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Fast Auroral Snapshot Explorer (FAST) Cleaning and Verification Plan

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FAST AURORAL SNAPSHOT EXPLORER (FAST)
CLEANING AND VERIFICATION PROCEDURE

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FAST AURORAL SNAPSHOT EXPLORER (FAST)
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Section 1.0 Introduction

1.1 Purpose

This document defines the cleaning and verification procedures necessary to maintain the Fast Auroral Snapshot (FAST) Explorer within established cleanliness requirements during integration and test at Goddard Space Flight Center (GSFC).

1.2 Responsibility

Responsibility for assuring that the procedures in the document are followed rests with Quality Assurance, the SMEX Project Office, and the Contamination Engineer. Questions regarding this document should be referred to the Contamination Engineer or the SMEX Contamination Control Manager.

1.3 Applicable Documents

1.3.1 SMEX Documents

a. SMEX-QA-002	Small Class Explorer (SMEX) Program Performance Assurance Requirements, Revision B (July 1990)
b. FAST-SPEC-005	Requirements Document for SMEX, FAST Mission, Revision B (April 1993)
c. FAST-SPEC-008	Fast Auroral Snapshot (FAST) Explorer Contamination Requirements and Control Plan (October 1992)
d. FAST-PROC-003	FAST Clean Area Operations Procedure (October 1993)
e. FAST-MGMT-013	FAST Launch Site Contamination Control Implementation Plan (expected out March 1994)
f. FAST-MGMT-014	FAST Subsystems Bakeout Plan (September 1993)

1.3.2 Reference Documents

a. FED-STD-209E	Federal Standard, Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones
b. MIL-STD-1246B	Product Cleanliness Levels and Contamination Control Program
c. NASA-JSC-SP-R-0022A	Specification Vacuum Stability Requirements of Polymeric Material for Spacecraft Application
d. NASA-JSC-SN-C-005	Specification Contamination Control Requirements for the Space Shuttle Program, Revision C
e. NASA-RP-1124-87	Outgassing Data for Selected Spacecraft Materials
f. UCB Space Sciences Laboratory Document	Contamination Control Plan for the Fast Auroral Snapshot Instrument

1.4 Acronyms

CCM	Contamination Control Manager
CE	Contamination Engineer
EESA	Electron Electrostatic Analyzer
ESD	Electrostatic Discharge
FAST	Fast Auroral Snapshot Explorer
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
I & T	Integration and Test
IPA	Isopropyl Alcohol
ITO	Indium Tin Oxide
MLI	Multi Layer Insulation
NASA	National Aeronautics and Space Administration
NIOSH	National Institute for Occupational Safety and Health

NVR	Non-Volatile Residue
OSHA	Occupational Safety and Health Administration
PVA	Polyvinyl Alcohol
QA	Quality Assurance
SMEX	Small Explorer
TEAMS	Time-of-Flight Energy Angle Mass Spectrograph

1.5 Terminology

Certification Log	Form (GSFC 4-30) that follows hardware from fabrication to final assembly for traceability. The cert log is applicable to all flight or flight support hardware and spares assembled or tested at GSFC. It includes a problem record log form, GSFC 4-31.
Clean Area	Area where airborne particle contamination levels are strictly controlled by air filtration and regulation of particle sources. Cleanrooms, clean tents, and clean benches are the most frequently encountered types of clean areas.
Contamination	Unwanted material that degrades the desired function of an instrument or other flight hardware. Contamination is usually separated into two types, particulate and non-volatile residue.
Contamination Control	Organized action to control contamination levels.
Fiber	Particle contamination with a length-to-width ratio exceeding 10:1 and a minimum length of 100 microns.
Gross Cleaning	Cleaning hardware surfaces in a normal work environment to visual inspection standards. This step precedes precision cleaning.
Non-Volatile Residue	Soluble material causing degradation in the desired function of flight hardware; usually measured in mg/ft^2.
Nitrogen Purge	Pressurized flow of clean, dry nitrogen through a system to displace impurities and reactive species.
Particle	Small quantity of solid or liquid material with definable shape or mass.
Particle Size	Maximum linear dimension or diameter of a particle.
Precision Cleaning	Cleaning procedure done in a clean area to attain a specific quantitative level of cleanliness.

Problem Record	Document for recording problems or anomalies pertaining to an item. If the record is part of the certification log, it is known as a problem record log. If the record is not part of a certification log, it is known as a problem record sheet.
Sensitive Surfaces	Flight hardware surfaces requiring a specific cleanliness level to meet minimum performance levels.
Solvent Flushing	Pressurized stream of filtered solvent directed against a surface to dislodge and rinse away contaminating material.
Solvent Washes	Quantitative method for verifying MIL-STD-1246B NVR levels by measuring molecular contamination in a solvent that has been washed over a surface.
Surface Cleanliness Level	Established maximum allowable particle and NVR contamination ranging from visibly clean to specific MIL-STD-1246B levels.
Swab Sample	Qualitative method of identifying contaminants by analyzing residue on a solvent soaked swab that was wiped over a surface.
Tape Lifts	Quantitative method of verifying MIL-STD-1246B particle contamination levels by measuring particle contamination on a tape sample that has contacted a surface.
Uncontrolled Area	Area where contamination sources are not restricted and airborne particle levels are not controlled by filtration.
Vapor Degrease	Item to be cleaned is exposed to heated solvent vapors that condense on the part and wash away contaminants. (NOTE: Halogenated solvents used to vapor degrease plastics are often outgassed or leached out later. Therefore, if plastics are degreased with halogenated solvents, a bakeout must follow.)
Visibly Clean	Clean surface as seen without optical aids (except corrected vision) when measured by a specific method. For this project, surfaces should be tested from 6 to 18 inches using black and white inspection lights with intensity $\geq$ 100 ft. candles.
Work Order	Form on which contract work for specific tasks is requested. Requests made by work order are for contract work funded for the project under a Task Action Request (TAR). A sample work order for hardware cleaning is included in Appendix 1.

Section 2.0 Safety

2.1 Hazardous Materials

a. Flammables: Isopropyl Alcohol, Acetone

b. Non-flammables: Detergent Solution (Low Residue, Non-Ionic Detergent)

2.2 Safety Precautions

a. Keep all possible ignition sources away from flammable liquids or vapors. Ignition sources include open flames, sparks, or high temperature surfaces such as ovens, incandescent lighting fixtures, etc,. Flammable liquids must be stored in approved safety cabinets.

b. Care must be used to prevent spills when dispensing hazardous fluids from bulk containers. When metal safety cans are used for storing the fluids, flash arresters must be used on the cans, and the containers must be grounded during filling.

c. Halon fire extinguishers must be present at the work site and within easy reach of the operators at all times when flammable fluids are used.

d. The flammable fluids must be used in a fume hood or a well ventilated area exhausted to the building exterior. If a fume hood is not used, the air flow rate must be sufficient to prevent flammable mixtures from forming.

e. These fluids are considered to be mildly toxic by NIOSH and OSHA. Ingestion in any form, either breathing, swallowing, or contacting with skin, must be avoided. If at any time any of the following symptoms appear while using the fluids, leave the area at once:

   1. Eyes, nose, or throat become irritated.
   2. Drowsiness, dizziness, cramping, or nausea occurs.

f. If first aid is required, perform the following procedures until medical attention can be obtained:

   1. Eye Contact: Immediately flush with cool water for a minimum of 15 minutes.

   2. Skin Contact: Immediately flush irritated skin area with cool water. Wash with mild soap and water.

   3. Breathing Difficulty: Withdraw from work area immediately and obtain medical attention as quickly as possible. Administer life support first aid as necessary.

****Report all incidents requiring first aid to the Health Unit immediately****

g. Latex gloves are not resistant to solvents such as alcohol and acetone. Wear polyethylene gloves when using these solvents.

h. Only ACS grade or better IPA and acetone are approved for hardware cleaning. All other solvents must be approved by the CCM and the FAST Instrument Manager.

Section 3.0 Surface Cleaning and Verification

3.1 Necessary Equipment and Materials

The following equipment and materials will be used for cleaning FAST flight hardware, support equipment, and facilities:

Acetone - ACS Grade or Better

Buckets - Polypropylene or Stainless Steel

Cleaning Vessels - Stainless steel, Teflon, or Polyethylene

Cleanroom Bagging Material - National Metallizing NMD-FR 100 N PA1-N or NMD-FR 190 N PA1-N, Cryovac EPG 227*, or RCAS 4200*.

Cleanroom Detergent - Low residue, Non-ionic

Cleanroom Garments - For Clean Tent: Smock, Cap, Shoe Covers, Latex Gloves, Polyethylene Gloves, ESD Wrist Strap with Grounding Wire. For Clean Bench: Latex Gloves, Polyethylene Gloves, ESD Wrist Strap with Grounding Wire.

Cleanroom Wipes - Lint-free Polyester, Extracted and Unextracted

Cleanroom Swabs - Lint-free Polyester, Extracted and Unextracted

Deionized water

Inspection Lamp - Portable, 100 Watt UV (365 nm.)

Inspection Lamp - Portable, 100 Watt Visible Light (546 nm, 577 nm, 579 nm)

Isopropyl Alcohol (2-Propanol) - ACS Grade or Better

Laminar Flow Clean Bench or Clean Tent

Mop - Stainless Steel or Aluminum Handle, PVA, Cellulose, Nylon or Polyurethane Sponge.

Nitrogen or Deionized Air - Filtered to 0.5 μm.

Ultrasonic Cleaner

Ultrasonic Cleaner Detergent - Alconox or Equivalent

Vacuum cleaner - HEPA-filtered

* Note: EPG 227 and RCAS 4200 cannot be used with flight hardware at the launch site.

3.2 Precautions

Before starting a hardware cleaning operation, the following precautions must be taken:

1. Identify the materials (substrate, coatings, adhesives, etc.,) used in the object to be cleaned. If the materials cannot be readily identified, consult the Code 313 Materials Engineer.

2. Determine whether the materials are sensitive to solvents. Materials sensitive to IPA include some adhesives, tapes, and titanium. Materials sensitive to acetone include many thermoplastics, adhesives, tapes, and elastomers. For specific information about the solvent sensitivity of a specific material, consult the Code 313 Materials Engineer. When a material is sensitive to either IPA or acetone, only use the acceptable solvent for cleaning. If the material is sensitive to both solvents, contact the CCM or Code 313 Materials Engineer.

3. Determine whether the object to be cleaned is sensitive to handling. Parts that frequently are sensitive to handling include conductive coatings (ITO), solar cells, microelectronics, detectors, and some thermal control coatings. If the handling sensitivity of the item to be cleaned is not completely understood, contact the subsystem engineer responsible for the hardware.

   If surfaces are sensitive to handling, the use of vacuuming, ultrasonic cleaning or solvent wiping as cleaning techniques must be limited or eliminated, depending upon the degree of sensitivity. Specific handling procedures for cleaning certain handling-sensitive items will be addressed in Section 3.4. For additional information or procedures for items not included, contact the CCM and the subsystem engineer responsible for the sensitive hardware.

3.3 Facility Requirements

The cleaning procedures in the following sections will only be done in a FED-STD-209E Class M 6.5 or better clean area or a FED-STD-209E Class M 4.5 or better clean bench. When the cleaning is done in a clean area, cleanroom garments (smock, cap, shoe covers, latex gloves (polyethylene gloves for solvent handling), and ESD wrist strap) will be worn and cleaning operations will be performed downstream and away from flight hardware not being cleaned. If an item is cleaned at the clean bench, all handling will be done with cleanroom gloves. Polyethylene gloves will be worn when solvents are handled, while latex gloves may be worn when solvents are not used. An ESD wrist strap and test system must be used when any electronic equipment is handled at the clean bench.

3.4 Cleaning Procedures

3.4.1 Facilities

3.4.1.1 Clean Tent

Clean tents housing the FAST spacecraft during integration and test in GSFC Buildings 5 and 7 will be cleaned before spacecraft arrival and recleaned biweekly. Additional cleaning may be scheduled if deemed necessary by the CCM. The clean tent cleaning will be done according to the following procedure:

1. Using the HEPA-filtered vacuum cleaner, vacuum the floor and all horizontal surface making sure that all loose particles have been removed from recessed surfaces and corners.

2. In a clean bucket, mix a solution of DI water and IPA (90-10 ratio respectively) or mix DI water and non-ionic cleanroom detergent (follow procedure on detergent bottle for proper ratio of concentration).

3. With sponge mop and liquid cleaning solution, clean the ceiling tiles (excluding light covers). Use a "pull and lift" method with the sponge mop, stroking in one direction only. Rinse the mop after covering approximately 10 ft^2, or more frequently if contamination is visible on the sponge. Replace the solution in the rinse bucket after five rinses, or more often if contamination is visible in the liquid.

4. For cleaning light covers, use clean wipes and DI water only.

5. Using the sponge mop and solution, clean the walls from top to bottom in each stroke. Begin on the walls near the most critical operation area and work toward the entrance door. Rinse the mop and replace solution as described in step 2.

6. Using sponge mop and solution, mop the floor using a "pull and lift method", stroking in one direction only. Rinse mop and replace solution as described in step 2.

NOTE: The clean area floor must never be waxed.

7. If the trash can is more than half full, put the lid over the can and remove it from the clean area to empty. Before returning the can to the clean area, wipe the external and internal surfaces with IPA.

8. Floor mats must be checked every day for cleanliness. If visible footsteps cover the mat area or the mat has otherwise lost adhesion, peel back the top layer.

3.4.1.2 Clean Bench

A clean bench will be used outside the Building 5 clean tent for cleaning hardware before it is admitted to the clean tent. The clean bench will be cleaned according to the same cleaning schedule as the clean tent. Clean bench cleaning will be done according to the following procedure:

1. With the HEPA-filtered vacuum cleaner, vacuum the work bench, the clean bench walls, and the ceiling of the bench. Make sure that all loose particles are removed from crevices and corners.

2. Lightly dampen an unextracted cleanroom wipe with IPA. Do not saturate the wipe or dip the wipe in the solvent container.

3. Wipe the surfaces of the clean bench in a unidirectional manner. Start with the top bench surfaces. If the wipe displays contaminants or becomes frayed, fold the wipe to expose a clean surface or obtain a new wipe.

4. Continue step 3 until the solvent wipe process leaves no visible contamination on the surface.

3.4.2 Ground Support Equipment

Before entering the clean tent, FAST GSE must be cleaned, inspected, and sealed in approved bagging. GSE that will directly contact flight hardware must be cleaned to a visibly clean-highly sensitive level per NASA-JSC-SN-C-0005, Revision C, while GSE that will not directly contact flight hardware will be inspected to a visibly clean-standard level. The GSE cleaning will be done according to the following procedure:

1. Determine the surface sensitivity to handling and solvents (see Section 3.2). If the surface is sensitive to handling or solvents, then modify the procedures in the following steps according to the restrictions specified in 3.2.

2. Remove loose particles from the GSE by thoroughly vacuuming all surfaces, including holes, crevices, and corners, with a HEPA-filtered vacuum. This step should not be done for items that are sensitive to handling. Vacuum with the nozzle one to two inches from the surface. Do not allow the nozzle to contact the GSE surface.

3. Lightly dampen an unextracted cleanroom wipe with IPA. Do not saturate the wipe or dip the wipe in the solvent container.

4. Clean the GSE surface with the IPA-dampened wipe. Wipe the surfaces in a unidirectional manner. Do not overlook crevices, corners, or holes. If necessary, lightly dampen an unextracted cleanroom swab with IPA and use the swab to clean recessed areas. Clean recessed surfaces with the swab by rotating the swab over the surface.

   During cleaning, fold the wipe to expose a clean surface or replace with a new wipe if the wiping surface becomes contaminated. Replace each swab after it has been rotated 360° over the surface. Lightly dampen each new wipe surface or swab with IPA and then continue cleaning. Repeat this process until the GSE surfaces do not display visible contamination.

5. After solvent wiping, inspect the surface to the appropriate level of visible cleanliness per the procedures specified in Section 3.5. If the visual inspection reveals surface contaminants, repeat the solvent wiping procedure specified in steps 2 and 3 and re-inspect. If, after solvent wiping, contaminants remain visible, repeat the solvent wiping procedure with acetone substituted for IPA. Before using acetone, however, make sure it will not degrade the materials undergoing cleaning. If contamination remains visible after using acetone, contact the CCM or CE.

3.4.3 Flight Hardware

3.4.3.1 Instrument

The FAST instrument will be delivered to GSFC at an external cleanliness level of 500A per MIL-STD-1246B. Following delivery, the instrumenters will be responsible for cleaning and verifying instrument surfaces. Prior to launch, all external instrument surfaces will meet Level 500A.

3.4.3.2 Spacecraft

All spacecraft hardware must be cleaned and inspected before it is admitted to the clean area. The hardware must be verified to Level 500A if it is being admitted while the FAST instrument covers are removed. If the hardware is being admitted while the instrument covers are installed, it must be verified to a visibly clean-highly sensitive level before being admitted to the clean area.

In addition to cleaning before admission to the clean area, integrated spacecraft hardware will be cleaned and verified to Level 500A during four scheduled spacecraft cleaning operations.

All spacecraft hardware cleaning will be done according to the procedures in the following sections.

(A) General Cleaning Procedure

The following procedure should be followed for cleaning uncoated flight hardware surfaces that are not sensitive to handling, IPA, or acetone. Procedures for hardware with thermal coatings and hardware that requires special precautions will be detailed in Sections (B), (C), (D), and (E).

1. Remove loose particles from the hardware by thoroughly vacuuming all surfaces, including holes, crevices, and corners, with a HEPA-filtered vacuum. This step should not be done for items that are sensitive to handling and items that might be picked up by the vacuum. Vacuum with the nozzle one to two inches from the surface, and do not allow the nozzle to contact the surface.

2. Spray the surface with acetone and wipe all surfaces with extracted cleanroom wipes. Do not overlook holes, penetrations or crevices.

3. Rinse the surface thoroughly with IPA.

4. For items that are small enough, place the item in an ultrasonic cleaner filled with a solution of Alconox or equivalent ultrasonic cleaning solution and run the cleaner for five minutes. After five minutes, invert the item and run the cleaner for another five minutes.

5. Rinse surface thoroughly with deionized water.

6. Rinse surface with IPA.

7. Dry surface with clean, filtered nitrogen gas.

(B) Procedure for Cleaning Surfaces with Thermal Control Coatings

Most surfaces of the FAST spacecraft will be coated with thermal control paints to achieve the desired spacecraft thermal properties. Four different types of paints will be used: Chemglaze Z307 and Z306, NSB 55, and MSA 94B. To remove contaminants while preserving the integrity of the coating, the paints must be cleaned according to the procedure listed below.

NOTE: Coated surfaces should only be cleaned by the Thermal Coatings Section, Code 724.5. If other personnel must clean coated surfaces, Code 724.5 should be notified beforehand to determine whether special precautions are necessary.

1. Vacuum the surface of the coated part. Hold the nozzle one to two inches from the surface and do not allow the nozzle to contact the surface.

2. Inspect the coated surface with visible and UV inspection lamps. Identify areas requiring cleaning.

3. Lightly dampen an extracted cleanroom wipe or swab with IPA. Do not saturate the wipe or swab and do not dip the wipe or swab in the solvent.

4. Clean contaminated areas of the coated surface with the IPA-dampened wipe or swab. Wipe the surface in a unidirectional manner and rotate the swabs over the surface. Do not allow solvent to spread from the contaminated area, as it could redistribute dissolved contaminants to clean areas. Also, minimize solvent application to paint-substrate boundaries, since solvent could diffuse under paint edges and promote delamination.

   During cleaning, replace the wipes or fold the wipe to expose a clean surface when the wipes displays visible contamination. Replace swabs after rotating 360° over the surface. Continue this process until the coated surface displays no visible contamination.

5. Re-inspect the surface with visible and UV inspection lamps. If surface contaminants remain visible, repeat the surface cleaning procedure described in steps 3 and 4.

(C) Procedure for Cleaning ITO Coated Surfaces

External surfaces of the FAST battery radiator plate and multi-layer insulation will be coated with indium tin oxide (ITO), a fragile material that acts as a conductive surface layer and prevents localized charge accumulation on spacecraft surfaces. The ITO layer's surface conductivity can be degraded if it is abraded or cracked. Consequently, to minimize handling and cleaning that might damage the coating, it must be kept as clean as possible. If ITO surface contamination does occur, however, cleaning must be done according to the following procedure:

1. Inspect the surface for contaminants with visible and UV inspection lights. Perform the UV inspection in a darkened area to make contaminant fluorescence more visible. Minimize handling of the ITO surface, and only clean surfaces that appear contaminated under the inspection lamps. If the surface contamination appears extensive under inspection, contact the CE or CCM. For ITO coatings on MLI, do not fold, bend or otherwise deform the blanket material, as this might crack the coating.

2. Remove particles observed under the inspection lamps by lightly brushing the surface with a cleanroom wipe or swab. Clean, dry nitrogen gas may also be used to drive particles from the surface, but the gas must direct the particles away from flight hardware surfaces. Do not allow particles being removed with wipes, swabs, or pressurized nitrogen to be dragged across the surface - doing so may allow the particle to scratch the coating.

3. Remove molecular contaminants observed under the inspection lamps by lightly wiping with extracted cleanroom wipes and swabs that have been dampened with IPA. Replace the wipe or fold over to expose a clean surface if the wipe displays visible contamination. Replace the swabs after rotating 360° over the surface. Continue this process until the hardware surface and used wipes and swabs display no visible contamination.

4. Inspect the cleaned ITO surface with visible and UV inspection lamps. Perform the UV inspection in a darkened area to highlight fluorescence from contaminants. If contaminants still appear under the inspection lamps, repeat steps 2 and 3. If contaminants remain after several cleaning attempts, contact the CE or CCM.

(D) Procedure for Cleaning Solar Arrays

This procedure will be prepared by the solar array supplier, TRW. When it is completed, the solar array cleaning procedure will be added to this document as an appendix.

(E) Cleaning Procedure for Harnesses

1. Vacuum the harness using a HEPA filtered vacuum to remove any loose contamination. Hold the vacuum nozzle as close as possible to the harness without directly contacting it.

2. Using extracted lint-free cleanroom wipes or extracted swabs dampened with IPA, wipe each cable and connector. Do not directly spray the harness with solvent. Reach as many crevices as possible where cables are bound together. Do not twist or bend the harness.

   If the harness is not integrated, it may be cleaned by solvent flushing instead of solvent wiping. Solvent flushing can be done by manually spraying solvent on the harness or by immersing the harness in an ultrasonic cleaner or a contained cleaning unit such as a Quadrex. The solvent flushing must not be done with halogenated solvents, however, unless the harness will be baked out *after* cleaning. After solvent flushing, excess solvent should be removed by directing clean, dry nitrogen over the harness or by wiping the harness with extracted cleanroom wipes.

3. Discard and replace wipes and swabs as they become visibly contaminated.

4. Continue cleaning until there is no apparent residue on the harness or the used wipes and swabs.

5. Dry the harness with dry, filtered nitrogen gas.

6. If the harness does not pass required verification, repeat the above procedures until the required cleanliness level has been reached.

3.5 Procedures for Surface Verification

Verifying surfaces to a visibly clean-standard level:

Note: This procedure applies to GSE that will be used in the proximity of flight hardware without directly contacting the hardware.

a. Examine the surface from a distance of 1 to 2 feet while the surface is illuminated with clean bench lighting. If the surface cannot be inspected at the clean bench, inspect it in a clean area under comparable lighting.

b. Remove isolated contaminants observed under inspection with unextracted cleanroom wipes and swabs. Lightly dampen the wipes and swabs with IPA if the surface under inspection will not be damaged by the solvent. Acetone may be substituted for IPA in cases where the surface is not degraded by acetone and cannot be effectively cleaned with IPA. Continue this spot cleaning process until no contaminants are visible when the surface is viewed under the inspection conditions specified in (a).

c. For cases where contaminants cannot be removed with the spot cleaning described in (b), repeat the original cleaning procedure from Section 3.4 that was used for the hardware. If repeating the Section 3.4 procedure is not effective, contact the CE or CCM.

Verifying surfaces to a visibly clean-highly sensitive level:

Note: This procedure applies to GSE that will directly contact flight hardware and flight hardware items that are being integrated while the FAST instrument covers are in place.

a. Examine the surface from a distance of 6 to 18 inches while the surface is illuminated with 100 ft. candles or more from a visible wavelength inspection lamp.

b. Remove isolated contaminants observed under the inspection lamp by wiping with cleanroom wipes or swabs. Only extracted wipes and swabs will be used for flight hardware, but unextracted wipes and swabs may be used for GSE. Lightly dampen the wipes and swabs with IPA if the surface will not be damaged by the solvent. Acetone may be substituted for IPA when the surface is not affected by acetone and cannot be cleaned effectively with IPA. Continue this process until no contaminants are visible under the inspection lamp.

c. Examine the surface from a distance of 6 to 18 inches while the surface is illuminated with 100 ft. candles or more from a UV (364 nm) inspection lamp. Perform the inspection in a darkened area to highlight fluorescence from contaminants.

d. Repeat the spot cleaning procedure in (b) for contaminants observed under the UV inspection lamp. Continue spot cleaning until no contaminants are visible under the UV inspection lamp.

e. If contaminants are visible under the visible wavelength or UV inspection lamps, but cannot be removed by the spot cleaning procedure specified in (b), repeat the original cleaning procedure from Section 3.4 that was used for the hardware. If repeating the Section 3.4 procedure is not effective, contact the CE or CCM.

Verifying surfaces to MIL-STD-1246B Level 500A:

Note: The procedure will be followed during scheduled spacecraft inspections and when flight hardware is being integrated while the FAST instrument covers are not in place.

a. Particulate Tape Lift Inspection

Tape lift samples are to be taken and analyzed according to the methods indicated in document GSFC-TLS-PR-7324-01 (see Appendix 2). The number and location of tape lift samples will be determined by the CEM and the QA representative. If the resulting particulate level does not meet the surface cleanliness requirement, the CEM and QA representative will note the surface area to be recleaned according to steps 1 through 8 above. The tape lift process shall then be repeated until the results meet Level 500 per MIL-STD-1246B. Upon completion of the tape lift inspection, the area sampled shall be inspected for tape residue and wiped with an IPA dampened wipe or swab.

Tape lifts shall not be performed on surfaces which may peel or be damaged when the tape is applied and removed. If there are any concerns or questions regarding the suitability of a surface for tape lift inspection, contact the project Materials Engineer before proceeding with the test.

b. Molecular Wipe/Wash Test

The number and locations of the wipe test samples shall be determined by the CEM and the QA representative. The Materials Branch Representative shall be notified when the item to be tested has been prepared. The representative shall then collect and analyze the wipe/wash samples and send a molecular analysis report to the CEM and the QA representative. If the results of this test do not meet MIL-STD-1246B Level A, the CEM and QA representative will determine the area to be recleaned according to steps 1 through 8 above. The cleaning and verification procedure will be repeated until the indicated cleanliness level has been reached.

Appendix 1. Contamination Control Work Order Form

FAST Contamination Control Work Order Authorization

Date of Request: Date Required:

Requested By: Code: Phone:

Submit Request To: Code: Phone:

Item(s) To Be Cleaned:

Clean Per Procedure: FAST Cleaning and Verification Procedure, FAST-PROC-002

Solvent Isopropyl Alcohol Freon Acetone Other

ESD Sensitive: Yes No Bag: Single Bag Double Bag None

Other Instructions:

Date Started: Date Completed:

Performed By:

Notes:

Inspected By: Date:

Inspection Notes:

ɔr information about FAST contamination requirements, contact Sharon Straka (x9736) or Mike Rodriguez (x9296).

Appendix 2. Procedure for the Tape Lift Sampling of Surfaces

CONTAMINATION CONTROL PROCEDURE
FOR THE
TAPE LIFT SAMPLING OF SURFACES

Prepared By: Eve M. Abrams 5-8-89
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CONTAMINATION CONTROL PROCEDURE
FOR THE
TAPE LIFT SAMPLING OF SURFACES

I. SCOPE

This procedure describes the technique for sampling of surfaces by means of a tape lift to determine the extent of particulate contamination on the surfaces. The methods for preparing a tape lift sample, taking a tape lift sample, counting the particulate contamination on the tape, and determining the cleanliness level per Mil-Std-1246B will be detailed.

Particulate contamination, or particulates, will refer to both particles and fibers. A fiber is a particle whose length measurement is 10 times that of its width. The terms 'particulate contamination' and 'particulates' will be used interchangeably throughout the procedure (Mil-Std-1246B does not distinguish between particles and fibers.)

II. RECOMMENDED MATERIALS AND EQUIPMENT AND APPROVED SOURCES

A. Class 100 Laminar Flow Clean Bench or Cleanroom Table, in a Class 10,000 (per Fed-Std-209D) Cleanroom.

B. Microscope, 100x power and equipped with an eyepiece micrometer with no larger than 10 micron divisions.

C. Laboratory Counter with at least 8 counting units.

D. Clean, pressurized gas - i.e. gaseous nitrogen, 99.95% minimum, oil-free and filtered to exclude particles of 1 micron or larger. Pressurized gas such as a Texwipe Micro Duster equipped with a filter may be used when gaseous nitrogen is not available.

E. Plastic, disposable Petri Dishes, 2" diameter, Catalog # PD-1004700, Millipore Filter Corporation, or project approved equivalent.

F. Tape, Scotch 3M #480, polyethylene film, 1" wide, transferred onto plastic core spools for cleanroom use. Can be obtained from Remco, In North Hollywood, CA; 213-877-0436. Need to specify plastic spools for cleanroom use.

G. Plastic Tape Dispenser for 1" wide tape.

H. Tape lift sample holder (see Figure 1), or equivalent. Holder or drawings for manufacture of the holder can be obtained from NASA/GSFC Contamination Control Section, Greenbelt, MD; 301-286-9964.

I. Spacial scanning grid with 3.085 mm (.1215") squares, as in Millipore Brand filters. The reading area will be 11 squares long by 6 squares wide. Grids with other sizes can be used. If this is done, adjust the calculations in Part IV A&B accordingly.

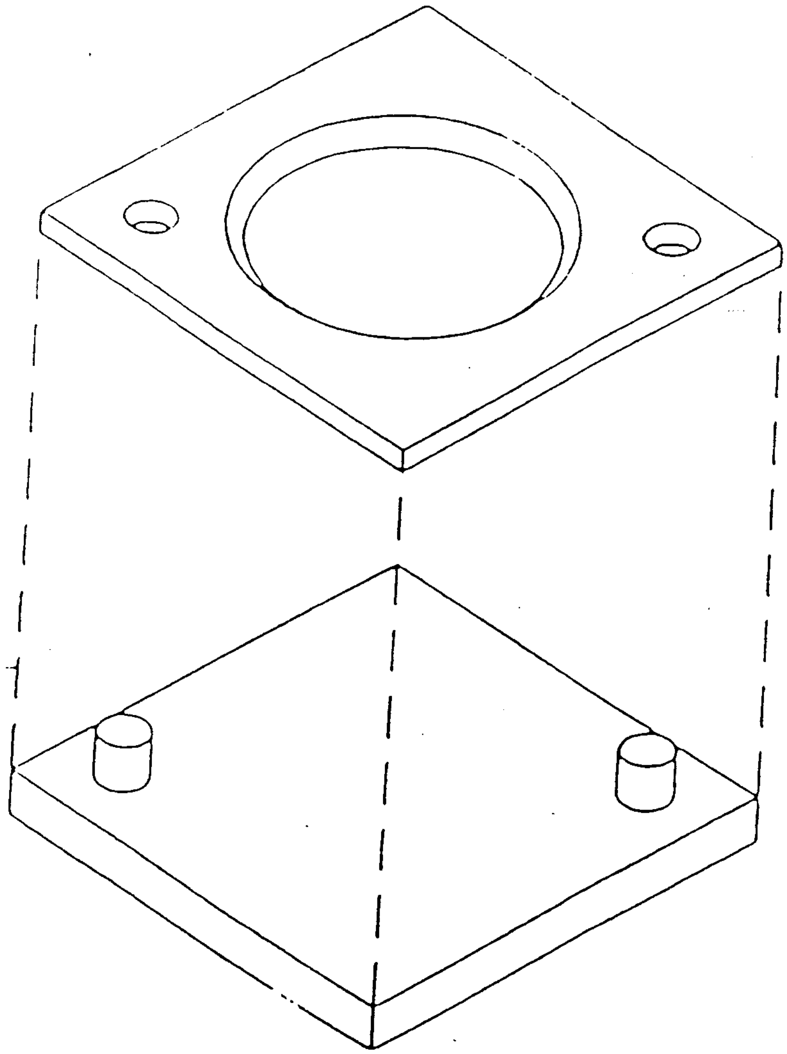
J. Tweezers, Scissors and/or razor blade.

K. Cleanroom wipes; Wilshire Contamination Control Wipes are recommended.

L. Isopropyl Alcohol, ACS, reagent grade or better.

M. Non-linting gloves; American Pharmaseal CR100 latex gloves or other project approved gloves.

N. Bags made from project-approved clean bagging material.



III. SAMPLING PROCEDURE

A. General Requirements

1. Do not use Tape Surface Sampling methods on surfaces which may be marred or peeled when the tape is applied or removed. If there is a concern about marring or peeling, contact the project Materials Engineer, or do a test on a sample surface.

2. Wear cleanroom or clean bench garments while carrying out this procedure. As a minimum, these shall include cleanroom lab coats, hoods, face masks and non-linting gloves.

3. Discard the tape at any point of this procedure if:

(a) The sampling portion of the tape touches anything other than the item being sampled.

(b) The tape gets creases or folds in it, except the handles.

4. Cut the tape with scissors or a razor blade.

5. Keep the tape transport time, which is the time when the tape is being moved through the air, as short as possible. This will minimize exposure to the environment.

6. Items that are cleaned for use on the laminar flow clean bench need to be recleaned periodically. Recleaning is necessary when the items are removed from the clean bench, are handled without gloves, or are contaminated above the cleanliness level of the items being sampled.

B. Preparation for Tape Lift Sampling

1. Items used in the tape lift procedure will need to be pre- and final-cleaned. These include the tape, tape dispenser, petri dishes, tape lift sample holder, tweezers, grid, laboratory counter, and microscope.

For working in a clean room:

- Preclean the items that are not yet in the cleanroom as described in steps 3 through 9.
- Put items in the pass-through window or bring them, in a cleanroom bag, through the changeroom. Once in the cleanroom, bring the items to a small table next to the one used for making and reading the tape lifts.

For working at a clean bench:

Clean a small table and put it by the clean bench.
Put items on the table and preclean them as described in steps 3 through 9. Do not put them on the clean bench yet.

2. Dress for working in the cleanroom or at the clean bench. Final clean the items as described below.

3. Clean the tape by blowing it off with clean pressurized gas. Pay special attention to cleaning the edges of the roll. Place the clean roll of tape on the clean bench or microscope table.

4. Clean the plastic tape dispenser by solvent wiping it and then blowing it off with clean pressurized gas. Place the tape dispenser on the clean bench or microscope table. (If the tape cutter on the dispenser does not work smoothly, clean scissors and use them for cutting the tape

(Preparation for tape lift sampling - continued)

5. Install the tape in the dispenser and discard the first six inches of tape from the roll.

6. Prepare the tape lift sample holder and petri dishes, each piece separately, and tweezers; cleaning them by thoroughly rinsing them with isopropyl alcohol and blowing off with clean pressurized gas. Examine the spacial scanning grid under the microscope and, if necessary, clean it by blowing it off with clean pressurized gas. Do this as gently as possible, as it is easy to shatter them. Place them on the clean bench or microscope table.

7. Clean the laboratory counter by thoroughly wiping it with an alcohol dampened cleanroom wipes. Place the counter on the clean bench or microscope table, and label each unit on it with one of the size ranges identified in Section IV A. Set all of the counting units to zero.

8 Clean the microscope by wiping it down with a cleanroom wipe slightly dampened with alcohol See microscope manual for any precautions necessary in the cleaning or use of the microscope. Place it on the clean bench or microscope table.

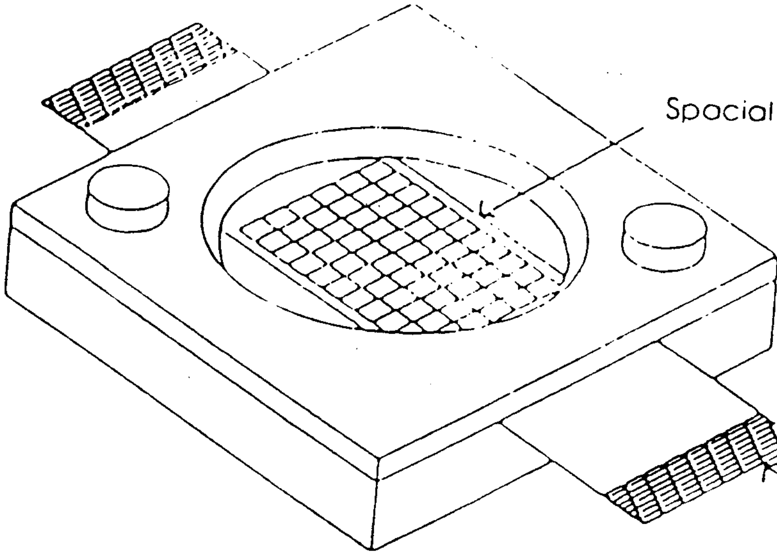


Figure 2 Tape Lift Sample in the holder with the Spacial Scanning Grid lined up underneath it.

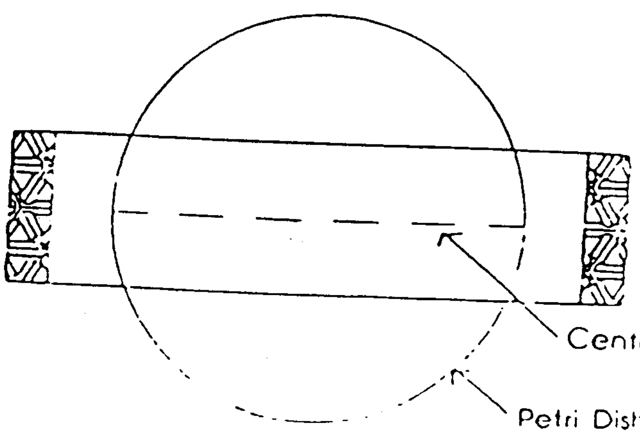


Figure 3 Tape Lift Sample placed along center line of the petri dish.

i C. Tape Lift Sampling

1. Preparing the Tape Sample

a. Take the top off of the tape lift sample holder and place it top down on the bench or table. Extract a piece of tape at least 3" long from the tape dispenser, pulling the tape slowly and with even pressure so as to minimize electrostatic charging. Pull the tape taut - <u>without</u> stretching it, and handle the tape only at the free ends.

b. Place the tape on the bottom side (which is facing up) of the sample holder top. Fold 1/4" of the surplus ends of the tape to make handles for the tape lift. (See figure 2.) Replace the top to the sample holder bottom; the adhesive side will now be facing up.

c. Make a background scan of the tape by counting the particulates as described in Part IV. After calculating the number of particulates per square foot, record these numbers on the data sheet (see Appendix A) as "background contamination."

d. Take the lid off of a prepared petri dish. Place the acceptable tape sample across the edges and along the center line of a clean petri dish, adhesive side facing the bottom of the dish. Allow the surplus to extend over the edge of the dish with an approximate equal amount extending on each edge (see figure 3). Keep the tape taut to prevent the adhesive surface from touching the bottom of the dish, again, <u>without</u> stretching it.

e. Cover the petri dish with the cover piece. The cover piece must be pressed down hard, or it will pop off due to the thickness of the tape. When the transport time is long, such as to another site, tape the lid down.

f. If the samples are going to be taken in a clean area, double bag the petri dish(es) with bags made from clean bagging material. Transport the petri dish(es) to the ite eing sampled.

2. Taking the Sample

a. At the site of the surfaces being sampled, remove the petri dish cover. Place it on a clean surface with the inside down so as not to contaminate the inside of the cover.

b. Remove the tape from the petri dish, handling it only with ~~the~~ handles at the tape ends. Do not allow the tape to touch anything but the item that is being sampled.

c. Place the tape on the surface of the item to be sampled, keeping it taut with the adhesive side contacting the sampling area. Place it down perpendicular to the surface (45° "angle of attack").

d. Carefully press down with one finger from one end to the other. Do this in one motion to ensure even contact between the adhesive surface of the tape and the sampling surface. Smooth the tape 2 or 3 times, as necessary for completely covering the surface, and move in one direction only.

e. Immediately remove the tape with a slow, steady force, handling it by the handles only. Keep the tape taut and at a 90° angle to the surface during removal (90° "angle of removal").

f. Replace the tape across the edges of the petri dish as described in step C.1.d.

g. Replace the petri dish cover, ensuring that the cover is secure, as in C.1.e above.

h. Transport the petri dish back to the clean bench and store for analysis. Transport in double clean bags if from a clean area. If not, clean the petri dish before putting it on the clean bench or bringing it into the clean room by solvent wiping the outside. (Do not let alcohol seep into the inside of the dish.)

V. ANALYSIS PROCEDURE

A. Counting the Particulate Contamination

Tape Lift Sampling of surfaces provides a method for obtaining a statistical estimate of the total number and the size distribution of particulates per square foot that is present on the sampled item.

Particulates are counted and distinguished individually according to their size. This will be an approximate diameter measurement for particles and a length measurement for fibers. All particulates larger than 500 microns in size are identified individually. The size ranges are as follows:

1. 11 - 25 microns
2. 26 - 50 microns
3. 51 - 100 microns
4. 101 - 150 microns
5. 151 - 250 microns
6. 251 - 350 microns
7. 351 - 500 microns
5. >500 microns

<u>Procedure</u>

1. Place tape in the tape lift sample holder, taping it to the bottom side of the top ece, adhesive side facing up. Use the tweezers to line up the spacial scanning grid underneath the tape sample (see figure 2). The grid should not be cut as the picture intimates; simply keep track of how many squares have been read. The reading area will be 11 by 6 squares, for a total of 66 squares.

2. Mount the tape lift sample holder on the microscope stage.

3. Focus the microscope on the tape and line the stage up to one corner square of the grid.

4. Count the particulates in the first square of the grid, determining the size range of each particulate with the eyepiece micrometer. Measure the exact size of the particulates that are larger than 500 microns. For each particulate in a size range, add one count on the appropriate size range unit of the laboratory counter.

5. Move the stage horizontally or vertically to the next square, and repeat step 4.

6. Continue along the rows systematically, repeating step 4 for each square until all of the particulates have been counted and measured. A statistical count may be done by counting half of the squares (33 squares) and doubling the particulate count obtained.

NOTES: If a statistical count is done, eliminate counting the particulates in the squares along the edges. The tape edges have the most possibility of containing particulates from sources other than that of the surface that was sampled, such as from manufacturing and shipping.

It is recommended that an entire tape sample is counted during one sitting to eliminate room contamination on the sample. A clean cover may also be used on the sample if this is not possible.

B. Determining the Cleanliness Level (Refer to Appendices A & B)

1. Once the particles and fibers have been counted, record the number particulates in each size range on the data sheet (Appendix A), including the individually sized particulates larger than 500 microns. Subtract the background count.

NOTE: As mentioned in Section II and above, the millipore grid reading area has 66 total squares, which has an area of 0.9739 in^2. Acceptable results have been attained by counting 33 squares. Adjust the area and scaling factor if the grid has different size squares than that of a Millipore filter.

2. Scale the count up to a square foot by multiplying the number of particulates in each size range by 295 for 33 squares (see DATA SHEET). The DATA SHEET and Mil-Std-1246B plot in the appendices were computer generated by inputting the appropriate particle size and number of particles per square foot. The numbers can be generated with a hand calculator, and can be hand plotted on a Mil-Std-1246B chart.

3. To obtain the plot on Mil-Std-1246B for the DATA SHEET use the following method. Find the total number of particles per square foot for each of the particle size ranges. Next, for each size range, find the total number of particles in and above that size range. This is the point to plot on the Mil-Std-1246B chart, and it is plotted at size 1 micron lower than lower number in the size range, representing the number of particles greater than that size.

For example, point 1 on the plot represents all the particulates greater than 10 um, which is 61,360, and it is plotted at 10 um. Point 2 represents all the particulates greater than 25 um. This number is 36,465; it is obtained by subtracting the number of particulates in the 11-25 um range from the total, and it is plotted at 25 um. Point 3 represents all the particulates greater than 50 um. This number is 20,355; it is obtained by subtracting the number of particulates in the 26-50 um range from the number reached for point 2, and it is plotted at 50 um.

The rest of the points are obtained and plotted using the same procedure.

4. The cleanliness level is obtained by viewing the Mil-Std-1246B plot and determining the highest level into which the particle count points fall. In our example, the cleanliness level (CL) is 750. This number is recorded on the DATA SHEET. To obtain an exact CL for a given particulate size, use the following equation:

$$\log n = 0.9260(\log^2 X_1 - \log^2 X) \qquad (1)$$

where:

n = number of particles
0.9260 = tangent of the angle
X_1 = cleanliness level
X = particle size

NOTE: If there is a particular size range in which the surfaces being sampled are particularly sensitive, that section of the plot can be the primary area to focus on. In addition, the equation above can be used to determine the cleanliness level at the size range in question.

SMALL EXPLORER (SMEX) DOCUMENTATION CONTROL FORM

ACTION CODE	NAME	MAIL CODE	ACTION CODE	NAME	MAIL CODE	ACTION CODE	NAME	MAIL CODE
	M. ADAMS	741		T. GRUNER	745.2		W. POWELL	822
	R. ALEMAN	740.4		K. HERSEY	737.1		G. RAKOW	743.3
	M. ANDERSON	745.2		L. HILLIARD	740.4		M. REID	512.2
	J. ARRISON	740.4		T. HUBER	700	✓	M. RODRIQUEZ/MDAC	724.4
	D. BAKER	690		F. HUEGEL	743.3		G. ROSANOVA	741.3
	M. BAXTER/STX	740.4		T. JACOBS	743.2		P. SALERNO	743.1
	D. BERRY	512.1		B. JOYCE	301		R. SCHNURR	745.2
	D. BETZ	740.4		D. JUNG	734.5		B. SETTLES	743.3
	M. BLAU	743.3		K. KEADLE-CALVERT	743.2		A. SHERMAN	700
	T. BUDNEY	745		J. KELLOGG	741.1		D. SHREWSBERRY	740
	J. BURT	740.4	✓	R. KOLECKI	740.4		D. SILVA	470
	J. BYRD	740.4	✓	T. LAFOURCADE	743.1		SMEXFOT/ATSC	740.4
	J. CATENA	740.4	✓	J. LYONS	734.4		G. SNEIDERMAN	741.3
	G. CHIN	693.1		H. MALDONADO	737.3		T. SPITZER	734.1
	C. CLAGETT	745.1		S. MANNING/UNISYS	740.4		M. STEINER	743.1
	SMEX CM	740.4		R. MENCIA/SWALES	724	✓	R. STONE	743
✓	G. COOPER	743.1		S. MEYERS	741	✓	S. STRAKA	724.4
	T. CORRELL	745.2		T. MICHAELIS	745.1		T. TRENKLE/MMS	743.1
	B. DEDALIS	302		P. MULE	750.2		B. VERNIER	470
	T. DOD/SWALES	737		Y. NGAN	737.3		M. WALKER	745.1
	D. EVERETT	743.1		D. NGUYEN	724		J. WATZIN	740.4
	B. FAFAUL	311.1		Q. NGUYEN	743.2		R. WEAVER	740
	L. FANTANO	724.1		D. OLNEY	745.1		J. ZEMBOWER/INTER	740.4
	O. FIGUEROA	740.4		D. OLSEN/STX	740.4			
	J. FIORA	740.4	✓	K. PARRISH	724.1			
	J. GALLEHER/HEI	740.4		R. PATSCHKE	743.1			
	D. GATES/ATSC	740.4		S. PATTON	741.1			
	T. GEHRINGER	740.4		C. PETRUZZO	745			
	D. GILMAN/NASA HQ	SZD		R. PFAFF	696			

NUMBER OF ENCLOSURES OR ATTACHMENTS INCLUDED 1

SUBJECT: Fast Cleaning + Verification Procedure
Fast-Proc-002

COMMENTS: FYI

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