remarks :			
Analysis related information			
Hydrocarbon-equivalent [10^{-7} g/cm^2] :		Remark :	
Ester –equivalent [10^{-7} g/cm^2] :		Remark :	
Methylsilicone–equivalent[10^{-7} g/cm^2] :		Remark :	
Σ molecular contamination [10^{-7} g/cm^2]:		Remark :	
Analyst : **Testlab :**		**Signature :** **Date :**	

EADS Astrium PROJECT: **Herschel**	CONTAMINATION CONTROL WIPE TEST LOG-SHEET	CONTAMINATION CONTROL LOG-BOOK **DATE :** **SHEET :**

Contamination Control Log-Sheet : Molecular Wipe Test

Molecular Wipe Test analysis acc. ESA PSS-01-705

Wipe Test related information

Operator :		Wipe location :	
Remarks :			
Description of hardware, surface, performed cleaning processes, etc. :			

Analysis related information

Hydrocarbon-equivalent [10^{-7} g/cm^2] :		Remark :
Ester –equivalent [10^{-7} g/cm^2] :		Remark :
Methylsilicone–equivalent[10^{-7} g/cm^2] :		Remark :
Σ molecular contamination [10^{-7} g/cm^2]:		Remark :

Analyst : **Testlab :**		**Signature :** **Date :**	

END OF DOCUMENT

	Name	Dep./Comp.		Name	Dep./Comp.
X	Alberti von Mathias Dr.	AOE22	x	Stritter Rene	AED11
	Alo Hakan	OTN/TP 45	X	Tenhaeff Dieter	AOE22
x	Barlage Bernhard	AED11		Thörmer Klaus-Horst Dr.	OTN/AED65
x	Bayer Thomas	AET52		Wagner Klaus	AOE23
X	Faas Horst	AEA65	x	Wietbrock, Walter	AET12
	Fehringer Alexander	AOE13		Wöhler Hans	AOE22
	Frey Albrecht	AED422			
x	Gerner Willi	AED11			
	Grasl Andreas	OTN/AET52			
	Grasshoff Brigitte	AET12	x	Alcatel	ASP
	Hauser Armin	AOE23	x	ESA/ESTEC	ESA
X	Hinger Jürgen	AOE23			
x	Hohn Rüdiger	AET52		**Instruments:**	
x	Huber Johann	AOA4		MPE (PACS)	MPE
	Hund Walter	ASE4A		RAL (SPIRE)	RAL
X	Idler Siegmund	AED432		SRON (HIFI)	SRON
X	Ivády von András	FAE22			
X	Jahn Gerd Dr.	AOE23		**Subcontractors:**	
	Kalde Clemens	APE3		Air Liquide, Space Department	AIR
	Kameter Rudolf	OTN/AET52		Air Liquide, Space Department	AIRS
X	Kettner Bernhard	AOE22		Air Liquide, Orbital System	AIRT
	Knoblauch August	AET32		Alcatel Bell Space	ABSP
	Koelle Markus	AET22		Astrium Sub-Subsyst. & Equipment	ASSE
x	Kroeker Jürgen	AED65		Austrian Aerospace	AAE
	Kunz Oliver Dr.	AOE23		Austrian Aerospace	AAEM
x	Lamprecht Ernst	OTN/ASI21		APCO Technologies S. A.	APCO
X	Lang Jürgen	ASE4A		Bieri Engineering B. V.	BIER
x	Langfermann Michael	AET52		BOC Edwards	BOCE
	Mack Paul	OTN/AET52		Dutch Space Solar Arrays	DSSA
	Muhl Eckhard	OTN/AET52		EADS CASA Espacio	CASA
x	Pastorino Michel	ASPI Resid.		EADS CASA Espacio	ECAS
	Peitzker Helmut	AED65		EADS Space Transportation	ASIP
	Peltz Heinz-Willi	AET42		Eurocopter	ECD
	Pietroboni Karin	AED65		HTS AG Zürich	HTSZ
	Platzer Wilhelm	AED22		Linde	LIND
	Puttlitz Joachim	OTN/AET52		Patria New Technologies Oy	PANT
	Rebholz Reinhold	AET52		Phoenix, Volkmarsen	PHOE
X	Reuß Friedhelm	AED62		Prototech AS	PROT
x	Rühe Wolfgang	AED65		QMC Instruments Ltd.	QMC
	Runge Axel	OTN/AET52		Rembe, Brilon	REMB
	Sachsse Bernt	AED21		Rosemount Aerospace GmbH	ROSE
X	Schink Dietmar	AED422		RYMSA, Radiación y Microondas S.A.	RYM
x	Schlosser Christian	OTN/AET52		SENER Ingenieria SA	SEN
	Schmidt Rudolf	FAE22		Stöhr, Königsbrunn	STOE
X	Schweickert Gunn	AOE22		Terma A/S, Birkerod	TER
	Stauss Oliver	AOE13			
	Steininger Eric	AED422			