NAVAL RESEARCH LABORATORY

NAVAL CENTER FOR SPACE TECHNOLOGY

Contamination Control Plan
for the
Full-Sky Astrometric Mapping Explorer (FAME)

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RECORD OF CHANGES

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1. INTRODUCTION

1.1 Purpose.

The purpose of this document is to define the contamination requirements associated with the FAME program and to present the overall contamination control program to be implemented for the FAME program.

1.2 Scope.

This document defines the contamination requirements and contamination control procedures for the FAME spacecraft from fabrication through launch. Each organization providing flight hardware for the FAME program is responsible for complying with the provisions of this plan and the applicable documents cited herein. The FAME program shall resolve conflicting interpretations of this document.

1.3 Contamination Control Approach.

A comprehensive approach to contamination control has been developed for the FAME program. The approach is as follows:

Evaluate mission objectives and performance goals.

Identify contamination-sensitive surfaces on both the instrument and spacecraft bus.

Assess performance degradation as a function of contamination accumulations.

Determine acceptable performance degradation levels.

Design an appropriate contamination control program which aids in ensuring allowable contamination levels will be met for each mission phase:

- Design
- Fabrication
- Assembly
- Integration and testing
- Transport and storage
- Pre-launch / launch site
- Launch
- On-orbit
- Post mission

Evaluate all categories of issues.

- Materials selection
- Clean room requirements
- Personnel requirements
- Handling requirements
- Hardware cleaning
- Monitoring program
- Vacuum bakeout program
- Protective devices

Develop necessary documentation in support of contamination control program.

Perform analyses and testing to verify contamination levels and performance degradation effects.

Implement contamination control program.

Ongoing assessment of cleanliness levels.

Identify and support pre-launch activities and requirements.

Perform final pre-launch certifications.

Monitor on-orbit operations.

Assess on-orbit contamination levels.

2. APPLICABLE DOCUMENTS

2.1 FAME Documents.

Number	Title	Paragraph Ref.

2.2 Reference Documents.

Number	Title	Paragraph Ref.
ASTM E-595	Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials	
FED-STD-209E	Federal Standard, Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones	
GSFC-TLS-PR-7324-01	Contamination Control Procedure for the Tape Lift Sampling of Surfaces	
MIL-P-27401C	Military Specification – Propellant Pressurizing Agent, Nitrogen	
MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program	
NASA-JSC-SR-R-0022A	Vacuum Stability Requirements of Polymeric Material for Spacecraft Application	
NASA-JSC-SN-C-005	Contamination Control Requirements for the Space Shuttle Program	
NASA-RP-1124-87	Outgassing Data for Selected Spacecraft Materials	

3. ACRONYMS

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4. TERMINOLOGY AND STANDARDS

4.1 Terminology.

The following definitions are included to establish the meaning of FAME contamination control terminology:

a) Clean Area - Area where airborne particle contamination levels are strictly controlled by air filtration and regulation of particle sources. Clean rooms, clean tents, and clean benches are the most common types of clean areas.

b) Contamination - Unwanted material that degrades the desired hardware function. Contamination is usually separated into two types: particulate and molecular.

c) Contamination Control - Organized action to control contamination levels.

d) Fiber - Particle with a length to width ratio exceeding 10:1 and a minimum length of 100 microns.

e) Gross Cleaning - Cleaning hardware surfaces in a normal work environment to visual inspection standards. This step precedes precision cleaning.

f) Nitrogen Purge - Pressurized flow of clean, dry nitrogen through a system to displace impurities and reactive species.

g) Particle - Small quantity of solid or liquid material with definable shape or mass.

h) Particle Size - Maximum linear dimension or diameter or a particle.

i) Precision Cleaning - Cleaning process done in a clean area to attain a specific, quantitative cleanliness level.

j) Sensitive Surfaces - Flight hardware surfaces requiring a specific cleanliness level to meet minimum performance requirements.

k) Solvent Flushing - Pressurized stream of filtered solvent directed against a surface to dislodge and rinse away contaminants.

l) Solvent Washers - Quantitative method of verifying MIL-STD-1246 NVR levels by measuring molecular contamination in a solvent washed over surface.

m) Surface Cleanliness Level - Established maximum allowable particle and NVR contamination ranging from visibly clean to specific MIL-STD-1246 levels.

n) Swab Sample - Qualitative method of identifying contaminants by analyzing residue on a solvent soaked swab wiped over a surface.

o) Tape lifts - Quantitative method of verifying MIL-STD-1246 particle cleanliness levels by measuring particle contamination on a tape sample that has contacted a surface.

p) Vapor Degrease - Item to be cleaned is exposed to heated solvent vapors that condense on the part and wash away contaminants.

q) Visibly Clean - Clean surface as seen without optical aids when measured by a specific method.

4.2 Contamination Control Standards.

Contamination control requirements are expressed in accordance with the following standards:

a) MIL-STD-1246, “Product Cleanliness Levels and Contamination Control Program”, establishes quantitative methods for describing surface particle and NVR levels. Particle levels are denoted by a number (100, 480, 650, etc…) while molecular NVR levels are represented by a letter (A, B, C, etc…). The number describing the particle level reflects a log^2 – log distribution of particle size and number. This relationship is illustrated by the graph in Figure X-X and summarized in Table X-X for different particle levels. The letter representing the NVR level signifies an NVR concentration (mg/0.1 m^2) within defined limits.

b) NASA-JSC-SN-C-0005, “Contamination Control Requirements for the Space Shuttle Program”, establishes methods for qualitative surface contamination evaluation. The evaluation method requires surface examination from a prescribed distance with an inspection lamp meeting or exceeding a specified intensity. When no contamination is visible on a surface undergoing inspection in this manner, the surface is deemed “visibly clean”. There are three grades of visibly clean surfaces, standard, sensitive, and highly sensitive, which are distinguished by different inspection lamp intensity and inspection distance requirements.

c) FED-STD-209, “Federal Standard, Airborne Particle Cleanliness Classes in Cleanrooms and Clean Zones”, governs the measurements of airborne contamination. It defines a term, the clean area “class”, which acts as a rating for clean area airborne particle levels. This term is approximately equivalent to the base 10 logarithm of the number of particles greater than 0.5 microns per cubic meter of air.

5. CONTAMINATION CONTROL REQUIREMENTS

The FAME program consists of the instrument and the spacecraft bus. The primary contamination control sensitive elements are located in the instrument. However, the spacecraft bus may also contain sensitive elements (thermal control surfaces, sensors/star trackers, etc…). In addition, to prevent excessive cross contamination between the spacecraft bus and instrument, the bus must be designed, fabricated, and assembled in a clean manner and must be verified as meeting cleanliness requirements prior to instrument integration.

The following subsections contain the overall contamination requirements for the instrument and the bus.

5.1 Instrument.

TBD

5.1.1 Performance Requirements.

TBD

5.1.2 End-of-Life Contamination Requirements.

TBD

5.1.3 Contamination Budget Breakdown.

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5.2 Spacecraft Bus and Subsystems.

The spacecraft bus and all subsystems must meet specific cleanliness and materials outgassing requirements so that cross-contamination will not occur. Bus and subsystem contamination requirements are designed to prevent instrument exposure to redistributed contaminants and to preserve functions in the power, thermal, and attitude control subsystems. Meanwhile, the attitude control subsystems must be kept clean so the sensors will not be affected by excessive contaminant accumulation and provide inaccurate readings. The thermal subsystem utilizes surface coatings with specific absorptance and emittance values that will degrade if the coating is contaminated.

All materials used on the spacecraft bus and in the subsystems must meet TML/VCM requirements set forth in NASA-SPR-0022. These outgassing requirements are designed to limit contaminant accumulation on the instrument measurement systems and sensitive subsystem surfaces during vacuum testing and on-orbit operations.

All spacecraft and subsystem parts will undergo vacuum bakeout per the FAME vacuum bakeout procedure (TBD).

All spacecraft and subsystem hardware shall meet Level TBD surface cleanliness requirements at delivery to the integration area. Surface cleanliness levels will be verified via TBD methods prior to instrument integration.

5.3 Ground Support Equipment.

Ground support equipment used in the vicinity of FAME must be visibly clean per NASA-JSC-SN-C-0005 before it is admitted to the spacecraft integration and test areas. Materials used in FAME clean areas also cannot generate excessive particulate contamination or residue.

The FAME nitrogen purge system is detailed in TBD. Nitrogen used for the instrument purge shall have less than 1.0 parts per million of total hydrocarbons and less than 5.0 parts per million of water vapor when sampled are the outlet to the instrument. Total impurities in the nitrogen shall meet MIL-P-27401 Grade B when sampled at the outlet to the instrument. At a minimum, the purge gas will be filtered with a desiccant, molecular absorber, and a particle filter before flowing into the instrument. Before purge system assembled, all purge plumbing shall be cleaned and certified to MIL-STD-1246 Level 100A.

6. CONTAMINATION SOURCES

To adequately protect FAME from contamination and more effectively clean contaminated components, it is essential to identify and understand the possible sources of contamination. These sources will differ at various stages of hardware development for FAME. Table 6-1 presents a summary of contamination sources that could adversely affect FAME.

Table 6-1. Sources of Contamination

Phase	Molecular (NVR)	Particulate
Fabrication	Machining oils, fingerprints, air fallout	Air fallout. Air fallout. Personnel, soldering, drilling, bagging material
Assembly and Integration	Air fallout, outgassing, personnel, solvents, soldering, lubricants, bagging, materials	Air fallout, personnel, soldering, drilling, bagging material, MLI fitting
Test	fallout, outgassing, personnel, test, facilities, purges, bagging material	Air fallout, personnel, test facilities, purges, MLI fitting, bagging material
Storage	Bagging material, containers, outgassing, purges	Bagging material, containers, purges
Transport	Bagging material, containers, outgassing, purges	Bagging material, containers, purges
Launch Site	Bagging material, air fallout, outgassing, personnel, purges	Bagging material, air fallout, personnel, launch vehicle surfaces and preparations, MLI fitting
Launch	Outgassing, venting	Launch vehicle surfaces, fairing separation, payload separation
On-Orbit	Outgassing	Micrometeoroid and debris impingement

7. CONTAMINATION CONTROL IMPLEMENTATION

7.1 Fabrication.

TBD

7.2 Integration.

TBD

7.3 Testing.

TBD

7.3.1 Thermal Vacuum Testing.

TBD

7.3.2 Vibration and Acoustics Testing.

TBD

7.3.3 Functional Testing.

TBD

7.3.4 Calibration Testing.

TBD

7.4 Transportation and Storage.

TBD

7.5 Launch Site Activities.

TBD

7.6 Launch and Orbit Insertion.

TBD

7.7 On-Orbit Operations.

TBD

7.8 Post Mission Activities.

TBD

A. APPENDIX A – INSTRUMENT PURGE PLAN

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B. APPENDIX B – CLEAN ROOM OPERATIONS PROCEDURES

TBD

C. APPENDIX C – SURFACE CLEANLINESS VERIFICATION PLAN

TBD

D. APPENDIX D – WITNESS PLATE TRACKING PLAN

TBD

E. APPENDIX E – THERMAL VACUUM BAKEOUT PLAN

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